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Review study of Ecodesign and Energy Labelling for Cooking appliances

Task 1 – Scope definition, standard methods and legislation

Task 2 – Market analysis

Task 3 – Preliminary work on analysis of user behaviour and system aspects. (Work in progress)

Task 4 – Analysis of technologies

FIRST DRAFT

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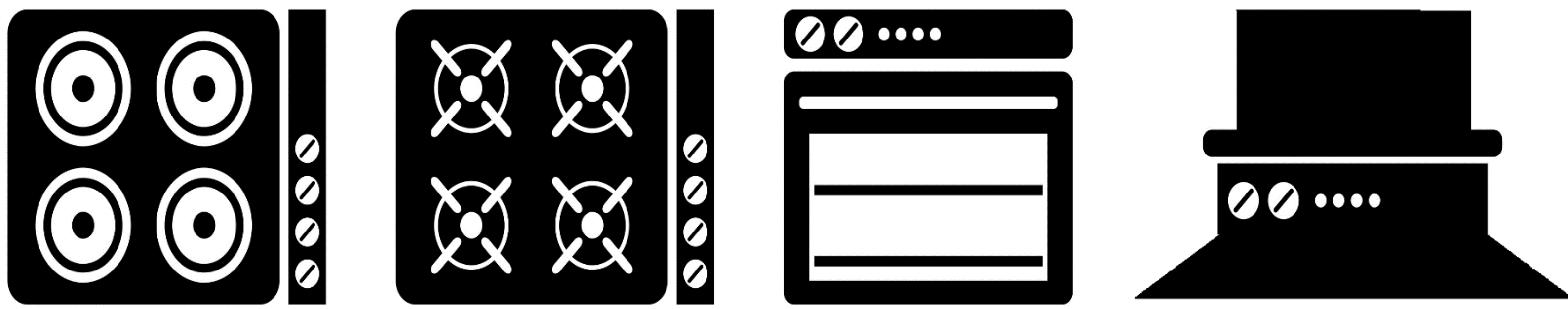

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Table of Acronyms

AEC – Annual Energy Consumption
ASTM – American Society for Testing and Materials
BEP – Best Efficiency Point
CE – Conformité Européene
CFL – Compact Fluorescent Light
CLP – Classification, labelling and Packaging

DG – Directorate Generale
DOE – Department of Energy
ECD – Environmental conscious design
ECHA – European Chemical Agency
ED – Ecodesign
EEE – Electrical and Electronic Equipment
EEI – Energy Efficiency Index
EF – Energy factor
EL – Energy labelling
EMC – Electromagnetic compatibility
EN - European Norm
EPA – Environmental Protection Agency
EPCA – Energy Policy and Conservation Act

EU – European Union
FDE – Fluid Dynamic Efficiency
GOST - Gosudarstvennyy Standart
GPP – Green Public Procurement
HDPE – High Density polyethylene
IEC - International Electrotechnical Commission
ISO - International Standardization for Organisation

JRC – Joint Research Center
LCA – Life Cycle Assessment
LCC – Life Cycle Cost
LED – Light Emitting Diode
LPG – Liquified Petroleum Gas
LVD – Low Voltage Directive
MADE – Manufacture, assembly, disassembly and end of life
MEErP - Methodology for Ecodesign of Energy-related Products
MEK – Methyl ethyl ketone
MEPS – Minimum Efficiency Performance Standards
NRVU – Non-residential ventilation unit
PBB – Polybrominated biphenyls
PBDE – Polybrominated diphenyl ethers
PET – Polyethylene terephthalate
PM – Permanent magnet
PVC – Polyvinyl chloride
REACH – Registration, evaluation, authorisation and restriction of chemicals
RFID – Radio Frequency Identification
RRR – Recyclability, recoverability, reusability
RVU – Residential ventilation unit
SEC – Specific Energy Consumption
SVHC – Substance of very high concern
TWG – Technical working group
UN-GHS – Globally Harmonised system
USA – United States of America
USB – Universal Serial Bus

VSD – Variable speed drive
VU – Ventilation unit
WEEE – Waste of Electrical and Electronic Equipment

Introduction

Background

In 2016, households in the European Union (EU) accounted for a quarter of the total final energy consumption, and from this the energy used for the main cooking appliances represented 5.4% in 2016 and 5.6% in 2017[1].

The Directive 2009/125/EC on Ecodesign established a framework for EU Ecodesign requirements for energy-related products with a significant potential for reduction for energy consumption. The implementation of such requirements would contribute to reach the target of saving 32.5% of primary energy by 2030 as identified in the Commission's Communications on Energy 2030 and on the Directive 2018/2002 on energy efficiency. Ecodesign measures may be reinforced also trough the Regulation 2017/1369/EU on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products.

The European Commission has launched the revision of the eco-design and energy-/resource label implementing measures for the product group "domestic ovens, hobs and range hoods". The revision study is coordinated by the European Commission's Directorate General (DG) Energy and is undertaken by the European Commission's DG Joint Research Center (JRC).

The methodology of the revision follows the Commission's Methodology for the Evaluation of Energy related Products (MEErP) (COWI and VHK 2011), consisting of the following steps:

- Task 1: Scope definition, standard methods and legislation
- Task 2: Market analysis
- Task 3: Analysis of user behaviour and system aspects
- Task 4: Analysis of technologies
- Task 5: Environmental and economic assessment of base cases
- Task 6: Assessment of design options
- Task 7: Assessment of policy scenarios

The comprehensive analysis of the product group following the steps above will feed as research evidence basis into the revision of existing Energy Label Regulation (EC) 65/2014 on domestic ovens and range hoods (European Commission 2010) and the Ecodesign Regulation (EC) 66/2014 on domestic ovens, hobs and range hoods (European Commission 2009).

The research is based on available scientific information and data, uses a life-cycle thinking approach, and is engaging stakeholder experts in order to discuss on key issues and to develop wide consensus.

A set of information of interest has been collected. Starting from the initial preparatory studies (so-called "ENER Lot 22" and "ENER Lot 23") prepared in 2011 and the resulting Regulations listed above on energy label and eco-design for domestic ovens, hobs and range hoods. Against this background, information is being revised, updated and integrated to reflect the current state of play, following the MEErP methodology.

As final result, the JRC produces an updated review study including a comprehensive techno-economic and environmental assessment for this product group. This will provide policy makers with an evidence basis for assessing whether and how to revise the existing regulations.

A Technical Working Group (TWG) has been created to support JRC along the study. This TWG is composed of experts from Member States, industry, NGOs and academia who have voluntarily requested to be registered as stakeholders of the study through the project website.

[1] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20180322-1

The TWG is contributing to the study data, information and written feedback to questionnaires and working documents. Interaction with stakeholders, has also taken through meetings organized by JRC. The contribution of stakeholders has been integrated in this report and is indicated as such.

Objectives and structure of this report

The review study on domestic ovens, hobs and range hoods builds on existing knowledge as far as possible. However, additional and complementary investigation is required to achieve the goals of the study. With this respect, the objective of this report is to:

- summarise the background information so far gathered for domestic ovens, hobs and range hoods
- identify areas which need to be revised, updated and integrated to reflect the current state of play and to align with the MEErP methodology.

This document is structured in the following chapters, following Task 1 to 7 of MEErP

- Chapter 1: Scope definition, standard methods and legislation
- Chapter 2: Market analysis
- Chapter 3: Analysis of user behaviour and system aspects
- Chapter 4: Analysis of technologies
- Chapter 5: Environmental and economic assessment of base cases
- Chapter 6: Assessment of design options
- Chapter 7: Assessment of policy scenarios

1 Task 1: Scope, legislation and standardisation

1.1 Product scope and definitions

1.1.1 Technical description of domestic cooking appliances

The following section provides a technical description of domestic ovens, hobs and range of hoods.

