Cooking Appliances

HIGHLIGHTS

PROCESS AND TECHNOLOGY STATUS – In developed countries, cooking appliances are mature technologies with very high market penetration. In the US, virtually every household possesses an oven and cooktop, and in the EU most households have at least one oven. Appliances generally use electricity or gas (natural gas or LPG), whilst biomass is also an important fuel in developing countries. A wide variety of devices exist that largely serve the same cooking requirements; recent trends in product innovation have moved towards increased integration and functionality. In recent years, domestic cooking accounted for 7.5% of total EU residential electricity consumption, 8% of US residential electricity and 50% of the natural gas consumed by US domestic appliances. Domestic equipment can be broadly categorised into ovens, grills, hobs and microwaves. These are often integrated into cookers or ranges. Electric ovens dominate the EU domestic market and are owned by 77% of EU households and 64% of US households. Commercial appliances tend to have significantly higher power ratings and are used more intensively, with a wider range of appliances to serve more specific needs. Key technologies include ovens, grills or broilers, hobs and microwaves as well as ranges, fryers, griddles and steamers. In the US marketplace, stock is well split between the different devices, with gas ovens accounting for the largest share with 16.6% of 2008 stock. In the EU-27, combi-steamers dominate the market: in recent years, 41,000 electric and 9,200 gas combi-steamers were sold. In developing economies, cooking energy is a more important end-use compared to developed economies: in India, cooking accounts for 90% of domestic energy consumption, with 75% of this provided by biomass. Appliance types vary significantly, but in rural areas they are often basic stoves.

PERFORMANCE AND COSTS – The performance of common cooking appliances varies widely depending on device type, fuel type and user behaviour. Real-life efficiencies differ substantially from standardised test values due to the impact of idle consumption, pre-heat input and user behaviour. With equivalent equipment, user behaviour can produce a variation in consumption of up to 30%. Annual consumption figures show that electric and gas hobs consume the most energy, with domestic devices using an average of 190-250 and 333-996 kWh per year respectively. Microwaves can offer substantial efficiency savings due to considerably shorter cooking cycles. Domestic appliance costs range from €50-1,500 with cheaper equipment generally being less efficient. Limited energy labelling schemes exist: in the EU, domestic electric ovens are rated A-G, and this qualification scheme has been credited with increased EU uptake of efficient electric ovens. In the commercial sector, gas appliances offer test efficiencies ranging from 25-50% and electrical appliances vary from 50-75%. The US Energy Star programme offers a voluntary qualification scheme for commercial fryers, ovens, steamers and griddles. Qualified appliances can save up to 14,650kWh per year compared to the equivalent conventional device. All commercial devices have shorter lifetimes of around 10 years; costs vary significantly with size and features, and fall within the range of €1,000-30,000. In developing economies like India, cooking devices consume much more energy, with efficiencies of 5-45% and lifetimes of around 3-7 years.

POTENTIAL AND BARRIERS – A range of opportunities for technology evolution exist, some of which are broad and apply across fuel-devices, whilst others are fuel or device-specific. Estimates of potential energy savings for domestic appliances vary; conservative assessments suggest potential long-term gains of 6-7% for ovens and 4% for microwaves. Product innovation of gas appliances could yield the largest energy savings. In the EU, technology could be transferred from electric appliances and commercial gas devices; in the US, the replacement of pilot lights with electric ignition systems will significantly reduce annual energy consumption. In the commercial sector, a number of existing technologies have yet to be implemented. These are estimated to offer an overall technical potential saving of 31% in the US marketplace. In both the domestic and commercial sector, significant savings could be made by switching to more efficient devices and adopting more efficient behaviours; however, barriers associated with capital costs, inertia, fuel choice, consumer information, convenience, fashion and usability all contribute to limit progress. Perhaps the most significant opportunity for global cooking efficiency exists in the developing world: improved biomass stoves and fuel switching promises large energy savings, but substantial cost and availability issues exist at present.

