bio Intelligence Service

European Commission (DG ENER)

Preparatory Studies for

Ecodesign Requirements of EuPs (III)

[Contract N° TREN/D3/91-2007-Lot 23-SI2.521679]

Lot 23

Domestic and commercial hobs and grills included when incorporated in cookers

Task 3: Consumer behaviour and Local infrastructure

Final Version - August 2011

In association with

ERA TECHNOLOGY

ERA Technology Ltd

Bio Intelligence Service - Scaling sustainable development
Industrial Ecology - Nutritional Health
Bio Intelligence Service S.A.S - bio@biois.com
20-22 Villa Deshayes - 75014 Paris - France
Tél. +33 (0)1 53 90 11 80 - Fax. +33 (0)1 56 53 99 90

Contact BIO Intelligence Service
Shailendra Mudgal – Benoît Tinetti
☎ + 33 (0) 1 53 90 11 80
shailendra.mudgal@biois.com
benoit.tinetti@biois.com

Project Team

BIO Intelligence Service

Mr. Shailendra Mudgal

Mr. Benoît Tinetti

Mr. Eric Hoa

Mr. Guillaume Audard

ERA Technology

Dr. Chris Robertson

Dr. Paul Goodman

Dr. Stephen Pitman

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3. TASK 3 – CONSUMER BEHAVIOUR AND LOCAL INFRASTRUCTURE

Consumer behaviour has a significant effect on the environmental impacts of domestic and commercial hobs and grills during all phases of their life-cycle: firstly through the selection of the appliance type (electric, induction, gas, built-in, free-standing, etc.), secondly through the actual use of the appliance over the life time and finally on the end-of-life of the product. To some extent, product-design can also influence consumer's behaviour and consequently the environmental impacts and the energy efficiency associated with the product use.

The aim of this task is to investigate the influence of consumer behaviour on the energy and environmental performance of Lot 23 products, as well as eco-practices in sustainable product use. Further, analysis of real life use conditions of products in comparison with standard test conditions will provide a more accurate picture of the real energy use. Also considered is the effect of providing product information to the end-users of Lot 23 equipment and whether it could be useful to consider labelling or provision of other eco-information (e.g. ecological profile) of the product. Barriers to the provision of such information and Ecodesign measures, due to social, cultural, and infrastructural factors will also be investigated.

3.1. REAL LIFE EFFICIENCY

The aim of this subtask is to understand how the real life efficiencies of domestic and commercial hobs and grills differ from those tested in standard conditions and to quantify user defined parameters.

The energy consumption of hobs and grills is strongly influenced by the user's way of cooking. Main factors exist including the choice of cooking utensils (pots, lids), temperature settings and the duration of the cooking process, all of which can vary considerably depending on the user's habits. These practices can relate as well to regional differences, but may strongly depend on individual preferences. Little influence through design is perceived on this part of the cooking process.

Sources outside the EU agree that cooking habits, not technology, represent the biggest potential for energy savings in the kitchen. Real life experiences, such as a test developed by the U.S. Bureau of Standards have shown that some people use 50 %more energy than others to cook the same meal[1]. Information in the following sections on user's behaviour provided for several Member States will prove that these differences are also present inside the European Union.

[1] Rocky Mountain Institute (2004), "Home Energy Briefs - #8 KITCHEN APPLIANCES".

3.1.1. DOMESTIC ELECTRICAL APPLIANCES

In the breakdown of final electricity consumption among residential end-use equipment presented by the Institute for Environment and Sustainability (IES) of the European Commission[2], the share for cooking equipment was 7% for the EU-15[3] in 2004. In particular electric hobs are responsible for 5% of the overall residential electricity use which represented 37 TWh in the same year. The total electricity consumption of residential equipment is broken down in Figure 3-1.

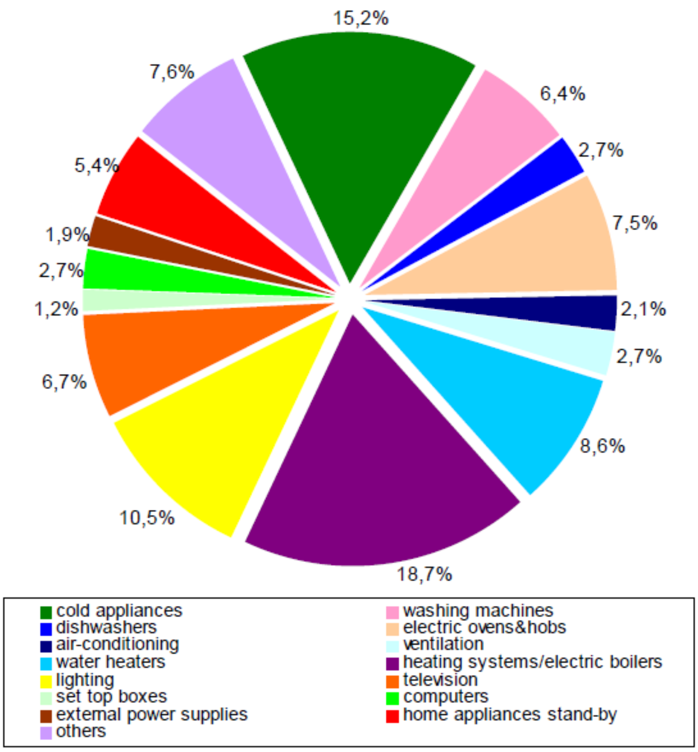

Figure 3-1: Electricity consumption among residential equipment in the EU-15 in 2004[2]

The tertiary sector, representing the public sector, education, healthcare, services and commerce, presents more difficulties to obtain data on electricity end-uses than the residential sector. It was agreed by the European Climate Change Programme (ECCP)[4] that cooking equipment (excluding commercial refrigeration) accounted for 6% of electricity consumption in this sector in 2000, where no information by type of appliance (or hobs consumption only) was available. This percentage represented a total of 40.0 TWh in 2003 and 40.8 TWh in 2004 for the EU-27[2]. The difficulty in obtaining accurate figures for this sector is due to the lack of available data for both sales and stocks, as presented in Task 2 (Economic and Market Analysis). In addition, the type of buildings and their associated energy consumption are very diverse ranging

[2] Bertoldi, P. and Atanasiu, B. (2006), "Electricity Consumption and Efficiency Trends in the Enlarged European Union", Status report.