1.1.1.1 Domestic ovens

An oven is an appliance which incorporates one or more cavities using electricity and/or gas in which food is prepared (Regulation 65/2014). In a general way, the main components of domestic ovens are:

- Cavity, where the food is located for cooking.
- Chassis, the structure that supports the cavity and the rest of the oven assemblies
- Door, which enables access to the cavity
- Heating elements, which will differ depending on heat source
- Fans, used to distribute heat evenly in convection oven
- Cables/pipes, which transfer energy from heat source to electrical resistance or burner

Depending on the characteristics of the main components, domestic ovens can be classified in multiple ways. In Table 29, a classification is provided considering four different criteria: heat source, cooking mode, number of cavities and mounting.

Table 1. Types of ovens

Heat Source	Cooking mode	Number of cavities	Mounting
Gas	Conventional	Single	Free-standing
Electricity	Convection	Multiple	Built-in
	Steam		Portable
	Microwave		

Considering **heat source,** domestic ovens can be powered either by gas or electricity. In principle, the main components of a gas or an electric oven (cavity, chassis, door, fans) are essentially the same, the only differences being in the way the heat is generated and the fuel transported through the appliance. Gas ovens generate heat via gas-fuelled burners, and therefore will need special pipes to transport it, chimneys for expulsion of fumes and gas-related control/safety systems. Electric ovens generate heat by using an electric resistance, so they will need cables to transport electricity. (Landi, 2019).

Considering **cooking modes**, domestic ovens can be classified, for instance, as conventional, convection, steam, or microwave. Other cooking modes offered in domestic ovens are grill and roasting. Some ovens can also offer a combination of these cooking modes. In conventional cooking mode, a stationary heat source radiates heat in the oven and therefore uses only natural convection for the circulation of heated air inside the cavity. The heat source is generally at the bottom of the oven, although in some models additional burners can be found at the top and at the back of the cavity. In convection cooking mode, a built-in fan circulates heated air inside the cabin, distributing it evenly throughout the cavity. They can run at slightly lower temperatures as they do not need to be as hot to heat up the inside of the oven.

Convection ovens will need a motor to operate the fan, increasing slightly the complexity of the appliance. A steam oven operates by injecting water in the oven into a boiler. This boiler will create steam to heat up the cavity of the oven, creating a very moist cooking environment within the device.

A microwave oven is an electric oven that heats and cooks food by exposing it to electromagnetic radiation in the microwave frequency range, inducing polar molecules in the food to rotate and produce thermal energy in a process known as dielectric heating. The cavity of the ovens is the enclosed compartment in which the temperature can be controlled for preparation of food.

In terms of **number of cavities**, the most common configuration is single-cavity oven, although multiple-cavity ovens (those with two or more cavities) can also be found.

Considering **mounting configuration**, ovens can be classified as built-in or free-standing (Figure 1). Free-standing ovens can be either installed separated from cabinets or by sliding them into an open space into the kitchen cabinetry. In the first type, their sides, as they are visible when installed, are generally finished and they do not required cabinet work. They tend to have controls in the back, storage or warming drawers in the bottom and larger capacity than other ovens. In the second case, they generally have a slightly protruding cooktop, allowing the appliance to sit flush with the kitchen counters. The side panels are not finished as they will not be visible after installation. These appliances can also be known as cookers, since they include both an oven and a hob.

Figure 1. Types of ovens based on mounting (APPLIA)

Built-in ovens, also known as wall ovens, are installed at a comfortable height in the wall, embedded between other kitchen cabinets or appliances. Finally, in Regulation 65/2014 ovens are also classified in terms of their portability: a portable oven is one with a product mass of less than 18 kilograms (although these are out of the scope in the mentioned regulation).

Ovens usually offer a wide variety of **heating types** or **settings** in which they can be operated. Some of these settings are common to the majority of ovens in the market today, whereas others are more specialized and can only be found on a few models.

The names of these settings are usually marketing driven and may not necessarily be common around the industry –potentially causing confusion to consumers-. Although not universal, symbols used to represent each of those settings tend to be similar and recognisable. The most common oven settings, their symbols and a brief description can be seen in **Table 2**.

Table 2. Typical oven modes

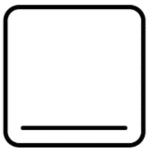
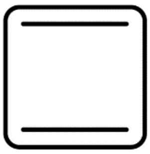
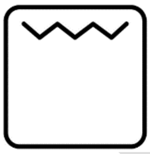
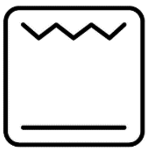
Symbol	Mode	Description
	Conventional – lower heating only	Heat will come solely from the heating element at the bottom of the oven. The fan won't be used to circulate the heat.
	Conventional – upper and lower heating	Heat will be generated by elements in the top and bottom of the oven. The fan doesn't come on for this setting – instead heat spreads through the oven by natural convection.
	Fan-forced heating	Heat comes from a circular element surrounding the fan at the back of the oven and the fan then circulates this heat around.
	Fan-forced with lower heating	Heat will be produced at the base but will be wafted around by the fan.
	Full grill	Heat is being produced by the whole grill element. Some grills are designed to be used with the door closed, while some need the door to be open
	Part grill	Only one section of the grill element gets hot
	Grill and fan	Grill and fan are on at the same time. The fan spreads the grill's heat, making it less fierce
	Grill and lower heat	The grill is used in combination with the lower heating element.
	Defrost	Fan is on but no heat is produced, so no cooking takes place. The moving air defrosts food much more quickly than simply leaving it on the kitchen table

	Plate warming	Plate-warming function. This gently warms plates or other dishes to prevent food from cooling too quickly when served.
	Pyrolytic cleaning	This program heats up the oven to around 500°C, which has the effect of incinerating burnt-on cooking grime.
	Eco	This is generally understood as the most energy-efficient mode of the oven, although it might be different for each manufacturer. In some occasions, it is a function for cooking small quantities of food, activating only a limited amount of the heating elements.

The definition of the most common oven settings is relevant at this point because they are directly related to certain aspects of current standards and legislation. For instance, current standard for energy consumption of gas ovens (EN 15181) requires that the standard load is heated in “conventional” and “forced-air” heating functions. In a similar way, current standard for energy consumption of electric ovens (EN 60350-1) requires that the standard load is heated in those two methods and in “hot steam” function as well.

Current Ecodesign (REG 66/2014) and energy labelling regulation (REG 65/2014) is also related to cooking settings. In both of them, it is established that energy consumption of a cavity oven shall be measured in a conventional and fan-forced mode. Then, “energy consumption per cycle corresponding to the best performing mode shall be used in the calculations”. This freedom of choice for manufacturers -who can choose which setting they will use to certify energy consumption of their products- has been highlighted by some stakeholders as an aspect to improve in future revisions of current regulation. This aspect will be covered in more detail in subsequent sections of this report.

1.1.1.2 Domestic hobs

A hob is a domestic appliance used for heating food. It generally works as a primary heat source which is used to warm a cooking vessel (a pan, pot, etc.), which then becomes the secondary heating source, transferring heat to the food within it. In the definitions section of Regulation 65/2014, European Commission differentiates between electric hobs, gas hobs and mixed hobs.

- Electric hob. Appliance which incorporates one or more cooking zones/areas, including a control unit, and which is heated by electricity
- Gas hob. Appliance which incorporates one or more cooking zones/areas, including a control unit, which is heated by gas burners of a minimum power of 1.16 kW.
- Mixed hob. Appliance with one or more electrically heated cooking zones/areas and one or more cooking zones heated by gas burners.

Depending on the characteristics of the main components, domestic hobs can be classified in different ways. In **Table 3**, a classification is provided considering three criteria: heat source, heating element, and mounting.

Table 3. Types of hobs

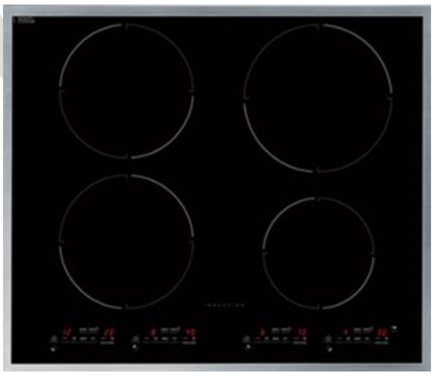
Heat Source	Heating element	Mounting
Gas	Burners (gas)	Built-in
Electricity	Solid plate (electric)	Integrated in a cooker
	Radiant (electric)	Portable or table top
	Induction (electric)	

Considering heat source, domestic hobs can be powered either by gas or electricity. Gas hobs imply the use of burners that, after being ignited, maintain a flame that transfer heat to a cooking vessel. Although they can differ in size, configuration and ignition type, gas burners are relatively similar between them. On the other hand, there are more differences between electric powered hobs, depending on the heating element they use (Figure 2).