PROCESS AND TECHNOLOGY STATUS

There are four heating mechanisms used for food cooking: conduction, convection, radiation and induction. **Conduction** refers to the heat transport from an energy source to the material. **Convection** occurs when fluids become less dense on heating, setting up convection currents that physically transfer heat and hot fluid to the material. **Radiation** refers to the energy propagation as an electromagnetic wave, which can heat the surface of a material. **Inductive heating** involves the induction of a current in a material due to a changing electromagnetic field, which then produces heat due to resistive losses. In general, cooking processes involve a combination of these mechanisms.

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A range of fuels can be used. In OECD countries, **electricity** and **gas** dominate, although relative proportions vary significantly. Electric appliances use heating elements and digital control systems. Gas systems use gas burners to regulate temperature; generally natural gas is used, although limited availability means LPG cylinders are also common (for example, 4.3% of US households had LPG cookers in 2009) [1]. Some appliances combine both fuel types.

In developing countries, traditional **biomass** is an important fuel; this includes fuel wood, animal dung, roots and agriculture residues. Traditional biomass accounts for approximately 10% of global primary energy consumption, and most is used for small-scale domestic heating and cooking [2]. IEA figures show that, in 2009, 37% of the world's population relied on traditional biomass as their primary fuel for cooking, with over half of this group living in either India or Sub-Saharan Africa [3].

■ **Domestic Cooking -** Domestic appliances are those that are primarily meant to be used in the household, although they may also be used in small commercial kitchens. In Europe, electric ovens and hobs accounted for 7.5% of residential electricity consumption in 2007, excluding stand-by power [5]. In the US, 2007 data reveals that cooking is responsible for 8% of total residential electricity consumption, and 50% of the natural gas consumed by residential appliances [6].

A variety of appliances compete in the domestic market, although they are not necessarily direct substitutes. Within each category, different technologies exist; the figures quoted in this briefing are for a representative device. An **oven** is the most widely used and versatile appliance. In the EU, the majority of domestic ovens are electric, with a market share of 77%, while gas ovens have a market share of 24%. Ovens can be conventional or fan-forced (convectional), the latter being most popular in the UK domestic market [7].

A **hob**, also referred to as a cooktop, incorporates one or more distinguishable cooking zones upon which pans can be placed for heating. The pan itself can be heated by any of the heating mechanisms (or a mixture), before heat is passed to the food via conduction. A variety of electric hobs currently exist. In the European market, the main product types include hot-plates (9.4% of 2007 sales), radiant hobs (70.8% sales) and induction hobs (19.8%) [8], which rely chiefly on conduction, radiation and induction respectively. In the US, 5.1% of households have separate gas cooktops and 6.6% have electric cooktops [1].

A **grill** is an appliance or part of an appliance in which food is cooked by radiant or contact heat, which can be applied from above or below. Within the EU, gas grills made up around 15% of the market in 2008 whilst electric radiant grills accounted for 40% and electric radiant covered grills 45% [7].

Electric **microwaves** use one or more magnetrons to generate microwave radiation at frequency of 2.45 GHz [2]. These can be integrated with other cooking systems: Estimates of current market share in the EU for conventional microwave ovens is 55%, combi-ovens is 10% and microwave with grills is 35% [7]. Microwaves sales are forecast to continue to increase with slowing growth as the market reaches saturation, with a predicted growth of 9.9% in the EU-27 from 2010 to 2020.

Appliance configuration is an important consideration in the domestic sector. As such there is an important distinction between **free-standing** and **built-in** equipment. Free-standing ranges, also referred to as cookers and stoves, combine ovens, hobs and sometimes grills, and can use gas, oil or electricity. Within the EU, 2007 data shows that virtually all built-in appliances were electric (98.9%) whilst free-standing models were 34.6% electric, 39.0% gas and 26.4% mixed fuel [7].

The situation is very different in many developing countries. In the domestic sector in India, 75% of energy requirements are met by fuel wood and agricultural waste, with cooking accounting for 90% of household energy consumption [9]. Equipment in rural area is basic, often just stones or pans, with efficiencies varying from 5% to 45% [9].