[3] EU-15 Countries : BE, DE, ES, FR, IT, NL, AT, PT, SE, UK, DK, IE, EL, LU, FI

[4] European Climate Change Programme (ECCP) (2000 – 2001), "Final Report of the ECCP-Joint Sub Working Group (JSWG) on Energy Efficiency in End-Use Equipment and Industrial Processes". Brussels.

from purely commercial catering establishments to schools or hospitals making it difficult to track information on the end-user's consumption behaviour.

- **Residential Sector**

Information regarding the real life use in the residential sector has been retrieved from several sources in a country level.

Cooking equipment in France has been classified according to their annual electricity consumption, in the following order[5] (from the more consuming to the less consuming appliance):

1. Induction hobs	337 kWh/yr
2. Ceramic hobs	281 kWh/yr
3. Ovens (average)	224 kWh/yr
4. Solid plates	198 kWh/yr

In general, 50% of the electricity consumption in France due to cooking appliances is from hobs use and 42% from ovens use. The same study shows that the consumption varies through the year depending on the season, with a maximum value in winter and a minimum during summer.

Annual consumptions per appliance differ mainly due to operation times. It is believed that for induction hobs the average cooking time is 58 minutes, whereas for the ceramic and solid plates it is 45 and 26 minutes respectively. There was no explanation in the report for the difference of nearly 50% in cooking times between induction hobs and solid plates, which are difficult to explain given that induction hobs heat food more quickly with lower heat losses and therefore should shorten the cooking time and consume less electricity annually than other types of hob. The higher annual consumption of induction hobs can be also attributed to additional features such as standby power consumption. This has been reported to be between 8 and 18 W depending on the model, representing 30% of the total electricity consumption per year in induction hobs. This is a historical figure because new hobs must comply with the Standby Regulation 1275/2008 which requires that household appliances consume less than 1 watt when in standby-mode[6] thus the proportion of electricity consumed in standby will be much lower for new models in the market.

Table 3-1 presents a summary of the data retrieved in France for the electricity consumption of different electric hob types. The differences of cooking times between the 3 technologies can be explained by different usage patterns: solid plate is used by small families or single people who are not cooking very often, while induction is used by larger families who are cooking more often.

[5] Sidler, O (2009). ENERTECH. "Notes techniques : Connaissance et maîtrise des usages spécifiques de l'électricité dans le secteur résidentiel".

[6] The 1 W target (2W with a display) set by the Ecodesign Regulation on standby power will reduce the electricity consumption due to this feature on appliances placed on the EU market since January 2010. From 2013, the maximum standby energy consumption will halve to 0.5W or 1 watt with a display.

Table 3-1: Hobs annual energy consumption in France 2008[7]

Type of hob	Annual Consumption (kWh/yr)	Using time per day (min)
Induction	337	58
Ceramic	281	45
Solid plate	198	26

Ceramic hobs with standby power consumption are reported to consume 34 kWh/yr only due to this feature. This corresponds to appliances where the standby power was thought to be 3.9W in 2008[7]. Induction hobs were reported as having standby power of 18W when they were first introduced in the market but with technological improvements this value decreased to 8W in the second generation and to 1W in the latest appliances released.

The Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe Project (REMODECE)[8] has created databases that enable users to access monitoring campaigns and surveys conducted in several countries in the European Union. The available data for domestic electric hobs and grills was retrieved mainly from a campaign conducted by Ecuel in France (1998) that measured the annual consumption of several cooking appliances.

A sample of 53 ceramic hobs was monitored 24h/day at 10 minutes intervals from which an average annual consumption of 275.5 kWh/yr was calculated. Additional data for other appliances in Lot 23 can be found in Table 3-2. The number of appliances that were measured has been included to provide information on whether the data collected can be assumed to be representative of the category. The minimum and maximum reported values give an idea of the spread of performance across different models, household behaviour and usage.

[7] Sidler, O (2009). ENERTECH. "Notes techniques : Connaissance et maîtrise des usages spécifiques de l'électricité dans le secteur résidentiel".
[8] http://www.isr.uc.pt/~remodece/database/survey.htm

Table 3-2: Annual consumption of several appliances in France 1998[9]

Type of Appliance	Number of samples	Annual Consumption (kWh/yr)		
		Min	Max	Average
Ceramic hobs	53	47.7	675.6	275.5
Sealed hobs[10]	12	26.8	537.4	212.8
Induction hobs	8	140.2	512.5	354.7
Hot plates	8	31.8	307.2	171.7
Grills	2	24.0	69.5	46.8
Standby in induction hobs	9	4.0	18.0	13.1

The average consumption values presented in this campaign (Table 3-2) are similar to those summarised in Table 3-1 for ceramic hobs, induction hobs and solid plates. However, there are important differences between the minimum and maximum values reported within each category. This confirms that consumer behaviour can have a major impact on consumption, as cooking times, temperatures and frequencies vary considerably among users.

The last row of Table 3-2 shows annual consumption due to standby power in induction hobs. Only three sets of values were recorded for this field during the measuring campaign: 4, 8 or 18 W. This corresponds to appliances that display different states of technology in standby power as previously explained for first, second or third generation releases. The three configurations for induction hobs in the time of the survey that consume either 4, 8 or 18 W in standby mode resulted in an average value of 13.1 W measured in the nine samples. As the average value is closer to 18 W, it means the stock mainly comprises appliances from the first generation.

For grills, only two appliances were tested; the average of 46.8 kWh/yr might not be representative of all models but there is no other data available.

Another source of user parameters (electricity consumption per use or number of uses per year) is the Market Transformation Programme (MTP) in the UK[11]. Their latest revised data from 2008 is presented in Table 3-3. In this case, the annual number of uses for all types of hobs (electric, induction or gas) is assumed to be constant and the difference in annual consumption is only due to the actual consumption per use. More information related to future trends or changes in consumer behaviour towards the use of hobs cannot be retrieved as the annual uses have been reported constant for the past 20 years. In the study, a test to actual ratio of 0.87 is used to take into account differences between standard test conditions and real life use. Background info on how the values were measured / converted and how the standard conditions were defined was not further specified.