Gas

Solid plate

Radiant



Induction

Figure 2. **Different types of hobs according their heating element (APPLIA)**

In terms of heating element, electric hobs can be classified in five different types:

- **Solid plate** hobs contain a sealed electric resistance, through which circulates electrical current, transferring heat to the cooking vessel on top of it.

- **Radiant hobs** are a type of radiant cooking appliance. They use an electrical resistance wire or ribbon with a current that makes it glow red hot, so that most heat is transferred to the cooking vessel by conduction via a glass-ceramic surface

- **Induction ho**bs are an electric cooking appliance where the hob itself is not specifically heated. Instead, below the surface of the hob there is a planar copper coil that is fed electrical power via a medium frequency inverter. This alternating current induces eddy currents in nearby metallic objects (cooking vessel). These eddy currents heat up the cooking vessel, transferring the heat to the food.

1.1.1.3 Domestic range hoods

A range hood can be defined as an appliance hanging above the cooktop in the kitchen which uses a mechanical fan to collect steam, smoke, fumes and other airborne particles that may be generated while cooking. Its main purpose is therefore to control smoke, smells and temperature changes that are associated with cooking at the stove. Range hoods also contribute in reducing the risks of food contamination and fire (Han, 2019). It has been demonstrated experimentally that making use of a range hood reduces the peak concentration of ultrafine particles by 50% (Rim et al., 2012).

The extraction system consists of a centrifugal blower composed on an impeller coupled to an electric motor, both housed inside a scroll. The energy is provided to the exhausts to expel the fumes. The system can work in multiple conditions of airflow rate, velocity and pressure (Bevilacqua, 2010). Generally, range hoods are manufactured with a combination of stainless steel, copper, bronze, nickel, zinc, tempered glass, aluminium, brass and heat resistant plastics. The main components of a range hood are:

- Capture panel and effluent plume, which are the elements that direct the thermal plume coming out of the cooking area towards the filter and ducting

- Filters, which are the elements of the range hood that capture the impurities when the cooking appliance is in operation

- Fans, which provide an active pressure gradient for ventilation

- Lighting, which provide a illumination onto the cooking area

Due to their predominantly visible location in kitchens, range hoods are increasingly seen not only as an appliance, but more as a piece of furniture. This is the main reason why a market for decorative hoods has been growing in the past years. Some hoods are also being offered with the ability to hold tools and objects, distributed on different levels. They may include hooks, shelves and even electrical outlets and Universal Serial Bus (USB) ports capable of charging electronic devices (Di Meo, 2018).

A typical classification of range hoods is in terms of **ventilation** system used. According to this, range hoods can either be ducted or ductless. A ducted range hood is connected to a duct with pipes that carry the airborne particles away from the kitchen to the outdoors (Gannaway, 2015). On the other hand, in a ductless hood, air is pushed through filters that scrub the fumes, removing grease and odours, venting them back into the room (Dooley, 2019).

In terms of **installation** method (**Figure 3**), range hoods can be defined as:

Built-in: hoods are built into or concealed within a cupboard or fitted kitchen so they are less noticeable to the eye.

  - Under cabinet, when it is mounted underneath of the cabinets which are positioned above the stove. This is one of the most common and compact options: the design of the venting system is simple; it is versatile enough with almost any kitchen style and tends to save some wall space.

  - Built-in means an under cabinet hood fully integrated in the kitchen cabinet.

  - Telescopic means an under cabinet hood fully integrated in the kitchen cabinet and one of the grease filters slides out of the cabinet. .

Non built-in: they are stand-alone units, which have not been integrated into a fitted kitchen. Non Built-in Cooker Hoods can be installed against a wall or directly below a cabinet above the hob.

- T-shape hood and chimney hood, when it is attached to the wall above the cooktop. In this case, the range hood is installed instead of a cabinet in the space over the stove. They often come with a chimney that helps with ventilation, typically venting out through an exterior wall behind them. This configuration can serve as a design element in the kitchen.
- Vertical hood, when the hood is installed vertically almost in parallel to the wall.
- Island mounted or suspended, for kitchens where the cooktop is located on an island or not against a wall. This is the configuration generally used for larger, professional style cooktops, in order to handle the extra output.
- Downdraft, when the range hood is kept inside the cook space, integrated into the worktop and hidden away until it is used. According to manufacturers, their main advantage is that they eliminate steam and odour right at the source. This is a less common configuration, a good solution for kitchens with limited space and when maintaining a clear sightline is a priority.
- Downdraft integrated, as already described in previous section regarding air venting hobs. This is an appliance that combines range hood and hob –usually induction- in just one. The working principles are similar to a downdraft hood.
- Ceiling mounted, when the hood is installed directly into the ceiling. The configuration is similar of that of an island mounted hood, but in this case the result is a completely smooth surface rather than a hanging appliance in the centre of the kitchen.



Under cabinet **Built-in** **Telescopic**



Chimney hood **Vertical hood** **Ceiling hood**



Suspended **Downdraft** **Integrated**

Pictures provided by APPLiA

Figure 3. Types of range hoods in terms of installation

1.1.2 Existing definitions and categories for domestic cooking appliances

The following section provides an analysis of existing definitions of domestic ovens, hobs and range of hoods using as its starting point the following categorisations:

- Ecodesign preparatory study Lot 22 and Lot 23
- European statistics
- Legislations, such as the current EU Ecodesign and energy label regulations, or third country regulations
- Standards and

- Other voluntary initiatives such as ecolabels

- The product scope and definition is analysed within the frame of the Ecodesign and Energy label Directives, in turn for each of the three sub-products that are a focus for the Review Study. Based on this information and further research and evidence, a preliminary revised scope and revised definitions are proposed. This proposal will take into account stakeholder feedback.

1.1.2.1 Ecodesign preparatory study Lot 22 and Lot 23

The *Preparatory study for Ecodesign requirements of energy-using product Lot 22: Domestic and commercial ovens (electric, gas, microwave) including when incorporated in cookers, Task 1* (section 1.1.1) defines

> "*an <u>oven</u> as an enclosed compartment where the power/temperature can be adjusted for heating, baking and drying food and used for cooking*"

The study provides further detail on the end-use of the ovens if they are domestic, commercial or industrial and provides several definitions:

> "*<u>domestic oven</u> includes ovens that are designed to be used in households. EN 30-1-1 defines domestic cooking appliances as "used by private individuals in domestic dwelling"*
>
> *"<u>commercial oven</u> (e.g. impinge oven to cook pizza) include ovens that are designed to heat or bake product that are supplied directly to the end-consumers such as in restaurant, hotels, bakeries, canteens in factories, offices, hospitals, etc retailers such as supermarkets, etc"*
>
> *"<u>industrial ovens</u> includes ovens whose primary use is to be used in an industrial setting, i.e. manufacture food that is sold to shops or other businesses and not directly to end-customers*

The *Preparatory study for Ecodesign requirements of energy-using product Lot 23: Domestic and commercial hobs and grills, included when incorporated in cookers, Task 1* (section 1.4) defines

- *A <u>hob</u> as an appliance or part of an appliance which incorporates one or more cooking zones, where a cooking zone is part of the hob or area marked on the surface of the hob which pans are placed for heating".*

Additionally, this study provides several definitions for a cooker or a range cooker.

- *A <u>cooker</u> is defined as a large metal device for cooking food using gas and/or electricity. A cooker usually consists of an oven and a gas and/or electric hob.*

1.1.2.2 European statistics

The European statistical database for manufactured goods PRODCOM classifies the products included in this product group under the following NACE Rev2 codes:

1 NACE 27.51 "Manufacture of electric domestic appliances"

2 NACE 27.52 "Manufacture of non-electric domestic appliances"

In its subcategories different types of ovens, hobs and range hoods are listed, as presented in Table 4.

