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Preparatory Studies for

Ecodesign Requirements of EuPs (III)

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Lot 22

Domestic and commercial ovens (electric, gas, microwave), including when incorporated in cookers

Task 3: Consumer behaviour and Local infrastructure

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In association with

ERA TECHNOLOGY

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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 ovens during all phases of their life cycle, firstly through the selection of oven type (electric, gas, microwave, built-in, free-standing, etc.), secondly through the actual use of the oven 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 22 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. The effect of providing product information to the end-users of Lot 22 equipment will also be considered 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 efficiency of domestic and commercial ovens differs from those tested in standard conditions and to quantify user defined parameters. Two sources of information have been sought to determine this difference: firstly, reported values of the share in the overall energy bill for which ovens can be accountable (country level data) and secondly, reported behavioural data by tests and surveys conducted in households (user level data).

The energy consumption in ovens is strongly influenced by the users' cooking habits. Main factors include the temperature settings, the duration of the cooking process, or the frequency with which the oven door is opened, which can vary considerably depending on the user's habits. The different settings in temperature and duration stem from different expectations on the cooking results. These expectations and practices can relate to regional differences, but can also depend on individual preferences. No influence (or very limited) through oven's design is possible on this part of the cooking process.

3.1.1. DOMESTIC ELECTRIC AND GAS OVENS

In order to gather relevant information for real life efficiency, data can be looked at a country level or at a user level.

3.1.1.1 COUNTRY LEVEL DATA

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, the share for cooking equipment was 7% for the EU-15 in 2004[1]. In particular electric ovens are responsible for 2% of the overall residential electricity use which represented 15 TWh in the same year. The remaining 5% is due to other cooking appliances mainly electric hobs. In 2000, electricity consumption of electric ovens was believed to be around 13.3 TWh per year, showing that demand due to this appliance increased nearly 13% in 4 years. The share of cooking equipment increased to 7.5% in 2007 for the EU-27, as shown in Figure 3-1. In addition, electric ovens are of particular interest as they contribute clearly to the peak load of the household.

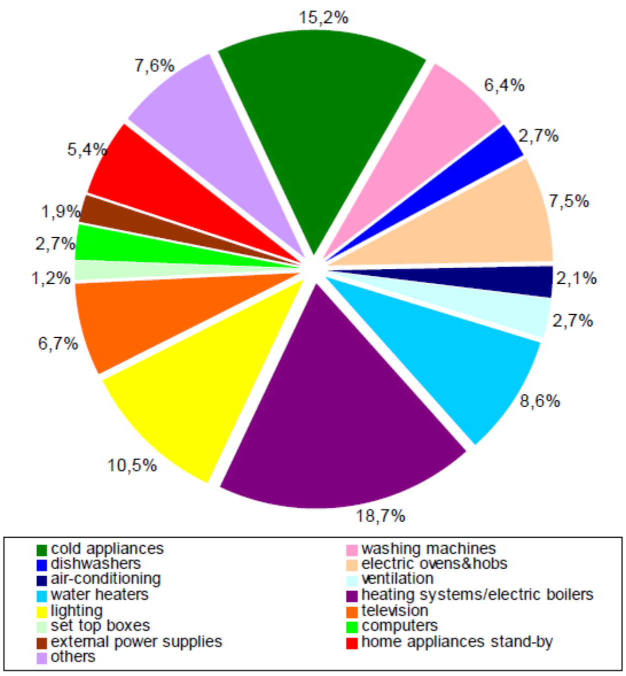

Figure 3-1: Breakdown of EU-27 residential electricity consumption, year 2007[2]

[1] Bertoldi, P. and Atanasiu, B. (2006), "Electricity Consumption and Efficiency Trends in the Enlarged European Union", Status report. Available at: http://re.jrc.ec.europa.eu/energyefficiency/pdf/EnEff%20Report%202006.pdf

[2] Bertoldi, P. & Atanasiu, B. (2009), "Electricity Consumption and Efficiency Trends in the European Union", Status report. Retreived from: http://re.jrc.ec.europa.eu/energyefficiency/pdf/EnEff_Report_2009.pdf

Individual countries display differences in household consumption patterns due to changes in cooking habits or preferences for certain equipment, affecting the percentage of cooking appliances in the overall electricity bill. The Final Report on Efficient Domestic Ovens from the SAVE II Project[3] presents figures for electricity consumption per oven (excluding microwaves) per year in the EU ranging from 44 kWh/yr in the Netherlands to over 200 kWh/yr in countries such as Finland, Sweden, France or the UK. Mid range values apply in Austria (102 kWh/yr) and Germany (80 kWh/yr).

These wide differences in oven electricity consumption can be explained by differences in cooking preferences and oven usage among the EU Member States. A study[4] conducted for the ADEME (French energy and environment agency) in 1999 tested the average consumption of several types of ovens, providing information on the performance for each type of operational mode. The SAVE II Project also provides information on user preferences regarding the type of meals cooked and frequency. The results of both studies, which are presented in the section 3.1.1.2, are useful to understand the reason of these differences in oven energy consumption among EU Member States.

Information related to domestic gas ovens is not as easily available as for electric ovens. The SAVE II project estimated that gas ovens consumed 15 PJ per year with a 24% market penetration in the EU-15 in the year 2000. Electric ovens, which are owned by more than 77% of EU-15 households, are far more popular than gas ovens. Member States with the highest proportion of gas ovens are France (50%), the UK (41.5%) and Italy (38.5%), while in Scandinavia gas ovens are practically non-existent.

In the UK, the Department of Energy & Climate Change (DECC) publish annually statistics about energy consumption in the UK[5]. In 2008, British households consumed 1.31 million tonnes of oil equivalent (15 TWh) for cooking, which is 2.9% of their total energy consumption (535 TWh).

3.1.1.2 USER LEVEL DATA

Consumers in the UK show a preference for electric over gas ovens and sales figures prove that the tendency is towards ovens with higher efficiency since the introduction of the EU Energy Label for electric ovens[6]. It has also been estimated that the electricity consumption per year derived from oven use in the UK has fallen as a result

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[3] Kasanen, P. (2000) “Save II Project - Final Report on Efficient Domestic Ovens”.

[4] Sidler O. (1999), “Maîtrise de la Demande d’Electricité : Etude expérimentale des appareils de cuisson, de froid ménager et de lavage/séchage du linge dans 100 logements”. Projet ECUEL - ADEME, EDF DER, Commission des Communautés Européennes.

[5] DECC, Energy consumption in the United Kingdom. Retreived December 2010 from: http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx

of sales of more efficient appliances and a reduction in the frequency of use[6]. The last one probably coincides with increased commercial catering (eating out, take-away meals, etc.), a tendency that has been exposed as well by the US DOE in its technical report to establish energy use of cooking products[7]. It had also identified a decline in the annual energy consumption from 1977 to recent years attributed to the fact that people is eating out more frequently and cooking less at home. Even though the annual energy consumption due to domestic oven use decreased, the overall energy use may not decrease as it shifted to the commercial sector.

Cooking appliances in France represented 5% of the total electricity consumption in the residential sector in 1999, with ovens being responsible for 42% of this amount[8]. Variations in the electricity consumption occur throughout the year due to seasonal changes in behaviour, reaching a peak in winter where consumption is 75% more than in summer.

According to data gathered by the ECUEL Project[4], the average total consumption of electric ovens is 224 kWh per year in France. The measured differences in operational energy consumption ranges from 233 kWh/yr for conventional ovens to 219kWh/yr for fan-forced convection ovens. Other types of functional modes are presented in Table 3-1 that summarises the reported average consumption for electric ovens.