■ **Commercial Cooking -** Commercial cooking refers to environments in which food is cooked or heated for consumers. In the UK, the total energy consumption of the catering industry is estimated to exceed 21,600 million kWh per year. 30% of this is used in purely commercial establishments, with an additional 17% in hotel restaurants, and more than 50% in non-profit bodies like schools, hospitals and public institutions [10]. Similar distributions can be observed in the EU and US [7], [11]. In the US, electric cooking energy use in buildings totaled 7 billion kWh in 2003 (0.7% of the total electricity consumption) 4 billion kWh of which was used in food service buildings [12]. The White Paper on Climate Change from the Catering for a Sustainable Future Group indicates that energy consumption in the commercial sector is important; however, very little empirical data is available on usage [10]. Most EU Member States accept that there has been an increase in commercial catering due to trends to eat out more regularly, potentially explaining falls in domestic energy consumption.

Commercial cooking is generally more energy intensive with larger portions and thus larger energy consumption. Usage patterns differ significantly from those in the domestic environment; equipment is often left on throughout the day. Different requirements and behaviors mean that different equipment is preferred [7]. Commercial ovens, grills (known as broilers in the US) and hobs operate in much the same way as their domestic equivalents. More specialized equipment also holds significant shares in the commercial market. **Fryers** involve the immersion of food in oil heated to 175ºC, which heats the moisture within the food, cooking it internally. **Griddles** cook food through contact with a hot surface heated to temperatures of 175-230ºC, which is supplied by gas burners or electric heating elements. **Steamers** heat food when water vapour condenses on the surface of the food, resulting

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in heat transfer. They can be boiler-based, using steam from a separate boiler to cook food, or use self-generated vapour, and can be pressurized or pressure-less.

Commercial **ranges** typically comprise a range top, with six open burners or heating elements, and a range oven, with an incorporated oven below. Gas models dominate, accounting for 91% of the US commercial stock [11]. Within the EU, little data is available. Stakeholders suggest that combi-steamer ovens account for most oven sales, as static and forced convection models become less popular. In 2007, 41,000 electric devices and 9,200 gas appliances were sold, with electric sales forecast to rise 10.5% by 2025 [7]. In developing nations, commercial consumption is less significant as most meals are eaten at home.

PERFORMANCE AND COSTS

Cooking performance can be measured with a range of metrics:

- **Efficiency**: A range of efficiency metrics are used in different reports, all of which consider the ratio of input energy to that supplied to the food. Thermal, specific and basic efficiencies are reported which utilise different conditions and measures, making direct comparison difficult. Values are typically tested during a simulated heavy-load cooking event, so do not factor in preheat or idle energy consumption.
- **Consumption rate**: This can be expressed in kWh/cycle or kWh/year; the latter may be a theoretical figure based on expected usage frequency, or an empirical measure based on real-life consumption data.
- **Effective useful lifetime:** This measure expresses the average lifetime of a product under normal operating conditions.

Performance comparisons are complicated by the fact that control tests may differ and usage patterns vary significantly across the world[1]. Efficiency also varies with the type and quantity of food, as well as appliance size. Furthermore, real-life efficiency is strongly influenced by users' cooking habit. Findings suggest usage differences can produce a variation in consumption of 30% amongst users with the same equipment [7].

■ **Domestic Cooking Appliances –** Average annual cooking appliance energy consumption in the EU can be summarised as follows: gas ovens consume 184 kWh per year, based on 111 uses; gas grills use 50 kWh per year over 52 uses; gas hob consumption rates in the UK average 333 kWh per year. US figures are comparable, although ovens tend to have better thermal insulation, and gas appliances often have higher idle consumption due to the prevalence of pilot lights.