Table 4. PRODCOM classification for cooking appliances

Product	NACE code	Category
Domestic ovens	27.51.28.10	Domestic electric cookers with at least an oven and a hob (including combined gas-electric appliances)
	27.51.24.50	Domestic electric toasters (including toaster ovens for toasting bread, potatoes or other small items)
	27.51.28.70	Domestic electric ovens for building-in
	27.51.28.90	Domestic electric ovens (excluding those for building-in, microwave

		ovens)
	27.52.11.13	Iron or steel gas domestic cooking appliances and plate warmers, with an oven (including those with subsidiary boilers for central heating, separate ovens for both gas and other fuels)
Domestic Hobs	27.51.28.10	Domestic electric cookers with at least an oven and a hob (including combined gas-electric appliances)
	27.51.28.30	Electric cooking plates, boiling rings and hobs for domestic use
	27.51.28.33	Domestic electric hobs for building-in
	27.51.28.35	Domestic electric cooking plates, boiling rings & hobs (excluding hobs for building-in)
	27.52.11.13	Iron or steel gas domestic cooking appliances and plate warmers, with an oven (including those with subsidiary boilers for central heating, separate ovens for both gas and other fuels)
	27.52.11.15	Iron or steel gas domestic cooking appliances and plate warmers (including those with subsidiary boilers for central heating, for both gas and other fuels; excluding those with ovens)
	27.52.11.90	Other domestic cooking appliances and plate warmers, of iron or steel or of copper, non-electric
Range hoods	27.51.15.80	Ventilating or recycling hoods incorporating a fan, with a maximum horizontal side ≤ 120 cm

In the *Preparatory study for Ecodesign requirements of energy-using products, Lot 22: Domestic and commercial ovens (electric, gas, microwave), including when incorporated in cookers* (Mudgal et al, 2011a), the classification of the domestic ovens corresponds with the classification presented in this section. Besides, the preparatory study Lot 22 included the classification of commercial ovens as well as those with a microwave function.

In the *Preparatory study for Ecodesign requirements of energy-using products, Lot 23: Domestic and commercial hobs and grills, included when incorporated in cookers* (Mudgal et al, 2011b), the classification separates those hobs that are built-in (NACE 27.51.28.33) from those which are free-standing, integrated in cookers or not (NACE 27.51.28.10 and NACE 27.51.28.35). Additionally, this preparatory study includes the classification of commercial hobs as well as grills and roasters, domestic and commercial.

1.1.2.3 EU Regulations

Regulation (EC) No 66/2014 with regard to eco-design requirements for domestic ovens, hobs and range hoods (European Commission 2009) applies to:

> *"domestic ovens (including when incorporated in cookers), domestic hobs and domestic electric range hoods, including when sold for non-domestic purposes.*
>
> *This regulation shall not apply to*

- *- appliances that use energy sources other than electricity or gas;*
- *- appliances which offer 'microwave heating' function;*
- *- small ovens;*
- *- portable ovens;*
- *- heat storage ovens;*
- *- ovens which are heated with steam as primary heating function;*
- *- covered gas burners in hobs;*
- *- outdoor cooking appliances;*

- *- appliances designed for use only with gases of the "third family" (propane and butane);*
- *- grills"*

Regulation (EC) No 65/2014 with regard to energy labelling of domestic ovens and range hoods (European Commission, 2010) applies to:

> *"domestic electric and gas ovens (including when incorporated into cookers) and for domestic electric range hoods, including when sold for non-domestic purposes.*
>
> *This Regulation shall not apply to:*

- *- ovens that use energy sources other than electricity or gas;*
- *- ovens which offer 'microwave heating' function;*
- *- small ovens;*
- *- portable ovens;*
- *- heat storage ovens;*
- *- ovens which are heated with steam as primary heating function;*
- *- ovens designed for use only with gases of the "third family" (propane and butane)*

For domestic ovens, hobs and range hoods the following definitions are given

> "*<u>oven</u> means an appliance or part of an appliance which incorporates one or more cavities using electricity and/or gas in which food is prepared by use of a conventional or fan-forced mode*"
>
> *"<u>range hood</u> means an appliance, operated by a motor which it controls, intended to collect contaminated air from above a hob, or which includes a downdraft system intended for installation adjacent to cooking ranges, hobs and similar cooling products, that draws vapour down into an internal exhaust duct*"
>
> *"<u>hob</u> means an electric hob, a gas hob or a mixed hob*"
>
> *"<u>electric hob</u> means an application or part of an appliance which incorporates one or more cooking zones and/or cooking areas including a control unit and which is heated by electricity*"
>
> *"<u>gas hob</u> means an appliance or part of an appliance which incorporates one or more cooking zones including a control unit and which is heated by gas burners of a minimum power of 1.16 kW*"
>
> *"<u>mixed hob</u> means an appliance with one or more electrically heated cooling zones or areas and one or more cooking zones heated by gas burners"*

The regulation includes the definitions of some products that are not included in its scope, such as:

> *"<u>Small oven</u> means an oven where all cavities have a width and depth of less than 250mm or a height less than 120mm"*
>
> *"<u>Portable oven</u> mean an oven with a product mass of less than 18 kilograms, provided it is not designed for built-in installations"*
>
> *"<u>Microwave heating</u> means heating of food using electromagnetic energy"*

For range hoods, definitions within Regulation (EU) No 1253/2014 with regard to ecodesign requirements for ventilation are also relevant:

- *<u>'Ventilation unit (VU)'</u> means an electricity driven appliance equipped with at least one impeller, one motor and a casing and intended to replace utilised air by outdoor air in a building or a part of a building;*

  <u>'Residential ventilation unit'</u> (RVU) means a ventilation unit where:

  (a) the maximum flow rate does not exceed 250 m3/h;

(b) the maximum flow rate is between 250 and 1 000 m3/h, and the manufacturer declares its intended use as being exclusively for a residential ventilation application;

<u>'Non-residential ventilation unit'</u> (NRVU) means a ventilation unit where the maximum flow rate of the ventilation unit exceeds 250 m3/h, and, where the maximum flow rate is between 250 and 1 000 m3/h, the manufacturer has not declared its intended use as being exclusively for a residential ventilation application;

1.1.2.4 Third country regulations

In the United States, the Department of Energy (DOE) Regulations define kitchen ranges and ovens, or "cooking products" as

> "*consumer products that are used as the major household cooking appliances. They are designed to cook or heat different types of food by one or more of the following sources of heat: gas, electricity or microwave energy. Each product may consist of a horizontal cooking top containing one or more surface units and/or more heating compartments*"

In addition, in an amendment carried out in 2016, the DOE proposed to define a combined cooking product as

> "*a household cooking appliance that combines a conventional cooking top and/or conventional oven with other appliance functionality, which may or may not include another cooking product*".

The DOE's regulation limits its scope to domestic cooking tops and domestic ovens (called as *conventional cooking tops* or *conventional ovens*).

United States of America (USA) regulation separated residential conventional cooking products into product classes. The classification followed refers to the following criteria: a) type of energy used, and b) capacity or other performance-related features such as those provide utility to the consumers.

For **gas cooking tops**, are defined as those equipped with gas cooking tops with burner inputs rates equal or lower than 14000 Btu/h. The product classes are:

- conventional (gas) burners:
- conventional electric cooking tops that are determined by the easiness of cleaning smooth elements and the typically higher use of energy than coil elements.

The product classes for electric cooking tops are:

- low or high wattage open (coil) elements and
- smooth elements.

For **electric ovens,** the DOE determined that the type of oven-cleaning is a utility feature that affects performance. The product classes are:

- standard oven with or without a catalytic line, and
- self-clean oven.

For **gas ovens**, the DOE determined that conventional gas ovens are those equipped with burner input rates equal or lower than 22500 Btu/h. For the classification, the same reasons as for electric ovens are followed. The product classes are:

- Standard oven with or without a catalytic line, and
- self-clean oven.