Table 3-1: Average energy consumption of electric ovens in France in 1999[8]

Type of Oven	Average Annual Energy Consumption (kWh/yr)
Electric Average	**224**
Conventional	233
Fan-forced Convection	219
Catalytic Ovens	199
Pyrolytic Ovens	243
Manual Cleaning Ovens	224

The average cycle consumption has been reported as 889 Wh, where the consumption is 1226Wh/h and the average time per cycle is 44 min. The cycle for pyrolytic cleaning is reported to have an average consumption of 3490 Wh, but no information was provided on the duration of this type of cycle. In pyrolytic ovens it is believed that the

[6] UK Department for Environment, Food and Rural Affairs (DEFRA) (2008), "Policy Brief: Improving the energy performance of domestic cooking products".
[7] US DOE (2009), "Final Rule Technical Support Document: Residential Dishwashers, Dehumidifiers, and Cooking Products, and Commercial Clothes Washers". Chapter 6. Energy use determination.
[8] Sidler, O (2009), "Notes techniques : Connaissance et maîtrise des usages spécifiques de l'électricité dans le secteur résidentiel".

number of times the pyrolytic cleaning cycle is used represents only 2.7% of all oven cycles. Despite this, it is responsible for 11% of the total energy consumption per year for this type of oven.

According to the study developed by Sidler[8] where 32 different types of cooking appliances were measured during a period of 1 month, the average time of use for ovens varies from 36 minutes in pyrolytic ovens to 27 minutes for catalytic ones. This difference in cycle duration is due to both technology and user behaviour. The approach used in the ECUEL project being to measure real-use, sociologic factors must be considered. Indeed, the users who cook the more tend to buy high-range products, likely to be the more energy efficient ones. This can have a significant impact on the consumption per appliance type; for instance, the more efficient equipment with a longer time per cycle does not bring any energy savings at the end of the day.

Other data gathered on user behaviour by the Working Group on Efficient Domestic Ovens of the SAVE II Programme, was used in conjunction with a methodology to establish the real energy consumption of electric and gas ovens in the EU. Specific information on typical dishes, number of times they were prepared and the temperature used was collected for several countries. Additional inputs included results from standards tests for energy consumption in each country to adjust the model. Table 3-2 presents the results for 9 Member States where data was available.

Looking at the consumption per cycle by country, it is possible already to identify major differences in oven use practices. A typical cycle in Germany for an electric oven has a consumption of 1.0 kWh whereas in UK the value reaches 1.6 kWh, a 30% difference from the average 1.3 kWh/cycle in Europe. For gas ovens with an average consumption of 1.25 kWh/cycle (4.5 MJ/cycle) in the EU, the difference between the extreme reported cases (Netherlands and UK) is 27%.

Table 3-2: Energy Consumption per cycle and per oven from consumer behaviour in 2000[9]

Member State	Dish frequency/ year	Electric Oven			Gas Oven		
		per cycle (kWh/cycle)	per oven (kWh/yr)	per country (TWh/y)	per cycle (MJ/cycle)	per oven (MJ/y)	per country (PJ/y)
Austria	88	1.17	103	0.26	4.22	371	0.23
Germany	80	1.16	214	0.47	4.15	768	0.02
France	150	1.07	161	2.37	3.84	577	4.76
Finland	185	1	80	2.37	3.57	286	2.14

[9] Kasanen, P. (2000) "Save II Project - Final Report on Efficient Domestic Ovens".

Member State	Dish frequency/ year	Electric Oven			Gas Oven		
		per cycle (kWh/cycle)	per oven (kWh/yr)	per country (TWh/y)	per cycle (MJ/cycle)	per oven (MJ/y)	per country (PJ/y)
Italy	23	0.96	23	0.29	3.43	80	0.72
Netherlands	47	0.94	44	0.19	3.33	157	0.22
Sweden	146	1.22	178	0.72	4.38	639	0.08
UK	127	1.56	198	2.68	5.67	719	7.19
Europe	110	1.25	138	13.36	4.51	498	15.26

The study collected information on six different types of uses for meal cooking: meat, home-made meals, cakes/bread, snacks, ready meals, and reheating. The number of times each dish was cooked (frequency) was used to determine the oven consumption per year and the results presented a wide range of values. According to this study, on average a household uses the oven 110 times per year. In the UK, France, Sweden and Finland households use their oven roughly more than three times a week, whereas in the Netherlands the oven is turned on less than once a week. Even for cooking the same food, important differences can be observed across Europe. For example, roasting of meat is done in closed pots inside the oven in certain areas, while in others areas roasting open is done on a wire rack. Both procedures show different results not only in terms of the resulting roasted meat but also in terms of the overall energy consumption. The use of the grill function, very common in the UK, can explain higher values of energy consumption per oven.

Table 3-2 was directly extracted from the source document, and several comments can be made: if the consumption per cycle of gas oven was converted in kWh of final energy (using 1 kWh = 3.6 MJ), it would be the same as the electric oven's one. This assumption is questionable, as when considering final energy consumption, gas appliances are on average less energy efficient. Moreover, the data presented at country and Europe level (likely to be EU-15 as the study was conducted in 2000 although there is no specific mention) is supposed to be based on the number of households and the market penetration figures for each country. However, the UK would represent 47% of the gas consumption at European level, which seems high. Consequently, only the dish frequency seems to be reliable, and other sources will be studied to get more reliable data regarding the energy consumption.

The same user parameters (electricity consumption per use or number of uses per year) have been compiled by the Market Transformation Programme (MTP) in the UK[10]. Last revision dated on 2008 provided data presented in Table 3-3.

Table 3-3: User parameters for domestic electric ovens in UK[10]

Year	Consumption per Use* (kWh/Use)	Standby Power Demand (W)	Standby Time (hrs/day)**	Annual Uses (Uses/Yr)	Total UEC (kWh/yr)***	Lifetime Average (Yrs)
1980	1.5	0.0	24	201	536	19
1985	1.4	0.1	24	189	400	19
1990	1.3	0.7	24	177	306	19
1995	1.2	1.6	24	164	258	19
2000	1.2	2.5	24	152	235	19
2005	1.1	3.0	24	140	217	19
2008	1.1	3.1	24	133	205	19

* Consumption per use values are adjusted with a *test to actual ratio* to take into account differences between test and real life uses.
** Standby time is rounded to 24h even though when the appliance is on there is no standby power consumption. The difference between real standby time and 24h should be discounted but the effect on the UEC is negligible.
***UEC: Unit Energy Consumption.

The consumption per use has decreased by 25% from 1980 to 2008 possibly due to the fact that the market share of A-class ovens and cookers has been increasing steadily[11]. By contrast, the standby power has increased from 0.0W in 1980 to 3.1W in 2008 due to the introduction of ovens with digital displays and other features that demand power 24 hours per day.

Regarding the total electricity consumption, the authors of the database use a 'test to actual ratio' of 1.4 to account for the differences between standard test conditions and real life conditions, so that the total electricity consumption is calculated from the consumption per use, annual uses, standby power demand and the test to actual ratio. No data was available on MTP website regarding the calculation method of this 'test to actual ratio'. There is no justification for this value of 1.4.

Other information related to future trends can be derived from analysis of data from previous years. For instance, there is a constant reduction in the number of uses/year

[10] MTP's online What if? Tool. Retrieved October 2009, from: http://www.mtprog.com/. Note: this database is not available anymore on this website since July 2010. No further details than the ones presented can be obtained.
[11] Market Transformation Programme. (2009). "*Factors influencing the penetration of energy efficient electrical appliances into national markets in Europe*"

for electric ovens which suggests people might use their ovens less frequently in the future.

Similarly to the trend observed in the UK, a decreasing energy demand from the use of ovens is foreseen in Germany[12]. This can be explained by more efficient equipment, shrinking households and the shift to other appliances (e.g. microwave ovens).

The Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe Project (REMODECE)[13], supported within the Intelligent Energy Europe Programme of the European Union, 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 ovens was retrieved from two major campaigns conducted under the projects EURECO in 2000 – 2001 and REMODECE in 2006 -2008. The campaigns measured the annual consumption and standby power consumption of several cooking appliances at a monitoring interval of 10 minutes. Table 3-4 presents the data measured on domestic electric ovens annual consumption by country. The number of samples in each measuring campaign, as well as the minimum and maximum values reported in every country are presented to illustrate the differences among users and appliances.

Table 3-4: Domestic electric ovens annual consumption: results of EURECO and REMODECE campaigns in several MS[13]

Project (Year)	Country	Number of households	Annual Consumption (kWh/yr)		
			Min	Max	Average
EURECO (2000 - 2001)	Greece	1	-	-	131
	Italy	8	30	303	130
	Portugal	8	51	538	144
REMODECE (2006 - 2008)	Czech Republic	7	30	304	170
	Germany	3	16	152	65
	France	1	-	-	104
	Hungary	4	35	224	100
	Italy	8	24	651	165
	Norway	7	170	583	298
AVERAGE ALL MS			51	393	145

[12] Energiewirtschaftliches Institut an der Universität zu Köln (EWI)/Prognos AG, *Energieszenarien für den Energie-gipfel 2007*, July 2007. Retrieved 2011 from: www.zfk.de/cms/Infothek/Energiewirtschaft_-politik/Energiewirtschaft_-politik/Energieszenarien.pdf
[13] REMODECE project website: http://www.isr.uc.pt/~remodece/
EURECO and REMODECE online databases available at: http://www.isr.uc.pt/~remodece/database/

The average minimum value of electric ovens annual consumption in both campaigns for all MS is around 51 kWh/y having a peak in Norway (170 kWh/y) where the minimum is much higher than the value reported in other countries. The maximum value varies among countries significantly: even in Italy where both campaigns measured appliances in different years, the maximum value increased from 303kWh/y in 2001 to 651 kWh/y in 2008. This could be attributed to new features in recent models (e.g. consumption in standby and cleaning functionality) that increase the overall consumption. The average value for all MS across both campaigns is 145 kWh/y, which is comparable to the value reported by the SAVE II Project in 2000 of 138 kWh/y. The number of ovens monitored in these studies in each Member State was small, thus these results are to be considered with caution.

3.1.1.3 ADDITIONAL ISSUES AFFECTING REAL LIFE EFFICIENCY OF DOMESTIC OVENS

- **Gas ovens vs. Electric Ovens**

The fact that domestic electric ovens have been labelled since 2002[14] (providing users with performance information of different models) might have influenced user's preference for them. Currently, gas ovens are not yet covered under any labelling programme in the EU and it was only until 2009 that a new testing standard for gas ovens, using the wet brick test (EN 15181:2009), was developed to provide information that correctly reflects their real energy consumption.

Electric ovens are perceived to give a more even heating according to an MTP Report on energy label for domestic ovens[15]. There is a market trend towards built-in appliances where installation of electric ovens can be more convenient. This trend together with the user's perception of better performance over gas models may account for a higher proportion of households owning electric ovens.

- **Free-standing vs. built-in gas ovens**

The SAVE II study suggested that for gas ovens, on average, built-in appliances consume less than free-standing appliances with the same useful oven volume. The available data suggests that built-in models are better insulated than free-standing models in order to protect the kitchen furniture in which they are fitted. However, built-in models are generally equipped with more accessories than free-standing appliances, which offer the potential for increased supplementary electricity consumption (e.g. cooling fans and catalytic cleaning).

[14] Directive 2002/40/EC with regard to energy labelling of household electric ovens.
[15] MTP (2006), "BNCK02: Energy label for domestic ovens".

Oven self-cleaning functionality

For electric ovens, the 1996 TSD[16] determined that the type of oven-cleaning system affects performance. The US Department of Energy (DOE) found that standard ovens and ovens using a catalytic continuous-cleaning process use roughly the same amount of energy. Self-cleaning ovens use a pyrolytic process that provides enhanced consumer utility with lower overall energy consumption as compared to either standard or catalytically-lined ovens. In a more recent study[17], the DOE compared again the efficiency of several available models in the market and pointed out that self-cleaning ovens tend to be more efficient than non-self-cleaning ovens, due to the thicker insulation required to maintain safe exterior temperatures during oven cleaning cycles. The parameter used to compare oven performance is the Energy Factor (EF), defined as the annual useful energy cooking output over the rated annual energy consumption. A higher EF value means the oven has a better performance due to a higher output from a lower input. Some self-cleaning electric ovens have EF exceeding 0.16 whereas no model of non-self-cleaning electric ovens is found to have EF over 0.15.

Some gas ovens also offer a self-cleaning functionality, the use of which influence the annual energy consumption. Unfortunately, no data is available to quantify this influence.

Standby power

The UK case presented in Table 3-3 showed that standby power in electric ovens had increased during the period 1980 – 2008 due to the introduction of ovens with digital displays. Additional data was retrieved from the REMODECE campaigns and is presented in Table 3-5. As the number of samples is really low, derive conclusions from this campaign is not relevant.

Table 3-5: Domestic electric ovens standby power annual consumption[18]

Project (Year)	Country	Number of samples	Annual Consumption (kWh/yr)		
			Min	Max	Average
REMODECE (2006 - 2008)	Germany	2	1.2	4.6	2.9
	France	14	0	5.2	2.6

[16] US Department of Energy (DOE) (1996), "Technical Support Document for Residential Cooking Products".
[17] US DOE (2009), "Technical support document: energy efficiency program for consumer products and commercial and industrial equipment: residential dishwashers, dehumidifiers, and cooking products, and commercial clothes washers".
[18] REMODECE project website: http://www.isr.uc.pt/~remodece/
EURECO and REMODECE online databases available at: http://www.isr.uc.pt/~remodece/database/

- **Testing Issues**

The brick test used for domestic electric ovens, which places a wet brick with two thermocouples in the middle of the oven, has been criticised for being a poor performance indicator and for not providing information on temperature distribution within the whole cavity in a realistic way. The small cakes test which assesses temperature uniformity within the oven cavity (currently under revision at IEC) has been considered in addition to the brick test, but experts disagree about whether this test can be realistically used as an indication of oven performance. Moreover, it does not measure energy efficiency or energy consumption.

Another issue is the comparison of performance between gas and electric ovens. A straightforward comparison using kWh consumption would give an impression of gas ovens being generally less efficient, while in reality they 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 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 CO_2[19] whereas 1KWh equivalent energy from natural gas emits only 190g CO_2[20]. In general gas cooking appliances use much less energy than their electric counterparts[21], 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 ovens could become more carbon efficient than gas ovens but this will take many years in most EU States. Further consideration is needed to resolve this matter. It will probably include the introduction of an ‘adjusted kWh’ that will indicate the true performance of gas ovens when compared to electric ones to account for the relative energy losses to each type of oven.

3.1.1.4 SYNTHESIS

Many studies analysing the cooking habits in the EU were published. Some figures presented in section 3.1.1 are not coherent with each other, and some assumptions made in other studies were showed to be biased. Therefore, from the available published information and in collaboration with CECED, use parameters of domestic gas and electric ovens were defined, and are presented in Table 3-6.

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[19] Calculated from total CO2 emissions from electricity generation and total electricity generated from www.carma.org

[20] David Mackay. (2009). “*Sustainable Energy without hot air*”, Retrieved from: www.withouthotair.com.

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

Table 3-6: Use parameters of domestic electric and gas ovens

	Unit	Domestic electric oven	Domestic gas oven
On-mode			
Number of cycles per year		110	110
Average duration of a cycle		55min	55min
Electricity consumption per cycle	kWh elec.	1.1	
Gas consumption per cycle	kWh NG		1.67
Standby mode			
Number of hours in standby mode		8595	
Electricity consumption per hour	kWh elec.	0.005	
Natural gas consumption per hour	kWh NG		
Annual energy consumption			
Annual electricity consumption	kWh elec.	164	0
Annual natural gas consumption	kWh NG		184

Most of the domestic gas ovens currently in use in the EU are basic models with no digital clock or screen. Therefore, they were considered to consume no electricity in standby, at the opposite of electric ovens.