Electric ovens typically consume 164 kWh per year, electric grills average 50 kWh per year (based on fewer uses) and average hob consumption ranges from 190-250 kWh per year, depending on type. Convection ovens are generally more efficient than conventional models (~20%) due to shorter cooking times. Microwaves are typically used over shorter periods of 2-3 minutes more frequently, so have an average annual consumption of about 75-91 kWh per year (average 86 kWh per year). For electric devices, standby consumption is significant: for microwaves, an average idle power of 2.2-3.6 W accounts for around 20% of annual consumption [7].

In the EU, the energy Labelling Directive 2002/40/EC covers domestic electric ovens. This provides an A-F label based on cycle consumption rates, with various boundaries for small, medium and large ovens (see Table 3). Energy-efficient devices have become increasingly popular, potentially due to improved labelling, in a selection of leading EU economies. Some 77% of the oven sales and 60% of cookers in 2008 had A-class labels [13]. Sales proportions vary considerably by country, with higher volumes of efficient equipment sold in Western Europe. In 2005, sales of A-class ovens ranged from 23.3% in Spain to 67.4% in France. [7] Standby regulation No. 1275/2008 also caps consumption at 1W for standby and off modes.

Price estimates for domestic equipment vary considerably, with a range of technology types, energy classes and levels of functionality within each product category. In 2007, EU figures suggest that gas ovens cost €200-600, gas grills range from €100-1500 and gas hobs €130-1000 [14]. Electric ovens range from €350-1500, electric grills form €80-1500 [14]. Average electric hobs prices differ significantly with type, and are inversely related to efficiency [14]. The 2007 data suggest that solid plate hobs typically cost €137, radiant averaged €380 and induction hobs averaged €810 [14].

■ **Commercial Cooking Appliances –** Commercial gas appliances offer basic efficiencies ranging from 25% to 50% while electrical appliances vary from 50% to 75% under the same test conditions. Service lifetimes can span 5-20 years, but are typically lower than domestic appliances at around 10 years [11].

It should be noted that measured efficiencies are relevant for pre-heated systems over a short-term cooking event. As a result, they are not representative of overall energy wastage in the commercial sector since equipment is often left on throughout the day and significant energy input is required to heat large appliances.

The Energy Star programme is a voluntary scheme run in the US, with classifications covering commercial gas and electric ovens, fryers, steamers and griddles. Energy star appliances are required to satisfy minimum efficiency ratios and maximum idle consumption rates (see table 4). Case studies indicate potential annual savings of 14,650kWh, 8790kWh and 9669kWh respectively for gas fryers, ovens and steamers, and 1,100kWh, 1,870kWh and 4,930kWh respectively for electric fryers, ovens and steamers [15].

[1] Note that gas and electric consumption and efficiency rates should not be directly compared, without consideration of electricity production and transmission. Despite higher end-use consumption, gas appliances can be up to 3 times more carbon efficient [15].

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Typical prices for commercial equipment vary significantly with capacity and features. In addition, prices are often negotiated with suppliers. As a guide, typical grill prices vary from €1,500-5,000 and gas/electric hobs average ~€2,900, whilst ovens can costs from €10,000-30,000.

POTENTIAL AND BARRIERS

There are three principal ways in which cooking energy efficiency can be improved: technological advancement, appliance or fuel switching, and improved user behaviour.

Most cooking appliances are mature technologies so incremental innovations are anticipated, with a current focus on multifunctional options and new cooking methods. Some technologies to improve efficiency are applicable to all devices: for instance, thermal insulation improvements. Fuel-specific technologies include infrared burners, pulse combustion and electric ignition, which could bring significant gains to domestic and commercial gas devices. Appliance-specific improvements, such as induction griddles, could also bring substantial energy savings [11].

Product switching can also bring savings as certain appliances are better suited to certain tasks. Using a microwave can save energy: for example, cooking potatoes in a microwave uses 70-75% less energy compared to using an electric hob [16]. Switching fuel type from electricity to gas can also bring considerable primary energy savings.

Cooking temperature, process duration, the use of lids and the frequency with which an appliance door is opened are all significant factors in determining efficiency. Improved user behaviors are therefore important to progress in cooking efficiency.