1.1.2.5 Standards

International standards

Three international standards have been identified as relevant for this product group:

- *IEC 60350-1:2016 on household electric cooking appliances – Part 1: ranges, ovens, steam ovens and grills – Methods for measuring performance*
- *IEC 60350-2:2011 on household electric cooking appliances – Part 2: hobs – Methods for measuring performance.*
- *IEC 61591:2019 Household range hoods and other cooking fume extractors. Methods for measuring performance.*

The standards IEC 60350 specify methods for measuring the performance of electric cooking ranges, ovens, steam ovens, grills and electric hobs for household use. The ovens covered by this standard may be with or without microwave function. However, if the microwave function is defined as primary function, IEC 60705 is applied for energy consumption measurement. If this primary function is not declared by the manufacturer, the performance of the microwave function and thermal heat should be measured as far as it is possible. The hobs covered may be built-in or for placing on a working surface or the floor. The hob can also be a part of a cooking range.

The standard IEC 61591 includes definitions for range hoods and other cooking fume extractors:

- Range hood: appliance installed over a hob and through which the air is passed to remove contaminants from the room
- Recirculating air range hood: range hood containing filters to remove contaminants after which the cleaned air is discharged back into the room
- Air-extraction range hood: range hood which discharges the collected air to the outside of the building by means of ducting
- Down-draft system: cooking fume extractor intended for installation adjacent to household cooking ranges, hobs and similar cooking appliances that draws vapour down into an internal / exhaust duct. NOTE: the filtered air may be discharged back into the room or ducted away.

European standards

The standard EN 50304/EN60350 "*Electric cooking ranges, hobs, ovens and grills for household use – Methods for measuring performance*" defines:

- An oven as *an appliance or compartment of a range cooker in which food is cooked by radiation, by natural convention, by forced-air convection or by a combination of these heating methods*.
- A hob is defined as *an appliance or part of an appliance which incorporates one or more cooking zones, where a cooking zone is part of the hob or area marked on the surface of the hob which pans are placed for heating.*

1.1.2.6 Labels and schemes

European labels

Range hoods

The scope of the German Ecolabel Blue Angel DE-UZ-147 for Household cooker hoods is given as follows:

> *"These Basic Award Criteria apply to household cooker hoods with an inbuilt fan for either recirculation operation[2] or exhaust operation[3] exhibiting a maximum air flow volume of 800 m^3/h at maximum continuous operation[4]*

[2] Recirculating operation: The cooker hood removes impurities to filters and returns the air to the kitchen

[3] Exhaust operation: The cooker hood guides the intake air to the outside via an exhaust system

[4] The calculation is based on the air flow volume (free air delivery) determined in accordance with DIN EN 61591, as amended, at maximum rotational speed for normal use. If the hood offers a high-speed or intensive power mode this mode shall not be considered as a normal use mode

Specific requirements on energy efficiency of the fan and the lighting, power consumption of the off-mode and standby mode, automatic reset, grease and odour removal and noise emissions are not differentiated by the size of the appliance.

US energy star labels

There is no ENERGY STAR label for residential ovens, ranges, or microwave ovens at this time. However, there are ENERGY STAR labelled commercial ovens

1.1.3 Feedback from stakeholders with regard to scope and definitions

The project team distributed a questionnaire in October 2019. To date, 17 stakeholders have submitted their feedback on "Task 1: Scope" via this questionnaire.

Existing definitions

The stakeholders proposed a set of modifications of the existing definitions in order to clarify primary and secondary functions of the products, and also the different technologies.

In the case of ovens, stakeholders proposed to include secondary functions as keeping the food warm. Proper definitions of the standardised cycle to be tested and eco-mode were also requested. In the view of the stakeholder, these definitions should be in line with the standard modes declared in the user manual.

Regarding hobs, some modifications are suggested to better reflect induction technology.

The definition of range hoods should take into account the filtration and recirculation of air, which are not properly covered by current definitions. The definitions should take into account the ones within EN 61591 Regarding functions, the main function is removing airborne grease, combustion products, fumes, smoke, heat, and steam from the air by evacuation of the air and/or filtration. However, recirculation would require a development of a test method that enables the rating of recirculation hoods. A secondary function mentioned by stakeholders is lighting, which should be also incorporated in the definitions.

Commercial and professional products

Some stakeholders proposed different options to define commercial and professional products and to make a clear distinction from domestic products. One suggestion was to include the different technologies that are common in the professional sector:

"Commercial ovens": static ovens, forced-conventional ovens, combi-steamer ovens, deck oven (bakery ovens), rotatory rack ovens, in-store bakery convection ovens, impinge ovens, hot food holding cabinets, convection steamers and convection ovens.

"Commercial hobs": catering equipment manufacturers usually design series of modular elements with standard dimensions, so that appliances can be placed side by side to form a worktop or succession of pans. The main technologies are commercial gas open burners, gas solid tops, electric boiler tables, electric hobs, electric infrared hobs, electric induction hobs, griddles, tilt braising pans, pasta cookers, deep fryers, freestanding pressure cookers and Bain-Maries.

Another proposal was based on the type of users and location where the appliance is to be used:

- Domestic. Appliances to be used in a household environment with an intended non-professional use.
- Commercial. Appliances to be used in an area accessible to the public (not a household) with an intended non-professional use.
- Professional. Appliances to be used in an area not accessible to the public with an intended professional use, with low scale production.

- Industrial. Appliances to be used in an area not accessible to the public, with an intended professional use, for large scale production.

Some stakeholders supported the development of Ecodesign/Energy labelling measures of professional products attending to their potential significant impact and its inclusion of Article7 of the current Ecodesign regulation. These stakeholders considered these measures as an important driver of the sector towards more efficient products. On the other hand, other stakeholders had a complete different view and are against the development of Ecodesign/Energy labelling measures. One of the main arguments for the exclusion is that professional appliances are completely different from household appliances with regards of:

- Cooking behaviour, user needs and pattern of use
- Cooking mode, in particular for ovens, is much more complex and with many cooking options
- Professional and commercial cooking appliances are in many cases part of cooking system and not stand-alone-products.
- Household appliances have much less variability in models differentiation and they are produced in high quantity; commercial and professional cooking appliances have high variability in models differentiation and they are produced in smaller quantities.

To the question whether commercial and professional products should be separated from domestic, some stakeholders suggest that since the function is the same, they should not be split up, which on top would delay the development and adoption of measures. Other stakeholders pointed out the need of different standard tests from domestic and different requirements, since the professional use patterns diverge from domestic, and consequently the design of the product. In general, a separated regulation of professional products is not discarded as feasible option for stakeholders in favour of including professional appliances, and would be the only feasible option for those that are against.

Exclusions of the current regulation

Some stakeholders support that appliances excluded from the current regulations are part of the review study, since their impact may be significant and they are similar appliances to the ones already within the scope. In the other hand, other replies were more detailed and provided information about each niche product. These comments are summarised below:

- Products proposed to be excluded:
  - Ovens with microwave function and solo microwave ovens: they should be excluded since their frequency of use is very little. Their classification (solo microwave oven, combi microwave ovens, ovens with integrated microwave, and microwave ovens with grill) may be very challenging, often designed in combination with other heating function. A measurement method for the very efficient combined modes is not available. The highest challenge is to measure the portion of microwave power.
  - Steam ovens: there is not enough data available, and they are not market relevant
  - Grills and grill ovens: there is no method to measure energy efficiency, and not market relevant in the EU and limited use.
  - Only recirculation hood: it is a niche product with 1% of the market.
  - Hoods without integrated fan for use with a central fan.
- Products proposed to be included:
  - Combi steam oven: they are market relevant, though they are often only used in their conventional heating function.

- Gas-cooking appliances designed for use only with Liquified Petroleum Gas (LPG). They are excluded from Regulation 66/2014 because at that time they were not covered by standard EN 15181, but this will change soon with an amendment.
- Aspiration hob: it is a domestic hob (induction, radiant or gas) integrating a blower and grease filter to remove airborne grease, combustion products, fumes, smoke, heat and steam from the air by evacuation of the air and filtration. It is an all in one product merging the functionality of a cooktop and of a range hood. The product has to satisfy both the requirement for range hood and for induction/radiant/gas cooktop. Products already in the market are sold with energy label and product fiche for the range hood section and with product information for the domestic hob section according to Regulations 65/2014 and 66/2014.
- Range hoods without lights
- Range hoods with mood lights

- Products for which there is no clear agreement:
  - Table top hobs

1.2 Test standards

The following section aims to provide an overview regarding the most recent and relevant existing standards which are applicable to domestic and professional cooking appliances. A higher level of detail will be provided for functional performance, use of resources and durability standards. This section has been completed with feedback from relevant stakeholders.