3.1.2. Domestic microwave ovens

Research into user habits shows that microwaves are used for cooking a limited range of foods on an infrequent basis. In general, preparing meals in a microwave is not a common practice in households. They are used mainly for reheating or defrosting precooked meals.

In addition to raw and reheated food, the microwave oven is also used for dried food, and for heating non-food items (e.g. wheat bags). According to the Market Transformation Programme[22], the main reasons for using a microwave oven over a conventional oven or a hob are because it is quick and easy to use.

In a data logging project undertaken by Intertek in 2005 in the UK (quoted in a document from MTP[22]), 23 homes recorded their microwave oven use daily, resulting in a total of 687 cooking events. These diaries showed the most common uses for microwave ovens were: heating drinks 23%, cooking or reheating vegetables 20%, cereals 11%, meat 10%, chilled and frozen ready meals 4%. Data on frequency and duration of use was also gathered, showing that users used their microwaves on average twice a day with a maximum of ten uses per day. The average time of use was

[22] MTP (2006), "*Historical microwave oven use and options to increase usage in the future*".

a two-minute period and the maximum length of time recorded was 77 minutes. The microwave oven was used to prepare an average of two portions at a time although a maximum of eight portions at one time was recorded.

The majority of uses employed the highest power mode (87%) with the remainder split between other modes such as defrost, auto programs, keep warm and simmer functions. The stock unit energy consumption per year is given as 87 kWh by the Domestic Equipment and Carbon Dioxide Emissions (DECADE) Team[23], whilst the MTP model[22] reports 91 kWh/yr where consumption per use is believed to be around 0.945 kWh with a frequency of 96 times per year. For an average oven that has a 2 W standby mode consumption, the annual consumption due to standby power would be 17.5 kWh, or nearly one fifth of the overall consumption per year.

Sidler[24] reported an average consumption of 75 kWh/yr for France, where simple microwaves consume around 55 kWh/yr and combined microwaves (with grill function) up to 102 kWh/yr. Their hourly consumption is 1035 Wh/h and typical cycle consumption is 69 Wh.

In order to better understand the differences in the values reported by both models, Table 3-7 presents a comparison of the values assumed by the UK MTP model in 2006 and by Sidler[24] in 1999. The energy consumption per use and the number of uses are used to calculate the average annual consumption. All values presented in Table 3-7 were reported in the documents, except for the number of uses (in grey) in Sidler's which has been calculated from the others. The energy consumption per use assumed in both models differs by over an order of magnitude but the difference in the annual average consumption is only 18% owing to a much higher frequency of use. Although Sidler's annual consumption is slightly below the value from MTP, he reported consumptions of combined microwaves up to 102 kWh/yr.

Table 3-7: Comparison between model's assumptions on values of energy consumption for microwave ovens

Energy consumption	MTP (UK - 2006)		SIDLER (France - 1999)	
Energy Consumption per use	0.945	kWh	0.069	kWh
Number of uses	96	times/yr	1087	times/yr
Total annual consumption	91	kWh/yr	75	kWh/yr

User parameters determined by the MTP are summarised in Table 3-8 from 1980 to 2008.

23 Fawcett T et al (2000), "*Lower Carbon Futures for European Households*".

24 Sidler O. (1999), "*Maîtrise de la Demande d'Electricité : Etude expérimentale des appareils de cuisson, de froid ménager et de lavage/séchage du linge dans 100 logements*". Projet ECUEL - ADEME, EDF DER, Commission des Communautés Européennes.

Table 3-8: User parameters for Microwave Ovens (Source - MTP[25])

Year	On Power Demand (kW)	Standby Power Demand (W)	On time (hrs/Yr)	Standby Time (hrs/day)	Total UEC (kWh/yr)*	Lifetime Average (Yrs)
1980	0.94	0.4	96	24	94	8
1985	0.94	0.7	96	24	97	8
1990	0.95	1.1	96	24	100	8
1995	0.94	1.5	96	24	104	8
2000	0.94	1.9	96	24	107	8
2005	0.95	2.2	96	24	110	8
2008	0.95	2.4	96	24	112	8

* Standby time is rounded to 24h even though when the appliance is on there is no standby power consumption. The difference between real standby time and 24h should be discounted but the effect on the UEC is negligible.

The reported on power demand has been stable for microwave ovens throughout the years presented in the table. Changes in the total unit energy consumption are due to the increase of standby power demand by new digital display related features.

Additional information was retrieved from the REMODECE project for several countries and is presented in Table 3-9. The average consumption of measured appliances in all MS in both campaigns was 38 kWh/y, much less than the values reported by both MTP (91 kWh/yr) and Sidler (75 kWh/yr).

[25] MTP's online What if? Tool. Retrieved October 2009, from: http://www.mtprog.com/.

Table 3-9: Microwave ovens annual consumption: results of EURECO and REMODECE projects in several MS[26]

Project (Year)	Country	Number of households	Annual Consumption (kWh/yr)		
			Min	Max	Average
EURECO (2000 - 2001)	Greece	16	5	64	33
	Italy	34	6	116	41
	Portugal	22	5	128	48
REMODECE (2006 - 2008)	Czech Republic	8	8	78	35
	Germany	9	8	121	53
	Hungary	56	2	86	26
	Italy	15	7	94	36
	Norway	3	30	40	34
AVERAGE ALL MS			9	91	38

The standby power consumption was also measured in two MS. The results are presented in Table 3-10 where it is found that the average standby annual consumption of 2.1 kWh/y represents 5.5% of the overall annual consumption of a microwave oven. However, due to the limited number of samples, these values might not be fully representative.

Table 3-10: Microwave ovens standby power annual consumption[26]

Project (Year)	Country	Number of samples	Annual Consumption (kWh/yr)		
			Min	Max	Average
REMODECE (2006 - 2008)	Germany	8	1.8	3.2	2.6
	France	24	0	5.6	2.1

- **Microwave Ovens vs. Conventional Ovens**

There is no consensus on the impact generated by the use of microwaves to cook food instead of conventional ovens or hobs. According to Sidler[27], if they were used to cook meals in a traditional way instead of conventional ovens, there would not be any significant reductions in the electricity consumption. This is supported by the fact that

[26] REMODECE project website: http://www.isr.uc.pt/~remodece/
EURECO and REMODECE online databases available at: http://www.isr.uc.pt/~remodece/database/
[27] Sidler, O (2009), "Notes techniques : Connaissance et maîtrise des usages spécifiques de l'électricité dans le secteur résidentiel".

small ovens with an average consumption of 898 Wh/h could be used to prepare meals in the same way than in microwaves; since they have a smaller consumption per hour compared to microwaves (1035 Wh/h) or larger conventional ovens (1226 Wh/h)[28], the electricity consumption could be reduced. However, the cooking time in the microwave will be much shorter and so will use less energy as discussed below.

On the contrary, the Market Transformation Programme estimates that microwave ovens can offer savings as an alternative meal preparation appliance to ovens or hobs[29]. This is supported by a Swedish study[30] that calculated energy used in cooking different types of food, testing the cooking of one portion and four portions of potatoes in a conventional oven and in a microwave. The cooking times are very different depending on the appliance, being about 7 – 24 minutes when the microwave is used and 65 minutes when potatoes are baked in the oven. The results showed that cooking with the oven uses 10 times more energy than using a microwave if one portion was cooked. However, if four portions were cooked then the ratio fell to 2.5 times the energy for the whole batch.