A number of barriers exist to consumer adoption of energy efficient equipment and behaviours, in both the domestic and commercial sector. These include [7]:

- **High cost of superior technology**: Lifetime energy costs are rarely provided by manufacturers or understood by consumers, so many will choose cheaper models that tend to be less efficient.
- **Inertia issues**: Many consumers will only update equipment after a breakdown or refurbishment, resulting in slow product turnover.
- **Lack of fuel choice**
- **Lack of information**: Energy labelling is limited and relevant information is often unavailable in stores.
- **Convenience:** Power management features are often seen as inconvenient by consumers.
- **Fashion shifts**: Electric ovens have become increasingly popular in both sectors.
- **Usability issues**: As an example, microwaved food is considered unappetising and some feel the technology is unnatural.

■ **Domestic Cooking Appliances –** Estimates of the potential for long-term efficiency gains for domestic ovens differ significantly: one group of equipment manufacturers indicates that a total improvement of around 6% to 7% is possible for gas and electric ovens, and about 4% for microwaves [23]. Other work suggests more significant gains of 14% for electric and 20% for gas may be achievable [7].

However, analysis suggests that further improvement is likely to involve increases in life-cycle cost, and incentives to provide further improvements are likely to be small given that most of the best performing ovens are A-rated [7]. As a result, a modified energy rating system, allowing differentiation of A-class equipment, may be required to drive long-term development and adoption of more efficient technologies. This could also be adapted to factor in stand-by and off-mode consumption.

A similar labelling system for gas ovens could bring substantial reductions, since they have received less attention from manufacturers: as a result, some existing technology advances could be transferred from current electric oven and commercial gas appliances. To allow gas/electric comparison, labels could supply a life-cycle costs or emissions data, or a unified system reporting primary consumption could be adopted. However, findings from the Market Transformation Programme in the UK suggest labelling is unlikely to change underlying consumer cooking preferences, so improvement may be limited [17]. Minimum Energy Performance Standards (MEPS) could reduce consumption, and would likely involve the ban of sales of lower energy class devices.

Life cycle costs for microwaves are already minimal; energy labelling and MEPS are problematic so reports suggest efficiency gains should come chiefly through more efficient product usage [7]. For hobs, consumption savings of around 10-15% can be achieved by moving from solid plate to induction or radiant varieties. This trend is expected over time [14].

Outside the EU, consumer information is limited. In the US, Energy Star qualifications do not apply to domestic cooking equipment.

Barriers to technology development also exist. Stakeholders suggest that efficiency gains due to improved technology are negligible in comparison to changes in consumer behaviour. Moreover, in 2009 the US Department of Energy concluded that energy conservation standards for domestic ovens and ranges are not technically feasible or economically justifiable, since they offer insignificant macroeconomic energy savings [18].

Significant opportunities for energy savings exist in developing countries: low efficiency fuels and devices are common and cooking accounts for a larger share of household consumption. The key barrier is lack of fuel choice as a result of supply issues and cost. Analysis of the Indian domestic sector suggests that typical investment costs (Net Present Value per unit energy consumption) for biomass or coal is 1.5 Rs/GJ (0.022 €/GJ[2]), to be compared to values of 267 Rs/GJ (3.95

[2] Using an exchange rate of 0.0148

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€/GJ) and 833 Rs/GJ (12.3 €/GJ) for LPG and electricity respectively [19].

Efficiencies are predicted to rise from 0.713 to 0.75 for electrical systems, from 0.604 to 0.66 for natural gas and from 0.14 to 0.21 for traditional biomass from 2007 to 2030 [20]. Significant savings can be made through the widespread use of more efficient biomass stoves, and this would also bring substantial health benefits [21]. Furthermore, with rising incomes, fuel switching to modern forms of energy occurs. This is currently being observed in China, although availability and reliability constraints can slow this transition [3].

■ **Commercial Cooking Appliances –** In the US, an overall technical potential saving of 31% in primary energy consumption has been suggested in the literature, including significant savings of over 30% with all gas appliances [11]. The largest savings of 73% occur with electric and gas steamers [11].