[9] http://www.isr.uc.pt/~remodece/database/survey.htm
[10] Gas hobs with partially covered burners.
[11] Market Transformation Programme. http://efficient-products.defra.gov.uk/cms/market-transformation-programme/

Table 3-3: User parameters for Electric and Gas Hobs in UK 2008[11]

Type of Hob	Consumption per use (kWh/Use)	Annual Uses (Uses/yr)	Total final UEC (kWh/yr)*	Lifetime Average (yrs)
Induction	0.5	424	189	20
Electric	0.7	424	269	20
Gas	0.9	424	334	19

***Unit energy consumption (UEC):** Consumption per use values are adjusted with a *test to actual ratio* to take into account differences between test and real life uses.

The above UEC figures seem closer to real use since an assumption of similar use time irrespective of type of hob is more reasonable than that use in Table 3-1 where the induction type is in use the most.

Additional information on user's parameters or performance of the appliances can be retrieved from sources outside the EU, such as the Australian Greenhouse Office (AGO) or the US Department of Energy (DOE).

In its final report in MEPS/labeling[12], AGO presented annual electricity consumption of hobs measured by three different sources from 1991 to 1999. The range of electricity consumption for the appliances is presented in Table 3-4. It is noticeable that the annual consumption has decreased during the period under study and how the recent values are close to those reported for induction hobs in the UK in 2008 (see Table 3-3).

Table 3-4: Annual consumption of electric hobs in Australia[12]

Source	Year	Annual Consumption (kWh/yr)
SECWA	1991	245
QEC	1993	169
Energy Efficient Strategies*	1999	187

*Personal Communication from the AGO

From the same report, information on grills is extracted from two sources presented in Table 3-5. These values are in the same range of those reported by the Ecuel campaign in France, where the average annual consumption of a grill was of 46.8 kWh/yr.

[12] Australian National appliance and equipment energy efficiency program. (2002) Options study – MEPS/Labelling possibilities for stoves & cook-tops.

Table 3-5: Annual consumption of electric grills in Australia[12]

Source	Year	Annual Consumption (kWh/yr)
SECWA	1991	54
QEC	1993	12

The US DOE[13] has reported values of annual energy consumption summarised in Table 3-6. These values are determined using the annual useful cooking energy output and the appliance (hob) efficiency in the equation with the general form:

$$E_{CA} = \frac{O_{hob}}{Eff_{hob}}$$

Where: E_{CA} = Annual cooking energy consumption

O = Annual useful cooking energy output

Eff = Energy factor or efficiency

Table 3-6: Annual energy consumption of domestic electric hobs in USA 2008[13]

Type of Appliance	Cooking Energy Output (O)	Energy factor (Eff)	Annual Consumption (E)
Electric Hobs	173.1 kWh/yr	0.740	234 kWh/yr

The Office of Energy Efficiency in Canada published a list[14] of cooking appliances by brand with their annual energy consumption. From that publication, data was retrieved for the brands that represent manufacturers in the EU and are relevant to this study. Table 3-7 gives an idea of the average performance of the equipment currently produced by these manufacturers. These values show that for "smooth top" the maximum variation is about 4.5% and about 3.5% for "conventional top". Therefore, these brands propose appliances with more or less the same level of efficiency.

[13] US DOE (2009), "Final Rule Technical Support Document: Residential Dishwashers, Dehumidifiers, and Cooking Products, and Commercial Clothes Washers". Chapter 6. Energy use determination.

[14] Natural Resources Canada (NRC) (2009), "Energy Guide Appliance Directory".

Table 3-7: Annual energy consumption of electric hobs by brand (2008)[14]

Type of appliance	Brand	Annual Consumption (kWh/yr)
Smooth top[15]	Bosch	230
Conventional top[16]	DeLonghi	227
Smooth top	Electrolux	237
Smooth top	Miele	234
Smooth top	Siemens	230
Conventional top	Whirlpool	235
Smooth top	Whirlpool	227

The annual consumptions of domestic electric appliances to be used in the rest of the study are presented in Table 3-8, which has been built from the EU-representative outcomes of Tables 3-3 and 3-7, and further adjusted after discussions with the Öko-Institute (DE), given complementary tests performed by the German "Stiftung Warentest" which respectively show an annual energy consumption of 260, 225 and 175 kWh/year for solid plates, radiant and induction hobs.

Table 3-8: Summary of energy consumption for all types of domestic electric hobs

Type of Appliance	Annual Consumption (kWh/year)
Electric hobs - Solid plates	250
Electric hobs - Radiant	240
Induction hobs	190

It should be also mentioned that the power factor of the appliance is not directly taken into account when considering the apparent energy consumption. Therefore, even though induction hobs present lower apparent energy consumptions compared to the other electric hobs, they may contribute to distribution energy losses due to the low power factor, which is mainly induced by the capacitive nature of the filters used for electromagnetic compatibility (EMC) compliance of the hobs.

[15] Ceramic, glass hob
[16] Solid plates

Other impacts of users habits in the residential sector

In addition to user parameters already described such as cooking times and frequencies, there are other issues that influence the energy use of cooking appliances. They are both related to choices made by the consumer that affect the final consumption and depend solely on the user's preferences and habits.

The first issue is revealed by the US DOE in its technical report[17] to establish energy use of cooking products, where it has identified a decline in the annual energy consumption from 1977 to recent years. This drop is attributed to people eating out more frequently and cooking less at home, although it appears from some other reports that there is a resurgence of interest in cooking at home in recent years[18]. Data from Australia in Table 3-4 shows the same behaviour, a decline in the annual consumption of electric hobs since 1991 up to more recent years. Although no information on the evolution of annual consumption of this appliance was found in the EU, mainly due to the assumption of constant annual uses in models such as MTP's in the UK, it is believed that this trend could pertain to the EU Member States. This is supported by a well documented case in another cooking appliance, electric ovens in the UK, where it has been shown that annual consumption has declined considerably since 1980 and is expected to continue[19].

If the general tendency to eat out continues to increase, the main contribution of energy using products in this category will shift from the residential to the commercial sector. This underlines the need to include commercial cooking appliances in this study.