It has been shown that some foods can be cooked in a more energy efficient way in the microwave than using the electric hob or oven[29]. The same study estimates that 10% of the energy could be saved by changing cooking methods. The test was carried out using several types of foods and cooking methods, and comparing the energy consumed by a combination microwave oven, a basic microwave oven, an electric hob and an electric oven. The general results in Table 3-11 showed that for some foods and in some circumstances, using a microwave oven was more energy efficient and took less time than cooking by traditional methods in an EU Energy Label A-rated medium electric oven or on a ceramic hob.

According to some stakeholders, in certain countries such as Belgium or Sweden there is a tendency to use combined microwave ovens instead of conventional ovens to cook meals. Whatever the publicly available and reliable research data that exists to compare traditional oven and microwave oven energy use, the results are highly dependent on how much food is cooked (as the Swedish study results proved[30]) and the appliances that are chosen (type of oven and energy rating).

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[28] UK Department for Environment, Food and Rural Affairs (DEFRA) (2008), "Policy Brief: Improving the energy performance of domestic cooking products".

[29] MTP (2006), "*Comparing energy use in microwave ovens with traditional electric fuelled methods*".

[30] Carlsson-Kanyama A. and Boström-Carlsson K. (2001), "*Energy Use for Cooking and Other Stages of the Life Cycle of Food*".

Table 3-11: A comparison of the energy saved when cooking with a microwave oven compared with traditional electric fuelled methods[29]

Food	Circumstance	Energy-saving range*
Milk	Up to 800 g cooked in 200 g portions in mugs in microwave vs a saucepan on the hob	25 - 50%
New potatoes	Cooked with little water, in microwave vs more water, on hob	70 - 75%
Frozen vegetables	Cooked with little water, in microwave vs more water, on hob	65%
Fresh salmon fillet	Cooked without water, in microwave vs poached in water, on hob	63 - 78%
Whole chicken	Cooked using convection and microwaves in a combination microwave oven vs electric oven	23%
Baked potatoes	Cooked using convection and microwaves in a combination microwave oven and microwave only methods vs electric oven	21 – 61%
Lasagne	Cooked using microwave only vs electric oven	40 - 81%
Indian 'ready meal'	Cooked using microwave only vs electric oven	38 – 63%
Frozen 'ready meal' for one	Cooked using microwave only vs electric oven	55 – 73%
Frozen pizza	Cooked using convection and microwaves in a combination microwave oven vs electric oven	22%

* energy-saving range varies with number of portions and microwave function.

Although the arguments favouring the use of microwave ovens to cook meals instead of conventional ovens are not definitive, a general consensus has been found in relation to potential savings related to standby power. Minimising standby power consumption in microwaves is thought to be the only cost-effective alternative to improve efficiency in this appliance. Average standby power consumptions in the UK are thought to be 3.6 W[31], whereas in France they have been reported as 2.2 W[32]. The 1 W target (2W with a display) set by the Ecodesign Regulation[33] on standby power has reduced the electricity consumption due to this feature on appliances placed on the EU

[31] UK Department for Environment, Food and Rural Affairs (DEFRA) (2008), "Policy Brief: Improving the energy performance of domestic cooking products".

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

[33] Commission Regulation (EC) No 1275/2008 of 17 December 2008.

market since January 2010. From 2013, the maximum standby energy consumption will halve to 0.5W or 1 watt with a display.

Consumers' choice of the type of oven to use however seem to be mostly related to the type of meal they wish to prepare which requires either microwave cooking or a conventional oven. The two cooking process having a different result in food quality (texture and taste), microwave ovens cannot be considered as an improvement of conventional cooking.

- **Synthesis**

Table 3-12 presents the use parameters of domestic microwave ovens, which were defined in cooperation with CECED.

Table 3-12: Use parameters of domestic microwave ovens

	Unit	Domestic microwave oven
On-mode		
Number of cycles per year		1200
Average duration of a cycle		2min36s
Electricity consumption per cycle	kWh elec.	0.056
Standby mode		
Number of hours in standby mode		8708
Electricity consumption per hour	kWh elec.	0.0022
Annual energy consumption		
Annual electricity consumption	kWh elec.	86

3.1.3. COMMERCIAL APPLIANCES USED IN RESTAURANTS

3.1.3.1 COUNTRY LEVEL DATA

Commercial kitchens are huge users of energy according to the White Paper on Climate Change[34] from the Catering for a Sustainable Future Group (CSFG). Nevertheless, the industry has highlighted the fact 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 oven use, it has been estimated that the catering industry (including commercial kitchen equipment for refrigeration, ventilation, ware washing and cooking) in general accounts for 21.6 TWh per year in the UK, equivalent to 4% of the total amount of energy consumed by UK

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

households, and 141% of the energy consumed for domestic cooking in the UK. How energy usage is shared between the main actors in the catering industry is presented in Figure 3-2.

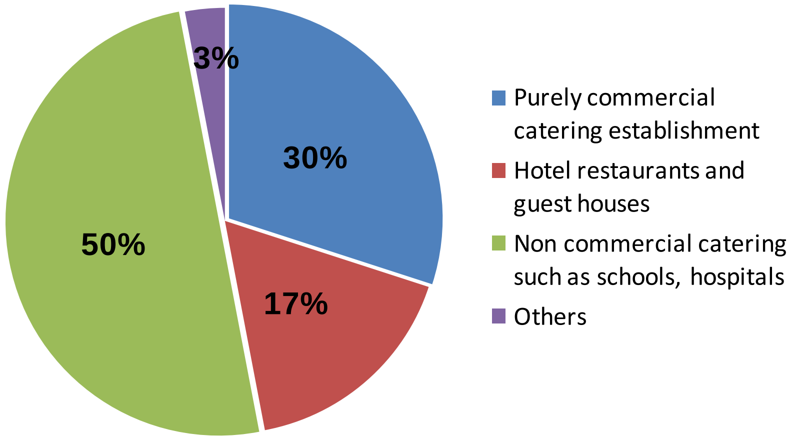

Figure 3-2: Main actors in the catering industry in the UK, 2008 by share of energy use[35]

In France, the energy consumed for cooking in the commercial sector is estimated to be 13.6 TWh[36]. Unlike the data available for the United Kingdom, this figure for France includes only cooking equipment.

3.1.3.2 USER LEVEL DATA

The use patterns of commercial appliances are very different from the domestic appliances ones. The appliances are used much more intensively, to cook larger portions of food, and thus consume much more energy over their lifetime.

The German catering equipment manufacturers association (HKI) provided an estimation of several use parameters for some commercial appliances, presented in Table 3-13. These are estimations from the German manufacturers, which give an appraisal of the real use of those appliances they produce for the EU single market.

[35] CSFG (2008), "White Paper on Climate Change - A sector strategy for energy efficient commercial kitchens".
[36] CEREN (2008). Suivi du parc et des consommations d'énergie du Tertiaire

Table 3-13: Estimation of use parameters for some commercial appliances

Type of commercial appliance	Power-on time of the heating	Time of using per year (h)
Electric combi steamers	30%	1,500
Gas combi steamers	30%	1,500
Electric oven	30%	1,500
Gas oven	30%	1,500

Modern ovens are also usually equipped with programmable systems, which allow the user to cook by selecting the type and quantity of food which is loaded in the oven. Then, the computer calculates the right cooking time. As presented in Table 3-13, combi steamers and convection ovens are heating the chamber during 30% of the cooking process. The food finishes cooking inside of the oven with the remaining heat.

In restaurants, ovens are used much more intensively than in households. Turning on the oven at the beginning of the day and turning it off only at the end is a very common practice. That way, the oven is always warm and ready to use instantaneously. Therefore, the energy consumed during this "standby" phase is not negligible compared to the energy consumed while cooking food.

Table 3-14 presents the use parameters which will be used in this study to characterize the use phase of restaurant ovens.