Commercial hobs can be improved in the same manner as domestic devices; a shift to induction devices (which only use energy when a pan is present) and inclusion of sensors may bring larger savings as equipment is often left running [14]. Appliance switching could provide significant savings: combi-steamers consume less energy than traditional ovens, with measured savings of up to 50%, and microwaves are also generally more energy efficient.

However, similar barriers to product development and adoption exist in the commercial sector: choices are often made on the basis of capital cost alone, and the focus is on the quality of the resulting meal rather than the efficiency [14]. A lack of operator training is also an issue given the significance of user behaviour, particularly in restaurants. Eco-design may help change user behaviour to achieve substantial energy savings through the development of improved sensors and power management features.

A lack of initiatives with government support is a significant barrier: in the EU, there is no energy labelling scheme for commercial ovens. To allow the development of MEPS, harmonised test standards would need to be set, and different commercial environments may need to be considered separately. In the US, the Energy Star Program could be extended to more product groups to drive improvement.

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Table 1 – Summary of key figures for domestic cooking technologies [7], [14]

Domestic cooking (gas)			
Technical Performance	**Oven** [7]	**Grills** [14]	**Hobs (4 zones)** [14]
Size (litres)	12-66+ (av 58)	No data available	-
Typical power rating (kW)	10.5 [a]	No data available	3-20 (av 9)
Average cycle duration (minutes)	55	10-60	No data available
Consumption per cycle (kWh/cycle)	1.67	0.96	0.75 - 0.9
Base Energy Consumption per year (kWh/yr)	51-393 [22] (av. 184)	47	330(UK), 992(US) [b]
Typical cooking efficiency	No data available	No data available	40%, 55% [c]
Technical Lifetime, years	15-20 (av 19)	19	19
Costs			
Capital cost, Euro/unit 2007	€200-600 (av 330) €160-1,500 (range)	€100-1500	€130-1000 (av €268)
Estimated Life-cycle cost, 2007 figures [d]	€477	No data available	€519
Market data and projections			
EU sales share (2010 estimates) [7] [e]	4.2% (cooker)	6.0%	6.4% Built-in 4.2% Cooktop
US stock (% household share, 2009) [1] [g]	34% (range/stove/oven) 35.5% stove 2.1% oven	0.4% (Built-in I and stovetop)	5.1% (Cooktop)
Potential energy savings estimates	6-7% [23] 14% [24]	No data available	No data available

Domestic cooking (electricity)				
Technical Performance	**Oven** [7]	**Grills** [7]	**Hobs (4 zones)** [14]	**Microwave** [7]
Size (litres)	34-66+ (av. 54)	No data available	-	18
Typical power rating (kW)	3.57	N/A	1-10 (av 7.4)	0.6-1.0+
Average cycle duration (minutes)	55	No data available	No data available	2.6
Consumption per cycle (kWh/cycle)	1.1 [f]	0.96	0.57 (solid plate) 0.55(radiant) 0.43 (induction)	0.056
Base Energy Consumption (kWh/yr)	51-393 (av.164)	24-703, (av 50)	250 (solid plate) 240 (radiant) 190 (induction)	9-91 [22] (av. 86)
Typical cooking efficiency	No data available	No data available	74% (solid plate) 72% (radiant) 84% (induction)	No data available
Technical Lifetime, years	19, 15-20	19	15-19(av. 19)	8, 10
Costs				
Capital cost, Euro/unit 2007	€350-1500 (av. 493)	€80-1500	€100-300 (av 137) solid €150-650(av 380) radiant €300-1200 (av 810) induction	€50-1,500 (av. 117)
Estimated Life-cycle cost, 2007 figures [d]	€858	No data available	€905	€213
Market data and projections				
EU sales share (2010 estimates) [7] [e]	10.9% BI oven 3.6% BI cooker 3.8% FS cooker **Total 18.3%**	Radiant 11.1% Contact 10.1% **Total 21.1%**	Solid hobs 0.8% Radiant 7.6% Induction 2.6% Cooker top 7.4% **Total 11.0%**	Conventional 16.4% Combined oven3.2% With grill 10.0% **Total 29.5%**
US stock (% household share, 2009) [1] [g]	60% (range/stove/oven) Stove 54.5% Separate oven 9.8%	0.9%	Separate cooktop 6.6%	96% [25]
Potential energy savings estimates	6-7% [23] 20%	No data available	No data available	4% [23]