Secondly, the choice of cookware has an important effect on the final consumption per use. Although there is no information on different types of cookware tested in various appliances (e.g. electrical, induction or gas hobs) to enable comparison between them, a test conducted on an electric hob of two different types of pans demonstrated the significance of this factor (see Figure 3-2).

[17] US DOE (2009), "Final Rule Technical Support Document: Residential Dishwashers, Dehumidifiers, and Cooking Products, and Commercial Clothes Washers". Chapter 6. Energy use determination.
[18] The Independent Electrical Retailer Press article (12 June, 2008), "Built-in ovens - Magic in the oven".
[19] Market Transformation Programme. http://efficient-products.defra.gov.uk/cms/market-transformation-programme/

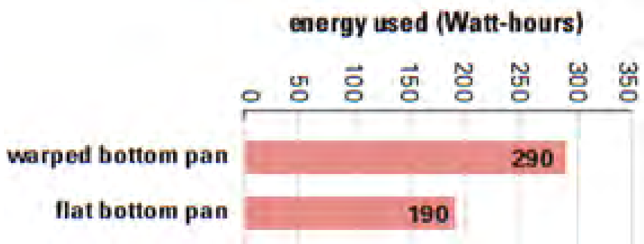

Figure 3-2: Energy used to boil 1.5 litres of water in an electric hob using a warped bottom pan or a flat bottom pan in USA 2003[20]

Energy required to maintain a specific temperature is also important and will vary with pan type but no benefits in energy savings will be made if the minimum electricity or gas settings of the hob are not sufficiently low so as to allow simmering or a temperature below boiling to be maintained.

More generally, consumer behaviour has a major influence on the energy consumption. Improved behaviour can notably address the following actions:

- Use a lid (in 2008, the REMODECE study shows that in Germany a lid is only used in 48% of all cooking procedures)
- Use adequate sized-cookware
- Use a pressure cooker when possible
- Avoid over-heating and higher
- Etc...

3.1.2. Domestic gas appliances

MTP in the UK[21] provides information on the evolution of gas hobs energy consumption used as input into their models of energy use. The actual energy consumption per year is given in terms of kWh/yr. Two parameters are assumed to be constant for the past 20 years: consumption per use and number of uses per year. The reason for changes in the reported annual consumption are a slight increase in the evolution of standby power demand and the test to actual ratio value, which is used to take into account differences between standard test conditions and real life use. These parameters are summarised in Table 3-9 from 1980 – 2008.

[20] Rocky Mountain Institute (2004), "Home Energy Briefs - #8 KITCHEN APPLIANCES"
[21] Market Transformation Programme. http://efficient-products.defra.gov.uk/cms/market-transformation-programme/

Table 3-9: Evolution of gas hobs annual energy consumption in UK

Year	Consumption per use (kWh/use)	Annual Uses (Uses/yr)	Total UEC (kWh/yr)	Test to actual ratio	Standby Power Demand (W)
1980	0.9	424	465.9	1.22	0.00
1985	0.9	424	423.5	1.11	0.00
1990	0.9	424	366.8	0.96	0.00
1995	0.9	424	333.3	0.87	0.00
2000	0.9	424	332.5	0.87	0.02
2005	0.9	424	333.3	0.87	0.12
2008	0.9	424	333.6	0.87	0.15

The previous table shows that the annual consumption of gas hobs has been more or less constant since 1995 at 333.5 kWh/yr.

Additional information on users' parameters or performance of gas appliances found in a source outside the EU, the US Department of Energy (DOE), is presented in Table 3-10.

Table 3-10: Annual energy consumption of domestic gas hobs in USA in 2008[22]

Type of Appliance	Cooking Energy Output (O)		Energy factor (Eff)	Annual Consumption (E)	
Gas Hob	527.6	kBtu/yr	0.156	3382	kBtu/yr
	154.8	kWh/yr		992	kWh/yr

The annual energy consumption figure in Table 3-10 for gas hobs takes into account the use of standing pilots, burning gas continuiously. As pilot lights are not used in the appliances available in the EU, this figure is not representative of the annual energy consumption in the EU. Therefore, the energy factor for gas hobs should be considered with great caution as it is does not correspond to the energy efficiency that is defined according to EN 30-2-1. However, the aim of this section is not to directly compare the energy consumptions with electricity and gas but to have a parallel understanding of the current consumption patterns.. This is described in section 3.1.4 and in more detail in Task 4.

3.1.3. Commercial appliances

Commercial kitchens are important users of energy according to the White Paper on Climate Change[23] from the Catering for a Sustainable Future Group (CSFG).

[22] US DOE (2009), "Final Rule Technical Support Document: Residential Dishwashers, Dehumidifiers, and Cooking Products, and Commercial Clothes Washers". Chapter 6. Energy use determination.

Nevertheless, the industry highlighted that there is very little empirical data on which the energy usage of commercial kitchen equipment can be evaluated. Even though no figure can be found on the exact consumption of energy due to hobs or grills use, it has been estimated that the catering industry (including commercial kitchen equipment for refrigeration, ventilation, warewashing and cooking) in general accounts for 21.6 TWh per year in the UK only, equivalent to 4% of the total amount of energy consumed by UK households, and 141% of the energy consumed for domestic cooking in the UK. The main actors in the catering industry shares are presented in Figure 3-3; this illustrates the diversity not only in the sector but also in kitchens uses and users.

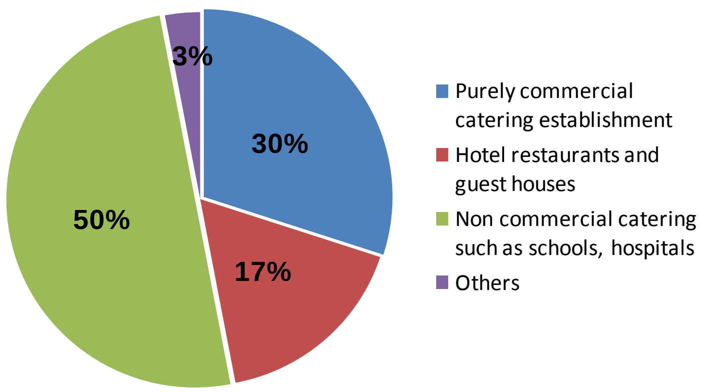

Figure 3-3: Main actors in the catering industry in the UK in 2008

The German catering equipment manufacturers association provided an estimation of several use parameters for some commercial appliances, presented in Table 3-11

Table 3-11: Estimation of use parameters for some commercial appliances

Type of commercial appliance	Power-on time of the heating	Time of using per year (h)	Average lifetime* (years)
Induction hobs	30%	1,500	12
Radiant hobs	50%	1,500	12
Electric cast-iron hobs	50%	1,500	12
Big hobs electricity operated	50%	1,800	12
Griddles electricity operated	30%	1,500	10
Infra grill electricity operated	80%	1,500	10

*(further refined with other manufacturers)

[23] CSFG (2008), White Paper on Climate Change, "A sector strategy for energy efficient commercial kitchens".