Table 3-14: Use parameters of restaurant ovens in the EU

	Units	Commercial electric combi steamer	Commercial gas combi steamer
On-mode			
Number of cycles per year		1872	1872
Average duration of a cycle		40min	40min
Electricity consumption per cycle	kWh elec.	4.2	0.4
Gas consumption per cycle	kWh NG		5.4
Standby mode			
Number of hours in standby mode		936	936
Electricity consumption per hour	kWh elec.	1.5	0.6
Natural gas consumption per hour	kWh NG		1.9
Annual energy consumption			
Annual electricity consumption	kWh elec.	9,266	1,310
Annual natural gas consumption	kWh NG		11,887

Gas combi-steamers also contain electric equipment, such as electronics, lights, pumps and fans, which need to be powered with 0.6 kW. Therefore, for a 40 minutes cooking cycle, 0.4 kWh is consumed. In "standby" mode, 0.6 kWh is consumed in one hour.

These use parameters are only estimates, as cooking habits are very different from a Member State to another, and as it must be representation of the use in both commercial and institutional restaurants. However, stakeholders believe that it is fairly representative of an average use in the EU.

3.1.4. BAKERY OVENS

The cooking habits in the EU are very diverse, and there are huge variations from a Member State to another on the use time of cooking appliances. This is also the case for bakery ovens. There are indeed strong cultural differences between Member States regarding the type of products which are baked, resulting in variations in ovens' use. In some Member States, most of the bread is produced industrially, while in others, artisan bakers still have a higher share in bread production.

Based on discussions with bakery ovens manufacturers, the typical use of bakery ovens in the EU is detailed in Table 3-15.

Table 3-15: Use parameters of in-store convection ovens and deck ovens in the EU

	Unit	Commercial in-store oven	Commercial electric deck oven	Commercial gas deck oven
Cycles				
Number of cycles per year		5000	1872	1872
Average duration of a cycle		30min	1h	1h
Electricity consumption per cycle	kWh elec.	2.5	25.2	0.8
Gas consumption per cycle	kWh NG			32.8
Annual energy consumption				
Annual electricity consumption	kWh elec.	12,500	47,174	1,498
Annual natural gas consumption	kWh NG			61,402

As manufacturers provided energy consumption data for this complete cycle, no distinction was made between on-mode and standby, as for combi-steamers.

A typical cycle of a commercial in-store oven corresponds to 20 minutes of baking followed by 10 minutes of standby. The total energy consumption for this 30 minutes cycle is estimated to 4 kWh for a typical 4 tray commercial in-store convection oven.

Deck ovens were considered to be turned on during 9 hours a day during 312 days per year. It was assumed that they were consuming energy at full power during 60% of the time (i.e. 6 hours a day), which results in 1872 hours in on-mode per year.

For rack ovens, an example of use protocol is as follows:

- Selecting a recipe
- Opening the oven door
- Loading the oven with a rack (30 kg of dough)
- Closing the oven door
- Starting to bake
- Baking for 18 minutes
- Pressing the stop button while the alarm is sounding
- Waiting for the rack to come in stop position
- Opening the oven door
- Unloading the rack

The total time for a baking cycle is around 20 minutes, which allows making three cycles per hour. However, this varies depending on the recipe.

As shown on Table 3-16, manufacturers estimate that rack ovens are used more intensively. Standby mode is defined as for combi-steamers: the oven is empty but maintained in temperature.

Table 3-16: Use parameters for rack ovens in the EU

	Units	Commercial electric rack oven	Commercial gas rack oven
On-mode			
Number of hours per year		2700	2700
Electricity consumption per hour	kWh elec.	25.5	2
Gas consumption per hour	kWh NG		28
Water consumption per hour	Litres	5	5
Standby mode			
Number of hours in standby mode		300	300
Electricity consumption per hour	kWh elec.	7.5	1.7
Natural gas consumption per hour	kWh NG		9.15
Annual energy consumption			
Annual electricity consumption	kWh elec.	71,100	5,910
Annual natural gas consumption	kWh NG		78,345
Annual water consumption	m^3	13.5	13.5

3.1.5. BEST PRACTICE IN SUSTAINABLE PRODUCT USE

As discussed earlier, energy consumption in ovens is very dependent on user behaviour, e.g. the cooking temperature and time, frequency of the use of ovens, use of cooking ware to cover the food, and pre-heating settings. Also, maintenance practices (e.g. cleaning) can strongly impact performance.

Already, a number of governmental agencies and organisations provide recommendations to end-users for smart use of ovens, such as the Australia's guide to environmentally sustainable homes[37] and the Energy Savers booklet from the US DOE[38]. 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, including ovens, and energy-saving best practices[39].

Such strategies to reduce energy use aim at reducing the amount of energy needed for cooking through better equipment settings and reduction of heat losses. Others aim at targeting the consumer prior to purchase of the equipment by providing information on the benefit of using gas ovens over electric ovens, when comparing greenhouse gas emissions or cost of use. There are some cases where gas ovens are cheaper to use, have more responsive controls and produce less greenhouse gas emissions. Regarding the purchase choice, these are the practices recommended for users:

- Prefer fan forced ovens that are about 30% more efficient than conventional units, which can waste up to 90% of the energy used[37].
- Some electric ovens can be divided into compartments for cooking small items or several shelves can be used to cook various dishes at the same time.
- Look for ovens with high levels of insulation and triple glazed, low-emissivity coated windows.
- When you need to purchase a natural gas oven or range, look for one with an automatic, electric ignition system. An electric ignition saves gas because a pilot light is not burning continuously.

Regarding cooking and oven use, the following are the best practices that users are advised to follow in order to cook more efficiently:

- Full-size ovens are not very efficient for cooking small- to medium-sized meals. Use small electric pans or toaster ovens for small meals rather than a large stove or oven. A toaster oven uses a third to half as much energy as a full-sized oven.

[37] http://www.yourhome.gov.au/technical/fs61.html
[38] http://www1.eere.energy.gov/consumer/tips/pdfs/energy_savers.pdf
[39] ADEME (2008), “Économie, efficacité, confort : branchez-vous malin ! équipements électriques”.

- Use pressure cookers and microwave ovens whenever it is convenient to do so. They will save energy by significantly reducing cooking time.
- Avoid preheating – for most meals, this step is unnecessary in a gas oven and should be minimised in an electric oven (especially in fan-forced ovens). However, for some meals, no preheating phase would affect the food quality (texture and uniformity in cooking).
- Avoid opening the oven door unnecessarily when cooking. Make sure the door seal is clean and in good condition.
- Use the oven rest heat, e.g. by switching off the appliance a few minutes before the advised time.
- Use appropriate cooking ware. Covering oven racks with foil blocks the flow of hot air. Food cooks more quickly and efficiently when the heated air can circulate freely.
- Check the oven door seal occasionally for cracks or tears as even a small tear or gap can allow heat to escape. In addition, a clean seal will provide better heat retention.
- In the case of ovens featuring self-cleaning, clean right after usage in order to take advantage of residual heat.

Setting the appropriate temperature for each meal is also advised by the French Association of Appliance Manufacturers (GIFAM is its acronym in French)[40] as shown in Table 3-17. This is general advice from manufacturers but it could influence user's preferences or habits.

Table 3-17: Recommended temperatures for different meal preparation

Temperature	Meal preparation
300°C - 270°C	Roasting, preheating
240°C - 220°C	Red meats, pizza
210°C - 180°C	Pork, chicken, fish
160°C - 140°C	Cakes, biscuits, quiches
120°C - 75°C	Reheat already cooked meals
60°C	Warm dishes
40°C - 30°C	Unfreeze

[40] GIFAM (2005), "Le Guide 2005 de la cuisson encastrable".