1.2.1 Functional performance standards of household appliances

1.2.1.1 EN 60350-1 Household electric cooking appliances – Part 1: Ranges, ovens, steam ovens and grills – Methods for measuring performance

This document consists of the text of IEC 60350-1:2011 and the corrigendum of February 2012 prepared by IEC/SC 59K "Ovens and microwave ovens, cooking ranges and similar appliances", of IEC/TC 59 "Performance of household and similar electrical appliances"

IEC 60350-1:2011 specifies methods for measuring the performance of electric cooking ranges, ovens, steam ovens and grills for household use. The ovens covered by this standard may be with or without microwave function. Manufacturers should define the primary cooking function of the appliance – microwave function or thermal heat. The primary cooking function has to be measured with an existing method according to energy consumption. If the primary cooking function is declared in the instruction manual as a microwave function, IEC 60705 is applied for energy consumption measurement. If the primary cooking function is declared as thermal heat, then IEC 60350-1 is applied for energy consumption measurement. This standard defines the main performance characteristics of these appliances which are of interest to the user and specifies methods for measuring these characteristics. It does not specify requirements for performance.

For energy consumption, the test consists in assessing the amount of energy required to heat a standard load. The load is a water saturated brick which simulates both the thermal properties and the water content of food. For that, a standard clay brick is placed in the geometrical centre of the oven. The temperature of the oven settings is risen for 3 different levels and 3 different cooking modes: conventional, convection and hot steam (see Table 2 for definitions of oven modes). The temperature of the brick is measured until it increases 55K, when test finishes. The electricity consumption required to conduct that temperature increase in the brick is measured.

Potential issues with the brick method test in ovens

A common request from stakeholders for the revision of current regulation and brick method standard is a clearer definition of the "standard" heating function. An oven can provide different modes (**Table 2**). According to a stakeholder, in the current regulation on ecodesign the manufacturer chooses which conventional or fan forced mode shall be considered for labelling (REG 66/2014 states that "the energy consumption per cycle corresponding to the best performing mode shall be used for the calculations").

For the revision, the "standard" heating function shall be clearer defined and indicated. The way it works today, the best declared energy consumption are usually reached with the "ecomode", that does not allow to cook all kind of dishes and is, in this way, not representative of a standard use.

Another stakeholder proposes that for the new version of the standard (brickmethod 2.0), it does no longer distinguish between fan-forced mode and conventional mode. More and more mixed modes are on the market and these modes shall be tested in the same way.

According to another stakeholder, potential improvements for these tests are described below:

- Option A) Test in one "standard" mode (compulsory) and in one "ecomode" (optional). These modes will need to be very precisely defined.

  For ovens, nor the regulation nor the measurement method specifies in which mode the oven shall be tested, which is crucial since most ovens nowadays are able to operate in several modes. At the moment, the test is done often in a not standard mode that allows baking or roasting all kind of foods. It is allowed to make the test in an ecomode (use of steam, oven totally airtight for a certain period of the cycle, lower the temperature within the oven for a certain part of the cycle...), which is more energy efficient but which is not often used by consumers. In their view, it would be more representative to make the test as follows:

  a1) One or two test(s) in normal/standard usage condition. These are available on every oven and relevant from consumer practice (for example 180° forced-air is the programme that is used the most in France)

  a2) One test in the best possible conditions (ecomode). Manufacturer would also declare its consumption. They should clearly indicate on the oven the cycle to be chosen in order to get the lowest energy consumption and the limit of this programme (regarding cooking performance). It could be seen as a bonus to stimulate the innovation.

- Option B) Calculate an average of the consumptions of different modes.

Another stakeholder agrees with the above reasoning, pointing out that for standardization it is enough to consider one or two modes, since the results of one or two modes give an indication of the efficiency also of the other modes. Currently, high-specialised modes for limited applications are applied for energy consumption measurements. Surveys show that hot air is the most common mode - the standard mode-. However, so called eco modes provide an energy saving application for certain dishes and shall be taken into account for future regulation. These eco modes will be more challenged by the new brickmethod 2.0 and consequently ensure a better performance than today. From their point of view the new classification should be triggered by a mix of eco mode and hot air function.

The same stakeholder drew the attention to the fact that a change of the addressed heating mode and the change to brickmethod 2.0 will lead to different energy consumption values than declared today. An adoption of the classification system and the minimum requirements is consequently essential.

Other stakeholders stated that current standard test methods and ecodesign regulations may promote ovens which are not in line which the actual needs of consumers. This stakeholder argues that consumers mainly use conventional cooking modes, since this is the cooking mode required for many of the most common recipes. However, current ecodesign regulation –based on the brickmethod test and aimed at reducing energy consumption- leads manufacturers to offer appliances with high-humidity cooking modes -able to achieve higher temperatures with lower energy consumption- but not capable of meeting consumers' needs. This stakeholder points out that brickmethod 2.0 may prolong this issue: it will promote even more tightly sealed cavities and 'wet' cooking modes, mainly to pass the tests, while the users will still be mostly using the conventional, higher energy consumption modes. To overcome these issues, they recommend:

- Including combined microwave modes in the standard
- Including the use of a temperature probe in the standard
- Including functions such as "half load" in the standard

Beyond that, according to stakeholders, the inclusion of the preheating phase in the energy consumption declaration should be explored, as it is the way consumers use their oven (in France people that always preheat their oven are 29%, and most of the time are 40%). The inclusion of information on the energy consumption of the cleaning function should be explored as well. A French ECUEL study (1995) showed that 44% of the people use the pyrolytic function. On the whole sample, pyrolytic cycles correspond to 10.8% of the total oven consumption. When people use it, pyrolytic function covers 25% of the total energy consumption.

Weaknesses and loopholes

In their feedback, certain stakeholders pointed to identified ambiguities, loopholes or other weaknesses in existing standards which may lead to circumventions to achieve better results in terms of energy efficiency.

With regard to ovens one stakeholder reported the following aspects:

- Energy Measurement: For electric ovens, the energy consumption value, which is declared on the energy label, is determined by measuring energy consumption using different heating functions and temperature settings as defined by the standard EN 60350-1. For each heating function, three different temperatures are requested, which have to be reached in the center of the oven. If the highest of these temperatures cannot be reached, the standard requires using the maximum temperature value that is reachable. This situation results in lower energy consumption for ovens not reaching the maximum temperatures, as the latter rises with rising temperature. However, an appliance concerned, not reaching the maximum temperature as defined in the standard, would still be compliant to eco-design (ED) and energy labelling (EL) requirements, subsequently. From their perspective this is a loophole in the test standard that should be tackled. Either the standard should be unambiguous (i.e. the same temperatures should be measured for all products) or the maximum temperature should be shown on the energy label in order to enable informed choices by consumers. Otherwise this situation could be exploited by manufacturers that offer ovens with lower maximum temperature (and thus higher energy efficiency) without sufficient transparency that also the performance is lower.
- Volume measurement: The volume of the oven is used to calculate the Energy Efficiency Index (EEI). In the harmonised standard (EN 60350-1), the paragraph related to the measurement of the volume states the following: "Removable items specified in the user instruction to be not essential for the operation of the appliance in the manner for which is intended shall be removed before measurement is carried out". This sentence should be revised as it may lead (and in many cases does lead) to higher declared volumes and thus better EEI compared to real-life usage of the ovens.

Another stakeholder pointed out that during product tests of ovens it was observed by market surveillance authorities that the temperature during the energy consumption measurement is lowered automatically when the "eco-mode" is selected. This ("most efficient") mode is used to measure the electricity consumption for the energy class. The temperature which the user adjusts by setting the thermostat and which is displayed on the appliance was only reached at the beginning of the product tests. Afterwards, the temperature decreased slowly combined with some interim heating periods. However, the original temperature was not reached again. After opening and closing the ovens in order to continue with other tests in line with the test method for the energy efficiency of ovens, the temperature increased automatically to the value set by the user, as required in the regulation. Summarized, the products may identify when a specific part of the testing procedure is interrupted/finished and as response changed their temperature automatically to fulfil the requirement of the next testing step. The test standard listed in the regulation specifies only the temperature and not the time how long this temperature has to be maintained, i. e. the products are compliant. However, this behavior is not considered to be consumer-friendly.