In restaurants, hobs and grills are used much more intensively than in households. Turning on the appliances at the beginning of the kitchen service and turning it off only at the end is not an unusual practice.

Based on manufacturers' feedback, Table 3-12 presents the use parameters which will be used in this study to characterize the use phase of commercial hobs and grills. The estimations for annual consumptions are based on an equivalent of 4 hours of full-power operation per day, 6 days per week.

Table 3-12: Use parameters of commercial appliances in the EU

On-mode	Units	Electric hob	Gas hob	Electric grill	Gas grill
Representative Power	kW	16	28	6.6	10
(Equivalent) Operating Time	Hours/year	1248	1248	1248	1248
Annual consumption	MWh/year	20	35	8.2	12.5

The presented annual energy consumptions are within the same order of magnitude than the available data for the US market[24], as seen in Table 3-13.

Table 3-13: Annual Energy Consumption for commercial hobs and grills in the US[24]

Appliance		Stock (2008)	US Annual Primary Energy Use (Btu/yr)	Annual Primary Energy Use per unit (Btu/yr)	Annual Final Energy Use per unit (MWh/yr)*
Hobs	Gas	748,000	8.33E+13	111E+6	32.6
	Electric	74,000	1.1E+13	149 E+6	14.3
Grills	Gas	276,000	1.63E+13	59 E+6	17.3
	Electric	276,000	2.53E+13	92 E+6	8.8

* Conversion rates of 3412 Btu/kWh for gas appliances and 10405 Btu/kWh for electric appliances. On- and stand-by modes are assumed to be included.

3.1.4. Gas / electric Debate

The study does not aim to directly compare the energy performance of gas and electric appliances. A straight comparison using kWh consumed would give an impression of gas hobs being generally less efficient, as it can be seen in Table 3-3, where gas hobs in the UK display an annual consumption higher than that of its counterparts, induction and electric hobs. In reality, gas appliances are more carbon efficient. This is due to the fact that the energy losses involved in the use of gas appliances are much lower, as the energy (heat) is converted directly from the fuel (gas). In the case of electrical

[24] US DoE, 2009, Energy Savings Potential and R&D Opportunities for Commercial Building Appliances

appliances, the fuel (coal, gas, etc.) is first converted to electricity then transmitted over long distances before reaching the households, requiring three or four units of fuel to produce one unit of electricity. The actual difference will depend on the mix of energy sources used to generate electricity. Countries which use a high proportion of fossil fuels will be different from those that rely on renewables or nuclear. Generation of 1kWh electricity in UK emits 614g CO2[25] whereas 1kWh equivalent energy from natural gas emits only 190g CO2[26]. In general gas cooking appliances use much less energy than their electric counterparts[27], thus they are regarded as being more carbon efficient. If in the future, the use of fossil fuels for electricity generation was replaced by renewable sources and nuclear, then electric hobs could become more carbon efficient than gas hobs but this will take many years in most EU Member States.

It would then be misleading to compare a primary energy source like gas with a secondary energy source like electricity. Conversions from final energy consumption to primary energy consumption could be made using an energy factor value of 2.5, which should be representative of the current EU situation. However, the use of a conversion factor relates to political considerations. In order to focus the study on the energy saving potentials of the current products and not transfer it to a debate on energy source, final energy consumptions were presented in the report. Only in Task 8 when suggesting and analysing potential regulation measures, a preliminary comparative discussion may be introduced.

3.1.5. Best practice in sustainable product use

As discussed earlier, energy consumed by hobs is very dependent on user behaviour, e.g. the cooking time, temperature, frequency, choice of cookware, use of lids to cover the food, among others. The maintenance practices (e.g. cleaning) can strongly impact performance as well.

Already, a number of governmental agencies and organisations around the world provide recommendations to end-users for smart use of hobs, such as the Australia's guide to environmentally sustainable homes[28] and the Energy Savers booklet from the US DOE[29]. In the EU, the French Environment and Energy Management Agency (ADEME) has published guides for consumers to disseminate specific information on existing energy efficient technologies and energy-saving best practices[30].

Such strategies to reduce the energy use aim at reducing the amount of energy needed for cooking which can be achieved through better equipment settings and the reduction of heat losses. Others aim at targeting the consumer prior to the purchase of the equipment by providing information on the benefit of using gas hobs over electric

[25] Calculated from total CO_2 emissions from electricity generation and total electricity generated from www.carma.org

[26] David Mackay, "Sustainable Energy without hot air", 2009, www.withouthotair.com.

[27] Rocky Mountain Institute (2004), "Home Energy Briefs - #8 KITCHEN APPLIANCES".

[28] http://www.yourhome.gov.au/technical/fs61.html

[29] http://www1.eere.energy.gov/consumer/tips/pdfs/energy_savers.pdf

[30] ADEME (2008). Économie, efficacité, confort : branchez-vous malin ! équipements électriques.

ones, when comparing greenhouse gas emissions or cost of use. There are some cases where gas appliances are cheaper to use, have more responsive controls and produce less greenhouse gas emissions.

The Australian National appliance and equipment energy efficiency program, after holding meetings with stakeholders from the sector, concluded that independently from the development of minimum energy performance standards (MEPS) or labels, information programmes are highly recommended as they believed that significant energy efficiency improvements are possible with changes to consumer usage of appliances and associated cooking utensils[31].