Roasting at 270 – 300°C would be regarded as very hot by UK consumers thus most ovens on the UK market have maximum temperature of 200 – 250°C.

3.1.6. Summary

Table 3-18 summarises the average energy consumption values attributed to different types of ovens for the purpose of this study. The consumption of electric appliances is expressed in kWh of electricity, while the gas oven's one is in kWh of natural gas. These two units are not directly comparable, natural gas being a primary energy, while electricity is produced from primary energy.

Table 3-18: Final energy consumption per use and per oven from consumer behaviour in EU (2008)

	Electricity consumption per year and per oven (kWh/yr)	Natural gas consumption per year and per oven (kWh/year)
Domestic electric oven	164.3	
Domestic gas oven		183.7
Domestic microwave oven	86.4	
Commercial electric combi steamer	9,266	
Commercial gas combi steamer	1,310	11,887
Commercial electric deck oven	47,174	
Commercial gas deck oven	1,498	61,401
Commercial in-store oven	20,000	
Commercial electric rack oven	71,100	
Commercial gas rack oven	5,910	78,345

3.2. END-OF-LIFE BEHAVIOUR

The information available regarding the end use of domestic cooking products is very limited. Impacts associated to their energy consumption during their life time are thought to be more important than those from the end-of-life.

3.2.1. Economic product life

- **Domestic ovens**

Data on the expected lifespan of ovens are sparse. However, by rationalising known sales and ownership data available for a few countries, an average lifespan of between 15 and 20 years can be estimated for gas and electric ovens. The cooking product lifetime that the US DOE estimated for the economic assessments in the Rulemaking Framework for Residential Cooking Products was an average lifetime of 19 years for conventional gas and electric ovens and 10 years for microwave ovens. The MTP estimates a lifetime of 19 years for electric and gas ovens, and 8 years for microwave ovens.

There is also a relationship between the price of the appliance and the rate of disposal. It is believed that for cheaper appliances, consumers might tend to dispose them earlier and get a new one rather than spending money on repairs.

In the context of this study Table 3-19 summarises the economic product life defined for the domestic products in Lot 22. Different values of lifetime for built-in or free-standing equipment have not been reported, thus it is assumed that on average the same lifespan applies for both categories in every type of appliance.

Table 3-19: Economic product life for Lot 22 domestic products

Type of Appliance	Lifetime Average (Years)
Electric Oven	19
Gas Oven	19
Microwave Oven	8

- **Commercial appliances**

The length of service of commercial catering equipment in general spans between 10-20 years. No data is available on specific oven types for the commercial sector. Information from stakeholders on this matter is that for the public sector the life duration of the appliance is between 5 to 10 years, whereas in the professional sector (restaurants, hotels) it increases to more than 10 years.

Table 3-20: Economic product life for Lot 22 commercial products

Type of Appliance	Lifetime Average (Years)
Restaurant - Combi steamers	10
Bakery - Deck ovens	15
Bakery – Rack ovens	10
Bakery - In-store ovens	8

3.2.2. RE-USE, RECYCLING AND DISPOSAL

The waste generated by oven disposal 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.

- **Domestic appliances**

According to data presented in the AHAM 2003 Fact Book for the United States[41], many old appliances, including ovens, are still being used after consumers purchase new units of same product. Table 3-21 presents the various routes that consumers use to dispose of their old appliances in the US. The US categories correspond to the categories defined in this study as follows:

US category for:		corresponds in this study to:
Ranges	→	Free-standing cookers
Built-in ranges	→	Built-in ovens

Table 3-21: Disposal routes for Previous Appliance in US in 2003[41]

Product	Kept It	Left with Previous Home	Sold / Gave Away	Recycling Facility	Left at Curb for Disposal	Retailer Took Away
Ranges	6%	37%	21%	13%	8%	15%
Built-In Ranges	4%	46%	11%	15%	12%	13%
Microwave Ovens	17%	11%	32%	12%	23%	4%

In the EU, the Waste Electrical and Electronic Equipment Directive (WEEE Directive)[42] imposes the responsibility for the disposal of waste electrical and electronic equipment on the manufacturers of such equipment. All domestic ovens considered in this study are included in the scope of this Directive. It also encourages the design of such products to take into account and facilitate dismantling and recovery although no Member State has adopted specific legal requirements to support this aspiration. The required rate of recovery for large household appliances (e.g. most domestic ovens) is 80% by weight and for small household appliances (e.g. possibly some portable products) is 70%. It is probable that the recast of the WEEE directive, currently under discussion, will increase both these targets by 5% - probably from 2012 but possibly

[41] AHAM (2003), "Fact Book 2003".
www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/cooking_products_tsd_ch3.pdf
[42] European Community Directive 2002/96/EC.

later if the deliberations drag on. Lot 22 products are also covered by the Restriction of Hazardous Substances Directive (RoHS)[43].

All producers of ovens are obliged by the WEEE directive to take responsibility for financing the collection and treatment of their products. The precise regime varies from State to State but in general it results in the reporting of the number and weight of appliances recovered as well as the quantities of recovered materials from recycling which allows the assessment of whether the recovery targets have being achieved. Table 3-22 presents data on large white goods collected in three Member States.

Table 3-22: Large white goods collected in three MS in the period 2004 - 2008 (in tonnes)

Member State	2004	2005	2006	2007	2008
Belgium[44]	15 141	16 649	17 822	18 909	19 108
Sweden[45]	-	36 300	45 500	45 453	-
Netherlands[46]	-	-	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 3-23 (first column), followed by the objectives set by the Environmental Policy agreements (second column). The compliance level was 100% recycling for the materials recovered from appliances in this category in Belgium. Information on the other Member States was not readily available.

[43] European Community Directive 2002/95/EC.
[44] RECUPEL (2008), “Annual Report 2008”.
[45] EL-KRETSEN AB (2007), “Annual Report 2007”.
[46] NVMP (2008), “Annual Report 2008”.

Table 3-23: Recovery rate per material stream in the category of large white goods, Belgium 2008[44]

Recycling* per material stream	2008	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

Recycling of ovens is likely to be energy consuming as they consist of a high proportion of steel (which must be melted) and relatively little plastics which would generate energy although with the emission of CO_2 (plastics are derived from fossil fuels). Recycling of steel however uses only about 33% of the energy used to produce virgin steel from iron ore[47].

- **Commercial appliances**

According to the information provided by HKI, all commercial appliances under the scope of Lot 22 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 do not take the typical recycling process like in the domestic sector.

Deck ovens used in Western Europe, especially gas ovens, were traditionally resold to Eastern countries or to African countries. When they must be disposed of, they are usually recycled by scrap dealers, as most of their weight comes for metals.

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.

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[47] http://www.need.org/needpdf/infobook_activities/IntInfo/ConsI.pdf

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 ovens 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 task aims to present the user/consumer's essential role concerning the environmental impacts of domestic and commercial ovens. One important factor is barriers that hinder users/consumers from behaving 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 ovens.

3.4.1. BARRIERS TO INCREASED OWNERSHIP OF MORE EFFICIENT COOKING APPLIANCES

The following barriers to fostering the purchase of energy efficient domestic and commercial ovens have been identified:

- High costs of better technology: many consumers may opt for a cheaper model (if given a choice) and are very rarely aware of the energy consumed by domestic and commercial ovens during their lifetime. In the case of domestic electric ovens, there are labels that display energy rating to inform users on their performance. These labels do not however indicate the lifetime energy cost of the ovens and the vast majority of purchasers would not be capable of estimating this from the energy rating. Clients of new commercial appliances ask for the cost regarding the energy consumption, but it is difficult to compare the information from different manufacturers.
- Inertia: some consumers are likely to change their oven only when the kitchen is given a 'make-over' or when their old models break down.