The need of a different standard for steam ovens

Regarding steam ovens, there is certain debate around the need of a different standard to test their energy consumption and efficiency. Currently, steam function is tested with the same function as conventional and fan-forced convection.

On this issue, one stakeholder firstly indicates that pure steam ovens have less market relevance in Europe and should not be in scope of the upcoming regulation. For combi steam ovens (ovens with conventional and/or forced circulation functions and a steam function), have a higher market share. Since these combi ovens are mainly used by their conventional and/or forced circulation function, these combi ovens should be covered only in these functions and not in their steam function. They also add that the energy measuring method for hot steam function will be withdrawn from EN 60350-1. This measurement leads to an unfair comparison of different hot steam modes because the amount of steam is not measured.

A second stakeholder agrees with this reasoning: "taking into account that steam is not a primary function, both types of oven can have the same requirement".

A third stakeholder shows an intermediate position on the topic, indicating that it should be the same standard with slightly different boundary conditions, but mainly with the same equipment and strategy.

Performance test standard based on cooking of food in ovens

Another topic of discussion on oven test standards is around how representative of real life is the testing of a brick. Certain stakeholders recommend a test standard based on cooking a specific meal, since energy efficiency should be linked to cooking performance. They elaborate indicating that so far, the energy label for ovens says nothing about the cooking quality of ovens. Not including the cooking performance in the first version of the label is acceptable, but in the long run it should be included so as to enable the consumer to better compare different ovens. The current brick method does not allow performance testing. The brick can be considered as a relevant load (similar to a joint of meat) but it does not allow testing performance (browning, influence of the humidity in the cavity, doneness).

Other stakeholders disagree with this approach, pointing out that measuring the energy consumption with real food is not possible as food can only be standardized to a very limited extend, which leads to high uncertainties. The brick as load and the resulting energy consumption and duration reflects an average household use case very well: Heating up with a load, maintaining a certain oven temperature and – depending on the design – using the residual heat efficiently. In the existing methods for ovens and hobs, objective measurable criterion are currently measured. There is an ongoing discussion to introduce additionally measurement based on food in order to extend the focus on performance. Baking a cake or roasting a chicken etc. causes very high uncertainties due to the variability of the food itself, the preparation of food and the assessment of relevant criterion like core temperature, browning, crispiness, etc. To retain the requested level of uncertainty this shall be avoided.

1.2.1.2 EN 60350-2 Household electric cooking appliances – Part 2: Hobs – Methods for measuring performance

This document consists of the text of IEC 60350-2:2011, prepared by IEC/SC 59K "Ovens and microwave ovens, cooking ranges and similar appliances", of IEC/TC 59 "Performance of household and similar electrical appliances".

IEC 60350-2:2011 defines methods for measuring the performance of electric hobs for household use. This standard defines the main performance characteristics of these appliances which are of interest to the user and specifies methods for measuring these characteristics. This standard does not specify requirements for performance.

For energy consumption, the test consists in assessing the amount of energy required to heat a standard amount of water. A standardised, stainless-steel cookware with lid is used. The hob is pre-heated for 10 minutes. The cookware is filled with water as specified in standard at 15C. The power control is set to maximum power until water reaches 90C and simmering starts. The energy consumed after 20 minutes of simmering is measured. The amount of energy consumed is normalized per 1000 grams of water.

The indicator used for standardization is energy consumption, measured as Wh/kg water.

Potential issues with water simmering test method

A stakeholder highlights that:

- The current method is difficult for unexperienced testers (market surveillance, external laboratories, etc.) to find the right setting (power) to get $T_{simmering}$. So it is proposed to give some indications in an informative annex.
- Choosing the position of the cookware can orientate the result in a favourable way for the manufacturer so this should be further assessed.

Another stakeholder disagrees with the position above, indicating that for electric hobs, the testing method is currently well applied. Different amounts and different selection of cookware sizes is already considered. Improvement potential so far is not known.

The same stakeholder adds that regarding gas hobs, the test method for gas burners is given in EN 30-2-1. It is a robust method that has been used for a long time to measure the efficiency. It already considers different pot sizes and amount of water depending on the power of the burner. The only concern they have is related with the lack of repeatability due to the new rounding included in the version of 2015, in correspondence with Reg. 66/2014.

Also regarding gas hobs, the intermediate rounding to the 1st decimal, requested in Reg. 66/2014 (Annex II, clause 2.2) and in EN 30-2-1:2015 (clause 5.2.1) for $E_{theoric}$ and E_{gas} of the burner should be re-evaluated or removed. Otherwise, a small difference in the input data gives a big difference in the final result. Previous versions of EN 30-2-1 did not include that rounding.

Another stakeholder suggested to explore the possibility of including a second test that covers longer lasting process.

1.2.1.3 EN 30-2-1 Domestic gas cooking appliances – Rational use of energy

This European Standard sets out the requirements and the test method for the rational use of energy of gas burning domestic cooking appliances. It covers type testing only, providing minimum requirements in terms of efficiencies of burners and ovens, indicating the necessary formulas to calculate efficiency in each case. It also provides guidance on how to conduct the test in terms of type of pans to be used, temperatures and conditions of the environment.

For gas hobs, the test consists in assessing how efficient the hob is in heating certain amount of water up to a specific temperature. For that, an aluminium test pan with a matt base, polished walls, no handles, with lid, is used. Different amount of water is used according a range of power consumption of burners. Burner is pre-heated for 10 minutes. Water is burned from 20C to 90C. The volume of gas required to reach this temperature increase is measured. This amount of gas is compared to a theoretical amount of gas needed to conduct this temperature increase. The efficiency of the hob is calculated as the ration between the theoretical amount of gas needed and the actual amount of gas consumed. The efficiency is measured in terms of percentage (%).

For gas ovens, the maintenance consumption of the oven is defined as the quantity of heat to be released per unit of time (power) by the gas combustion to maintain the oven temperature constant. Maintenance consumption of the oven is calculated as follows: with the oven empty, the burner central device is adjusted so that under steady-state conditions, the temperature rise at the geometrical center of the oven is 180K above ambient temperature. The standard indicates that the maintenance combustion of the oven shall not exceed the value obtained according a formula dependent on useful oven volume. Maintenance consumption of the oven is measured in kW.

1.2.1.4 EN 30-2-2:1999 Domestic cooking appliances burning gas – Part 2-2: Rational use of energy – Appliances having forced-convection ovens and/or grills.

This European Standard sets out the requirements and test method for the rational use of energy of gas cooking appliances having forced-convection ovens and/or grills using combustible gases. It covers type testing only, providing minimum requirements in terms of efficiencies of ovens, indicating the necessary formulas to calculate efficiency. It also provides guidance on how to conduct the test in terms of temperatures and conditions of the environment.

This standard is equivalent to EN 30-2-1, in this case applicable to gas ovens with forced convection air. As in EN 30-2-1, maintenance consumption of the oven is the quantity of heat to be released per unit of time by the gas combustion to maintain the oven temperature constant. It shall not exceed the value obtained according a formula dependent on useful oven volume. This energy consumption is calculated as follows: with the oven empty, the burner central device is adjusted so that under steady-state conditions, the temperature rise at the geometrical centre of the oven is 155K above ambient temperature. Maintenance consumption of the oven is measured in kW.

1.2.1.5 EN 15181 Measuring method of the energy consumption of gas fired ovens

This European Standard specifies the method of test for determining the gas energy consumption in gas-fired domestic ovens. It applies to gas-fired domestic ovens which are capable of utilizing gases of group H or group E, possibly after conversion according to instructions for use. It is applicable to gas-fired domestic ovens, whether they are separate appliances or component parts of domestic cooking appliances. It also applies to domestic appliances that can utilize gas and/or electrical energy to provide heat for cooking when the ovens are utilizing gas energy to provide heat for cooking, but not when electric energy is used to provide any or all of the heat for cooking in the oven. Amendments and modifications to this Standard are provided in EN 15181:2017/prA1.