The general recommendations provided to consumers in the guides and booklets previously mentioned are presented below. Regarding purchase criteria, there are several things that users are advised to consider when buying a new appliance:

- Gas hobs have some efficiency advantage over electric cook tops, but they are more likely to produce harmful combustion gases (such as carbon monoxide), than electric cooking.. Thus, one should have a ventilation system when purchasing a gas appliance,
- When purchasing a natural gas range cooker, get one with an automatic, electric ignition system. An electric ignition saves gas because a pilot light is not burning continuously. (This is already well-implemented in the EU)
- For induction hobs special pots and pans are required.

Regarding cooking process, the following best practices are recommended to cook more “efficiently”:

- Develop the habit of “lids-on” cooking to permit lower temperature settings. According to the Rocky Mountains Institute32 this can reduce energy use by up to two thirds.
- For boiling, minimise the water used for cooking to avoid having to heat more than is needed.
- Begin cooking on highest heat until liquid begins to boil. Then, lower the heat control settings and allow food to simmer until fully cooked.
- The heating needed can be minimised by using the smallest pan and burner possible.
- When using a gas burner, do not turn up the flame too high if the pot is a small one. A good rule for gas cooking is if the flame can be seen anywhere up the side of the pot, then it is set too high.

[31] Australian National appliance and equipment energy efficiency program. (2002) Options study – MEPS/Labelling possibilities for stoves & cook-tops.

[32] Rocky Mountain Institute (2004), “Home Energy Briefs - #8 KITCHEN APPLIANCES”.

- In natural gas appliances, the colour of the flame should be blue; yellow flames indicate the gas is burning inefficiently and adjustment may be needed.

Regarding the use of appropriate cookware:

- Check the best material suitable for each type of appliance.
- The condition of the pots is important to avoid wasting most of the heat in electric hobs. A flat bottom pot or pan that makes full contact with the heating element is recommended. For gas hobs rounded pots are more efficient.
- Put the cookware centralised the cooking zone. This is also particularly important in the case of inductions hobs in order to avoid electromagnetic fields, which can be a health concerns for consumers.
- Get accustomed to use a pressure cooker as frequent as possible as it is more energy efficient

The same guides also refer to the use of other appliances instead of electric or gas hobs to reduce energy use. Depending on the cooking requirement, a pressure cooker, a crock-pot or a kettle could do the same job more efficiently.

3.2. END-OF-LIFE BEHAVIOUR

Information available regarding the end use of domestic cooking products is very limited. Impacts associated with their energy consumption in use are thought to be more important than those from the end-of-life (this will be confirmed in Task 5 when conducting the environmental impact assessment of various types of products).

3.2.1. ECONOMIC PRODUCT LIFE

Data on the expected lifespan of hobs and grills are sparse. However, considering known sales and ownership data available for a few countries, an average lifespan of between 15 and 20 years appears reasonable. Replacement data for this type of appliance from countries outside the EU such as Australia has been estimated as 15 years[33]. The cooking product lifetime that the US DoE estimated for the economical assessments in the Rulemaking Framework for Residential Cooking Products[34] was an average of 19 years for both gas and electric hobs.

Inside the EU, MTP[35] from the UK estimates a lifetime of 19.8 years for electric and induction hobs, and 18.6 years for gas hobs. Whether the lifetime of 20 years for induction units is a reasonable figure is perhaps open to question. Induction hobs are more complex in terms of number of parts and technology than either conventional electric or gas. It would not be surprising if lifetimes more similar to other consumer electrical products around 10-15 years were actually realised.

In the context of this study Table 3-14 summarizes the economic product life defined for the products in Lot 23.

The service lifetime of commercial catering equipment spans between 5-20 years in general. For hobs and grills, those values were further discussed with main manufacturers and also presented in Table 3-14.

Table 3-14: Economic product life for Lot 23 products

Type of Appliance	Lifetime Average (Yrs)
Domestic electric hobs - solid plates	19
Domestic electric hobs - radiant	19
Domestic electric hobs - induction	15
Domestic gas hobs	19
Domestic grills	19
Commercial hobs	12
Commercial grills / fry tops	10

[33] Australian National appliance and equipment energy efficiency program. (2002) Options study – MEPS/Labelling possibilities for stoves & cook-tops.
[34] US DOE (2009), "Final Rule Technical Support Document: Residential Dishwashers, Dehumidifiers, and Cooking Products, and Commercial Clothes Washers". Chapter 8. Life-cycle cost and payback period analysis.
[35] Market Transformation Programme. http://efficient-products.defra.gov.uk/cms/market-transformation-programme/

3.2.2. RE-USE, RECYCLING AND DISPOSAL

The waste generated by disposal of hobs is mainly in the form of ferrous metal, followed by plastics and non ferrous metals in a smaller proportion. The majority of these products are recycled at end-of-life[36].

- **Domestic appliances**

According to data presented in the AHAM 2003 Fact Book for the United States, many old appliances are still being used after consumers purchase new units. Table 3-15 presents the various routes of disposal used by consumers for their old appliances.

Table 3-15: Disposal routes for old appliances in US[34]

Product	Kept It	Left with Previous Home	Sold / Gave Away	Recycling Facility	Left at Curb for Disposal	Retailer Took Away
Range cookers	6%	37%	21%	13%	8%	15%

The Waste Electrical and Electronic Equipment Directive (WEEE Directive)[37] imposes the responsibility for the disposal of waste electrical and electronic equipment on the manufacturers of such equipment. Lot 23 products fall under Category I "large household appliances" of the Directive, meaning that manufacturers are required to take responsibility for their disposal. The Directive also encourages the design of such products to take into account and facilitate dismantling and recovery although there are no specific targets to promote this. The rate of recovery for products falling under category 1 is expected to increase to at least 80% by an average weight per appliance.

Lot 23 products are also covered by the Restriction of Hazardous Substances Directive (RoHS)[38] and so must not contain the restricted substances except in exempt applications.

All major producers of appliances covered by the WEEE directive will have already taken the appropriate steps to comply. Although requirements vary between Member States, in general this involves registration as a producer in each MS where products are put on the market, joining or forming a compliance scheme and paying a fee. WEEE Directive requires reporting of the weight and sometimes the number of appliances (requirements vary between MS) collected by category, and the percentage of materials recovered. This reporting also serves to provide information on whether the targets of recovery have being achieved. Table 3-16 presents data on large white goods collected in three Member States (by weight in tonnes). Currently there is no figure on the exact number of collected gas or electric domestic hobs or grills at EU or Member State level.