- Lack of fuel choice: gas appliances are considered to be up to three times more efficient in primary energy terms than an electric equivalent[48], 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, people do not know how to use power management features.
- Convenience: e.g. use of power management or shutting off devices seems too time-consuming for users. This is the case of microwave ovens with digital displays that could be unplugged to minimise standby power consumption but then require manual resetting when the power is restored.
- Fashion: Gas ovens are less popular than electric and the ratio of electric to gas has increased during the past decade, whereas in most EU States, gas ovens result in lower CO_2 emissions than electric. Most consumers are unlikely to be aware of the difference in global warming gas emissions from these two energy sources. The move to increasing use of renewable energy sources should slowly reduce the CO_2 emissions from electricity.

3.4.2. Barriers to ecodesign (technological barriers)

Ovens are mature products according to the Final Report on Efficient Domestic Ovens (SAVE II Project, 2000), which means that any major changes in design are more likely to be towards multifunctional options and new ways of cooking rather than improvements in the conventional oven.

This statement is also supported by the DOE in its final ruling of Energy Conservation Standards for Certain Consumer Products[49] (including microwave ovens, and electric and gas kitchen ranges and ovens). In order to adopt 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 and ovens are not technologically feasible or economically justified.

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

[49] US Department of Energy (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.

On the other hand, in the USA, there is a new ruling for gas kitchen ranges and ovens requiring that residential gas ovens without an electrical supply cord manufactured after the 9 April 2012 must not be equipped with a constant burning pilot light.

3.4.3. CONSUMER BEHAVIOUR AND AWARENESS

Some of the technological options which might achieve significant energy savings may have a potential impact on consumer usability. For example, eliminating the oven-door window would improve insulation but would have a direct impact on consumer behaviour (frequency of door opening or preference for other equipment).

Switching from conventional methods of cooking to microwave ovens could save energy in some cases. While the majority of households have a microwave oven, consumers do not generally regard them as primary cooking appliances, except for specific tasks. The UK MTP consumer research[50] shows there are a number of barriers to be overcome before people would consider using their microwave more often. These findings are related to:

- The food itself: e.g. that the food was unappetising, it was difficult to learn how to use the microwave oven well, that the food cooked unevenly, that it is easier to use the hob, that it is not possible to cook everything in a microwave oven.
- Oven-design: e.g. that the cavity is too small, the controls are too difficult to use, the handbooks are too complicated, and that it is not possible to see the food inside the oven.
- Fear of electromagnetic fields: In 2002, the German Federal Office for Radiation Protection polled hundreds of households on their concern about electromagnetic fields (EMF), generated by electronic devices[51]. 35% of participants expressed a general concern about EMF regarding potential negative health impacts. Out of these 35%, 56% explained that EMF from microwaves threatens them. This can also explain the reason why it is difficult to motivate people to use microwaves more often, despite their superior energy efficiency.
- Other aspects: e.g. that using a microwave oven is unnatural, that microwavable food products are just 'fast food' or 'convenience food' and thus unhealthy.

[50] MTP (2006), "*Historical microwave oven use and options to increase usage in the future*".
[51] Ergebnisse der bundesweiten Telefonumfrage im Auftrag des Bundesamtes für Strahlenschutz, 2002. Retrieved 2011 from: www.bfs.de/elektro/papiere/befuerchtungen.pdf

The level of consideration of different aspects of the product depends on what the customer is looking for: either low end products performing the basic function or more sophisticated appliances performing different kinds of functions with higher prices. Table 3-24 presents the most relevant criteria for consumers when purchasing an oven.

Table 3-24: Level of consideration by customers of different criteria for oven purchase

Criteria	Level of consideration by customers			
	Very Low	Low	High	Very High
Technology/ performance	*		X	
Functionality	*		X	
Size			*X	
Fuel Used				*X
Design		*	X	
Price		X		*

X: high end ovens

*****: low end ovens

3.4.4. BARRIERS 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. For commercial equipment the buyer of the appliance might not be the same as the final user. Hence a split incentive arises. As an example consider the case of catering facilities used by public bodies; the buyer of the appliance is a procurement officer and the final user is the operator in the kitchen. The following are the main barriers found:

- **Higher capital cost**

The purchase price is often the determining factor in the purchase decision, tending to lead towards the choice of less efficient equipment.

- **Absence of economies of scale**

The sector is very fragmented in relation to operators who buy the equipment, suppliers in the dealer network and manufacturers, thus the advantages of economies of scale are not significant, a factor that may not work as an incentive to produce more efficient appliances due to the lack of high volumes sold of each product type.

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 in other countries outside the EU can be found in the US Energy Star Program that developed a Guide for Restaurants, explaining all the benefits of using energy efficiency equipment in the day to day business. Nevertheless, it is thought that these initiatives alone without the proper back up of government agencies are not enough to translate the content into effective measures.

Lack of information

Currently there is no easily available information on appliance performance for procurement officers that could be accessed when there is a need of new equipment. Thus, a comparison between appliances' energy performance cannot be made and the purchase decision turns again on the price. To address this, the Energy Star Program has created the 'ENERGY STAR qualified products' list[52] that provides information on manufacturers and models that fulfil specification requirements of good energy performance. Public or private procurement officers could access this lists when looking for new equipment. A similar initiative in the EU could have an important impact on the energy consumption of the commercial sector, bearing in mind that the category named earlier in Figure 3-2 'non commercial catering industry', where key public bodies such as schools, hospitals, prisons, account for 50% of the total consumption in the commercial sector.

Lack of operator training

Following the same principle as in the residential sector, significant improvements could be achieved by promoting sustainable practices in the use of cooking equipment. For this, operator training in efficient use of ovens needs to be prioritized in the commercial sector as another means to achieve energy savings but for this to be effective there needs to a direct benefit for the operator or kitchen concerned (e.g. a reduced energy bill which feeds through as a staff benefit). An energy efficient kitchen will soon lose this advantage if the equipment is not operated in accordance with manufacturers' instructions for warm up times or optimum loading capacities, according to the Catering for a Sustainable Future Group (CSFG)[53].

[52] ENERGY STAR qualified products' list, http://www.energystar.gov/index.cfm?fuseaction=find_a_product.
[53] Catering for a Sustainable Future Group (CSFG) (2008), "White Paper on Climate Change - A sector strategy for energy efficient commercial kitchens".

3.5. CONCLUSIONS TASK 3

The section findings are mostly related to the effect on energy consumption in ovens by the users' habits and the differences among EU users. It was discussed how differences in oven use (due to cooking habits, type of meal, etc.) can account for an overall energy consumption variation of up to 30% within the same oven type. Even though an average typical value for energy consumption per use or number of uses per year must be defined for the purpose of this study, those aspects that can produce changes in consumer's behaviour previously discussed will be included in the sensitivity analysis of the different options later on.

Other issues affecting energy consumption that have been discussed include the self cleaning functionality or the standby power options; both account for a recent increase in the overall energy use of ovens in certain MS. The section on sustainable product use identifies certain practices that could encourage consumers to use their appliances more efficiently; however they need to be communicated effectively and additional economical, technological and awareness barriers must be overcome.

Additional findings relate to the importance on price or performance that users give when purchasing appliances. It was presented where these main differences occur and how they are due to the final end or purpose of the appliance: some users prefer appliances that perform basic functions while others are looking for sophisticated functions or designs to enhance the cooking experience. The final use of the appliance plays a main role on the consumer's final choice when purchasing new equipment.

Finally, it is discussed how commercial kitchens are huge users of energy but there is very little empirical data on which the energy usage of commercial kitchen equipment can be evaluated. However, as shown in Task 2, in most Member States, it has been acknowledged that there is an increase in commercial catering (eating out, take-away meals, etc.) attributed to the fact that people is eating out more frequently and cooking less at home. If the annual energy consumption due to domestic oven has showed a decrease and one of the reasons could be related to this trend, the overall energy use may not decrease as it shifted to the commercial sector.