[a] Figure refers to full cooker so includes cooktop capacity.
[b] US data, 2008 – based on device with continuous pilot light, not relevant to EU.
[c] Values refer to primary energy efficiency (US DOE estimates).
[d] Calculated using Ecoreport, with average product price, estimated consumption, discount rate of 4% and price of energy as follows: €0.1554/kWh and 0.01481€/MJ.
[e] Proportion of known sales, projected for 2010 from 2007, with cookers including oven and hobs counted once in total sales number.
[f] Value used in Ecocooking base-case to represent average product in EU stock; same report suggests that the average product sold in 2011 used 0.84 kWh/cycle.
[g] Based on provisional RECS 2009 data.

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Table 2 – Summary of key figures for commercial cooking technologies [11]

Commercial Cooking (gas)							
Technical Performance	**Oven**	**Range**	**Fryer**	**Griddle**	**Steamer**	**Grill/ Broiler**	**Hobs** [14]
Typical power rating (kW) [a]	25	47	29	18	62	10 (EU) 26(US)	28
Average cycle duration (minutes)	No data available				40[b] [7]	No data available	
Consumption per cycle (kWh/cycle)	No data available				5.4[b] [7]	No data available	
Base Energy Consumption per year (kWh/yr) [c]	31,000	35,000	22,000	22,000	40,000	53,000 [11] 13,200 [d] [14]	35,000
Typical cooking efficiency [e]	40%	45%	35%	29-47% 40%	50%	25%	-
Effective useful lifetime, years	10	10	12	10	10	10	12
Costs							
Capital Cost, Euro/unit [14], [7]	No data available	€1500-12000	€2,400 [f]	No data available	€13,200[b]	€1500 -5000 (av. 2400)	€800-4000 (av 2950)
Market data							
% of US commercial cooking energy consumption	16.9%	15.9%	8.1%	3.1%	3.9%	6.1%	No data available
US stock, 2008 [g]	16.6%	12.3%	10.7%	4.5%	3.2%	3.0%	No data available
EU 2007 sales [14]	No data available		7,500 [f]	No data available	9,200 [b]	No data available	16,700
EU 2007 stock [14]	No data available		75,000 [f]	No data available	80,000 [b]	75,000	200,000
Data projections							
Estimates of technical potential efficiency reductions[h]	35.1%	40.5%	38.3%	43.1%	73.5%	45.4%	No data available

Commercial cooking (electricity)								
Technical Performance	**Oven**	**Range**	**Fryer**	**Griddle**	**Steamer**	**Grill/ Broiler**	**Hobs** [14]	**Microwave**
Typical power rating (kW)	15	16	12	12	26	7 - 13	16	1.0-3.2 (2.1)
Average cycle duration (minutes)	No data available				40[b]	No data available		
Consumption per cycle (kWh/cycle)	No data available				4.2[b]	No data available		
Base Energy Consumption per year (kWh/yr) [c]	13,100	15,000	4,500	11,200	170,000	28,400 [11] 9,270 [b] [14]	20,000	2000
Typical cooking efficiency [e]	68%	75%	75%	65-76% 70%	65%	50%	No data available	No data available
Effective useful lifetime, years	10	10	12	10	10	10	12	10
Costs								
Capital Cost, Euro/unit [14], [7]	No data available		€2,300 [f]	No data available	€11,900	€1500-5000 (av 2300)	av €2900 (solid plate)	No data available
Market data								
% of US commercial cooking energy consumption	17.3%	2.1%	7.1%	4.8%	9.9%	0.9%	No data available	3.8%
US stock share [g]	13.5%	1.2%	7.7%	4.5%	6.5%	0.3%	No data available	16.1%
EU 2007 sales [14]	No data available		7,500 [f]	No data available	41,000 [b]	No data available	10,833	No data available
EU 2007 stock (000's) [7]	No data available		75,000 [f]	No data available	145,000 [b]	75	No data available	No data available
Projections								
Estimates of technical potential efficiency reductions [h]	0%	0%	7.0%	18.4%	73.0%	0%	No data available	0%