[36] UK Department for Environment, Food and Rural Affairs (DEFRA) (2008), "Policy Brief: Improving the energy performance of domestic cooking products".
[37] European Community WEEE directive 2002/96/EC.
[38] European Community directive 2002/95/EC;

Table 3-16: Large white goods collected in three MS (in tonnes)

Member State	2004	2005	2006	2007	2008
Belgium[39]	15 141	16 649	17 822	18 909	19 108
Sweden[40]	-	36 300	45 500	45 453	-
Netherlands[41]	-	-	14 394	13 292	13 601

The recovery rate per material stream in the category of large white goods during 2008 in Belgium is presented in Table 3-17 (first column), followed by the objectives set by the Environmental Policy agreements (second column). The compliance level was 100% for the materials recovered from appliances in this category in Belgium. Information on the other Member States was not available.

Table 3-17: Recovery rate per material stream of large white goods, Belgium 2008 [39]

Recycling* per material stream	Actual	Legal objectives**
Ferrous metals	100%	95%
Non-ferrous metals	100%	95%
Synthetic materials	98%	80%
Others	22%	-

* This figure refers to recovery of materials collected. It doesn't mean that 100% of ovens disposed are collected but that 100% of the materials s.a. ferrous metals from collected appliances are recovered.

** Objectives imposed by the Environmental Policy agreements

- **Commercial appliances**

According to HKI, all commercial appliances under the scope of lot 23 have a high residual value due to the high proportion of stainless steel. The largest proportion of material goes back into the professional recycling process by specialized companies and does not take the typical recycling process like in the domestic sector.

[39] RECUPEL (2008), "Annual Report 2008".
[40] EL-KRETSEN AB (2007), "Annual Report 2007".
[41] NVMP (2008), "Annual Report 2008".

3.3. LOCAL INFRASTRUCTURE

The only effect that local infrastructure can have on consumer behaviour is related to the choice of the appliance energy type in certain MS. In Germany, electric appliances are considered to be safer than gas appliances thus a preference of the first one over the second is present. In Italy, there is a restriction or threshold in the electricity consumption on households, thus gas appliances are preferred.

Many rural locations throughout the EU are not connected to natural gas distribution networks and so if gas cooking is preferred, users need to use bottled gases which are far more expensive than natural gas. This cost difference encourages the selection of electric hobs instead of gas.

No other effects of local infrastructure have being identified as barriers or opportunities to a change in consumer behaviour.

3.4. POSSIBLE BARRIERS TO ECODESIGN

This section aims at presenting the user's essential role concerning the environmental impacts of energy-using products. One important factor is to identify the barriers that hinder users to behave in a more environmentally sound way. The issue is related not only to how many and what kind of products are being purchased but also how these products are being used and for how long.

Several barriers have been identified in areas such as increased ownership of cooking appliances, ecodesign (technological) barriers, and consumer behaviour and awareness. Together they account for greater environmental impacts related to the design, purchasing, use and disposal of hobs and grills.

3.4.1. BARRIERS TO INCREASED OWNERSHIP OF MORE EFFICIENT COOKING APPLIANCES

The following barriers to foster the purchase of energy efficient domestic and commercial hobs and grills have been identified:

- **Higher costs of better technology**: many purchasers may opt for a cheap model (if given a choice). Domestic buyers rarely take into account energy consumed during the products lifetime. In the commercial sector there may be more awareness but the pressure to reduce up front capital costs will tend to dominate unless the specifications deliberately considers cost in use. This is unlikely to be the case where installations are chosen on the basis of the lowest quote. However, this cost aspect can be differently considered in the different Member States.
- **Inertia**: some consumers are likely to change their hobs only when the kitchen is given a 'make-over'.

- **Lack of fuel choice**: gas appliances are considered to be up to three times more efficient in primary energy terms than an electric equivalent but there are still many homes not connected to a main gas supply. Liquid petroleum gas (LPG) is an accessible option. Gas bottles need to be refill regularly (e.g. on an annual basis), making it less convenient than a supply through a network.
- **Lack of knowledge** e.g. relevant information is not available in stores, appliances are not labelled to inform consumers on differences in performance, people do not know how to use power management features.

3.4.2. Barriers to ecodesign in the domestic sector

A detailed analysis of potential improvement options for domestic ovens is developed in Tasks 6 and 7. In this section, a preliminary approach, based on the outcomes from the Australian options study on MEPS and labels for cook tops (2002), highlights the main barriers for improving energy efficiency in hobs. That includes:

- **Small potential in energy efficiency gains** related to technology changes that could be implemented to improve the general efficiency of the appliance. Stakeholders consulted for the Australian report argue that the efficiency gains in the appliance itself would be dwarfed by consumer behaviour factors. On the other hand, this means that there is a potential to improve efficient use of the appliance by the end-user.
- **Lack of a comparative energy or performance test data** that could be used to differentiate performances of different appliances. Such comprehensive data is currently not available in Europe. The EN 60350:2009 test for non portable hobs and grills can provide information on the efficiency to heat a pan of water close to the boiling point, but does not cover the performance of the appliance in maintaining the temperature through the whole cooking process. This fact represents an important difference between real life usage of the appliance and testing conditions that could affect the assessment of appliance performance by using only this test. Harmonised and more representative standard tests would enhance the comparability of data at EU level and thereby the reliability of the assessment of the appliance performance.
- **Low energy cost of the appliance** does not drive the purchase of more efficient products. The energy cost related to the use of the appliance is lower in comparison to other larger appliances in the EU. The grill situation illustrates this very well; they have a reported annual consumption of 47 kWh/yr that is much lower than that of others appliances in this same Lot which is reported as 250 – 300 kWh/yr. Even if there was an energy rating system for the appliance that provided information on energy savings, users

most probably would not be influenced to buy a more efficient model as savings would be negligible.

The US Department of Energy (DoE) in its final ruling of Energy Conservation Standards for Certain Consumer Products - 2009[42] (including electric and gas kitchen ranges) proposes a "no-standard" standard for these appliances on the basis that the amount of energy saved would be insignificant.

In adopting energy conservation standards, the DoE follows three primary criteria: technological feasibility, economic justification and significant conservation of energy. After an assessment to evaluate energy conservation standards for cooking products, which started in 2006, the DoE has tentatively determined that energy conservation standards for residential electric kitchen ranges are not technologically feasible or economically justified.

Despite this, there is a new ruling[42] for residential gas kitchen ranges requiring that appliances without an electrical supply cord manufactured after the 9 April 2012 must not be equipped with a constant burning pilot light.

3.4.3. Barriers to ecodesign in the commercial sector

The barriers to ecodesign in the commercial sector show similarities to those found in the domestic sector but should be approached taking into consideration the differences between the end-users. The split incentive is a significant issue - the fact that in some cases the buyer of the appliance is not the same as the final user. Catering facilities in public bodies provide a good example of this; the buyer of the appliance is a procurement officer and the final user is the operator in the kitchen (possibly an external contractor). The following are the main barriers found:

- **Focus on the quality of the meals:** restaurants often do not want to make any compromise between energy efficiency of the hobs/grills and quality of their meals.
- **Higher capital cost**: many purchases are made on the basis of the capital purchase price alone. This tends to lead towards the choice of less energy efficient equipment.
- **Isolated initiatives without government support**: there are several initiatives carried out by associations in the sector, mainly in the form of generic guidelines to design energy efficient kitchens. The guide of the CSFG Chartered Institute of Building Services Engineers (CIBSE) is one such reference. Examples outside the EU include the US Energy Star Program that developed a Guide for Restaurants, explaining all the benefits of using energy efficiency equipment in day to day business. Nevertheless, it is thought that these initiatives alone

[42] US Department of Energy (DoE) (2009), "Energy Conservation Program: Energy Conservation Standards for Certain Consumer Products (Dishwashers, Dehumidifiers, Microwave Ovens, and Electric and Gas Kitchen Ranges and Ovens) and for Certain Commercial and Industrial Equipment (Commercial Clothes Washers)", Final Rule.

without the proper back up of government agencies are not enough to translate the content into effective and rapid measures.

- **Lack of information**: currently there is little easily available information on appliance performance for procurement officers that could be accessed when there is a need of new equipment. Thus a cost comparison between appliances on the basis of energy performance cannot be made. Consequently, purchase price remains the decisive factor. To address this, the Energy Star Program has created the 'Energy Star qualified products' list that provides information on manufacturers and models that fulfil specification requirements of good energy performance. Public or private procurement officers can access this data when looking for new equipment. A similar initiative in the EU could have an important impact in the energy consumption of the commercial sector, bearing in mind that in the category named earlier in Figure 3-3 'non commercial catering industry' accounts for 50% of the total sales in the commercial sector. This corresponds to key public bodies such as schools, hospitals and prisons.
- **Lack of operator training**: following the same principle as in the residential sector, considerable gains could be made by implementing sustainable practices in the use of cooking equipment. Therefore, operator training in efficient use of hobs may be a priority in the commercial sector so as to achieve energy savings. A kitchen which has been designed to be energy efficient will soon lose any advantage provided by the equipment and installation if it is not operated in accordance with manufacturers' instructions or using the proper cookware according to the Catering for a Sustainable Future Group (CSFG)[43].

Users practice is assumed to determine mostly the final energy consumption of cooking. Good practice can save up to 40-70% of energy used for cooking.

[43] Catering for a Sustainable Future Group (CSFG) (2008). White Paper on Climate Change. A sector strategy for energy efficient commercial kitchens.

3.4.4. Consumer behaviour and awareness

As mentioned in Section 3.4.2. , there is a lot of potential to improve energy consumption of hobs and grills by changing consumer behaviour. Providing information to users on ways to cook efficiently is thought to be worthwhile and to have a greater impact on energy consumption than improvements in design. However, findings on later Tasks, especially Tasks 6 and 7 that deal with BAT and BNAT, might provide more information on potential energy savings when looking at design and technology changes.

3.5. Conclusions Task 3

The report findings are related to the effect on energy consumption in hobs and grills by the users' habits and the differences among EU users. The average consumption values presented have been measured and reported in several sources in the EU for solid plates, radiant hobs, induction hobs, gas hobs and grills, and seem to be consistent. However, there are important differences between the minimum and maximum values reported within each category. This confirms that consumer behaviour can have a major impact on consumption, as cooking times, temperatures and frequencies vary considerably among users.

Other issues affecting energy consumption that have been discussed include the general tendency to eat out (that may not be relevant for all Member States), resulting in the contribution of energy using products in this category shifting from the residential to the commercial sector. The choice of cookware is the second issue found to have an important effect on the final consumption per use of this type of product.

Barriers to the ecodesing of more efficient appliances were also studied. As reported by other sources outside EU, for some appliances under this category the potential for improvement has been found insignificant (e.g. grills) as the annual energy consumption is very low, the apliance price is low and users most probably would not be influenced to by a more efficient model.

Table 3-18 summarises data for domestic and commercial appliances that are useful for the remaining study tasks.

Table 3-18: Proposed values to be used in this study for domestic appliances

	Type of Appliance	Range of cooking time	Uses/year	Annual Consumption (kWh/year)	Economic lifetime
Domestic sector	Gas hobs	10 - 120 min	438[44]	330	19
	Electric hobs - Solid plates	10 - 120 min	438	250	19

[44] An average of 1.2 uses/day

	Type of Appliance	Range of cooking time	Uses/year	Annual Consumption (kWh/year)	Economic lifetime
	Electric hobs - Radiant	10 - 120 min	438	240	19
	Electric hobs - Induction	10 - 120 min	438	190	19
	Mix hobs	10 - 120 min	438	-	19
	Gas grills (radiant)	10 - 60 min	52[45]	50	19
	Electric radiant grills	10 - 60 min	52	50	19
	Electric contact grills	10 - 60 min	52	50	19
Commercial sector	Gas hobs	-	-	35,000	12
	Electric hobs - Solid plates	-	-	20,000	12
	Gas grills/ fry tops	-	-	12,500	10
	Electric grills / fry tops	-	-	8,200	10

[45] An average of 1 uses/week