[a] Typical values converted from Btu to kW using 3,413 Btu/kWh.
[b] Baseline EU values for commercial combi-steamers.
[c] Estimates calculated using US restaurant data, with Consumption = Rated capacity x Utilisation factor x Operating hours/year.
[d] For gas combi-steamers, EU average consumption breaks down as 11,887kWh for natural gas and 1,310kWh for electricity.
[e] 2008 baseline efficiencies defined using FSTC 2002, EPA 2008a and EPA 2008b.
[f] Figures based on EU values for fry tops.
[g] Expressed as a proportion of total recorded 2008 stock, excluding hobs and other devices (such that weightings total 100%).
[h] 2008 Estimates based on projected efficiency savings associated with a range of broad and specific technologies, already available or developed but not commercialised. Broad technologies include infrared burners, power burners, pulse combustion appliance insulation and electric ignition.

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Table 3 – Summary of Energy Class and Energy index for EU domestic ovens [7]

	Small cavities (12-35L)	Medium cavities (35-65L)	Large cavities (65L+)
Energy Efficiency class	kWh/cycle	kWh/cycle	kWh/cycle
A	<0.6	<0.8	<1.0
B	0.6-0.8	0.8-1.0	1.0-1.2
C	0.8-1.0	1.0-1.2	1.2-1.4
D	1.0-1.2	1.2-1.4	1.4-1.6
E	1.2-1.4	1.4-1.6	1.6-1.8
F	1.4-1.6	1.6-1.8	1.8-2.0
G	>1.6	>1.8	>2.0

Table 4 – Summary of US Energy Star Requirements and Savings [26]

	Electric						
Efficiency and savings	Oven	Fryer	Griddle	Steamer	Ranges	Grill	Microwave
Minimum Heavy Load Energy Efficiency	70%	80%	70%	50%	Not yet classified		
Maximum Idle Energy Rate (kW)	1.0, 1.6[1]	1.0	3.44kW/m [2,3]	0.4-0.8 [2]	Not yet classified		
Potential annual energy savings (kWh/yr)	1,870	1,100	No data available	4930	Not yet classified		
Potential Life cycle cost savings	$1,800	$950	$1,800	$10,350	Not yet classified		
	Gas						
Efficiency measures	Oven	Fryer	Griddle	Steamer	Ranges	Grill	Microwave
Minimum Heavy Load Energy Efficiency	44%	50%	38%	38%	Not yet classified		
Maximum Idle Energy Rate (kW) [3]	3.81	2.64	8.36kW/m^2	6.25-12.5 [2]	Not yet classified		
Potential annual energy savings (kWh/yr)	8790	14650	No data available	9,669	Not yet classified		
Potential Life cycle cost savings	$3,400	$4,400	$1,650	$11,500	Not yet classified		

[1] Lower limit applies to half-size appliances, upper to full-size devices.
[2] Efficiency requirements depend on pan capacity (3-6+ pans).
[3] Figures converted from Btu and feet using standard factors.

Table 5 – Performance statistics for typical developing nation fuel-device combinations [9]

Fuel	Device	Efficiency (%)	Life (years)	Capital Cost ($) [27]
Wood	Three stone	15.7	3	-
	Traditional three pan	14.2	3	-
Biomass	KVIC Burner	45.1	3	-
Kerosene	Nutan	60.2	7	~30-40
	Perfect	40.4	7	
LPG	Super flame	60.4	20	~45-60
Electricity	Hotplate	71.3	7	-

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