The test consists in assessing the amount of energy required to heat a standard load. The load is a water saturated brick which simulates both the thermal properties and the water content of food. For that, a standard clay brick is placed in the geometrical centre of the oven. The temperature of the oven settings is risen for 3 different levels and 2 different cooking modes: conventional and convection (see Table 2 for definition of oven modes). The temperature of the brick is measured until it increases 55K, when test finishes. The volume of gas required to reach this temperature increase is measured. The amount of energy contained in this volume of gas is calculated.

1.2.1.6 EN 61591 Cooking fume extractors – Methods for measuring performance

EN 61591:1997 is based on the text of IEC 61591:1997, prepared by IEC TC 59, Performance of household electrical appliances, without any modification.

IEC 61591:1997 applies to range hoods incorporating a fan for the recirculation or forced removal of air from above a hob situated in a household kitchen. This standard defines the main performance characteristics of range hoods and specifies methods for measuring these characteristics, for the information of users. This standard does not specify required values for performance characteristics.

Performance is measured in terms of input power, pressure, flow, capacity of grease absorption, capacity of odour extraction and effectiveness of hob light.

Grease absorption:

This test is used to measure the efficiency of the grease filter. The mass of range hood is measured without grease filter and odour extraction filter. A hob is placed 600 mm below the range hood, heating a pan of 200 mm at 250C. Range hood is operated at highest setting control. Corn oil is dripped onto the heated pan at constant rate together with water. Hob is working for 30 minutes and range hood for additional 10 minutes. Range hood is weighed again after removal of grease filter. Mass of oil retained is determined. Absorption factor is calculated as the ration between mass of oil in grease filter and total mass of oil in the system. Grease absorption capacity is measured as a percentage (%).

Concerning the performance rating of range hoods (EN 61591:1997/A12:2015), a manufacturer has asked for clarification on how to measure the grease filtering efficiency for a range hood with centrifugal filtering system. The applicable standard contains no defined method for this kind of product.

The formula used in the regulation implies that the mass of oil in the grease filter and all removable covers is compared to the total mass of oil in the range hood, the ducting and the absolute filter used during testing. A product that has no removable filter but uses a fixed part that is cleaned with a cloth to remove grease would be at a disadvantage in the rating even when the grease filtering works well.

<u>Odour reduction</u>:

This test is used to assess effectiveness of odour filters of recirculating-air range hoods and capacity of air-extraction range hoods to remove odours. Test is carried out in sealed room of 22 m3. Range hood is installed along one of the longer walls of the room, centrally above a hob, 600 mm above it. A solution containing certain mass of methyl-ethyl ketone (MEK) in distilled water is continually dripped on the pan, and then evenly dispersed throughout the room by means of a fan. The concentration of MEK at that point will be C1. The room is then ventilated until concentration is less than 1%. Then, the same amount of MEK and distilled water is dripped on the pan, with the range hood in operation for 30 minutes. The air in the room is again evenly dispersed with a fan and the concentration C2 measured when the value has stabilized. The odour reduction factor is measured as the ration between C1-C2 and C1. Odour reduction capacity is measured as a percentage (%).

In a study from the Swedish Energy Agency (Blomqvist et al, 2019) the authors provide recommendations for a modification in the ecodesign and energy labelling regulations for range hoods. The rationale behind these modifications is based on the fact that current regulation is based only on energy efficiency in relation to airflow and pressure, but not on the primary function of a range hood, which is ventilation efficiency (or odour reduction).

Moreover, in their view, a range hood with a higher airflow could have the same labelling as a hood with a significantly lower airflow, whereas the ideal case would be to promote low airflow hoods (low energy consumption hoods) with high odour removal efficiencies. Therefore, current ecodesign and energy labelling regulations for range hoods do not reward high efficiency and does not drive manufacturers towards more energy efficient products, guiding the end-users to purchase not optimal products.

The authors recommend that regulations should be based on a calculation which considers the aspects below:

- efficiency of capture cooking odour
- energy consumption of heating or cooling of replaced air
- energy consumption of range hood

The study that supports this proposal shows the results of the methodology applied to several hoods including those without motor installed in central ventilation systems. The results prove that the central ventilation configuration would result in annual energy consumptions one order the magnitude lower than range hoods equipped with an electric motor. The effect of the energy consumption of heating or cooling of replaced air does not compensate the pressure losses due to the charcoal filter in recirculating hoods, which result in annual energy consumptions one order of magnitude higher.

In the study, the authors provide a method in which the Energy Efficiency Index (EEI) could be improved in order to capture all those aspects.

Other stakeholders expressed their disagreement with this proposal, arguing that the energy efficiency of a product should not depend on external factors, such as heating or cooling systems or ventilation systems, since it would discourage any technological progress within the reach of manufacturers and product designers. Besides, moisture, grease and pollutants from cooking need to be eliminated and, in many cases, the most efficient way is expelling the fumes out of the building.

Other stakeholders also allude to this topic when looking at key aspects that the new standard should revise: grease extraction (to introduce efficiency for removal of fumes and grease, not only the grease retention currently included), moisture extraction; odour extraction, appropriate size (a canopy that spreads all the way across the width of the cooker), power settings and lights.

Another relevant point regarding EN 61591 mentioned by a stakeholder is that the present and next versions of the standard EN 61591 for the performance rating of range hoods contain a test method for the odour reduction with the substance MEK. This test method was designed for activated carbon filters. Plasma filters can eliminate odours as well but not the test substance MEK. Therefore, the rating with MEK would create a technical barrier for plasma filters. This should be considered in case the odour reduction will be included in the energy labelling or ecodesign.

On the field of range hoods, a stakeholder highlighted that a revised or new test for the evaluation of the capture efficiency of pollutants could improve the consumer relevance of the performance test. The same flow rates can lead to different capture rates depending on the shape of the airflow and where the range hood is positioned in relation to the hob. Therefore, the capture efficiency cannot be determined by the flow rate but requires a test method with a standardized kitchen and a source of pollution that is representative for cooking fumes. The test should determine the share of pollutants that was removed from the air. Such a test is similar to the odour reduction test in the standard EN 61591. However, the odour reduction test has a small standardized test room that is not representative for an average kitchen and uses the polluting substance MEK which is harmful to the test personnel and might not be representative enough for cooking fumes.

Effectiveness of hob light:

The range hood is positioned 600 mm above a hob. Adjacent worktops are covered with a sheet of matt-black plywood or similar. The hob light is switched on and a lux meter used to measure the luminance at four point on the board. The average of the values of lux are measured. Effectiveness of light is measured in lux.

According to stakeholder feedback, the publication of the new edition 2.0 is foreseen for 2019-12-06. IEC 61591 Ed. 2.0 is already published.

According to stakeholders, EN 61591 will be updated in the beginning of 2020 based on the already published IEC 615915:2019.

The main improvements of this new version are:

- Introduction of the definition of “Cooking Fume Extractor”.
- Update of the Climatic Test Condition from 20+/-5°C to 23+/-2°C with introduction of admitted rang of climatic pressure.
- Modification of the Calculation method of the Fluid Dynamic Efficiency (FDE)- by introducing at least 3 different measuring points at different levels with different blower speeds (instead of taking the Best Efficiency Point (BEP) for the highest level possible) . This improvement will better reflect the real usage of the range hood at the domestic environment.
- Eliminate the Light efficiency calculation from EEI formula, considering that there is only Light Emission Diode (LED) now in the new generation range hoods and LED are separately regulated by Lighting ED regulation.
- Eliminated oil density requirement for grease efficiency test.
- Fixed specific installation set up for the lighting efficiency test of ceiling range hoods.

With regards to lighting efficiency in range hoods, a stakeholder argues that the standard test of EEI considers only the fluid dynamic efficiency of the blower system and the power consumption of the lightning system, but not its efficiency. From their point of view the technology driven efficiency of the lighting system has come to a maximum, so that the light itself is no longer a quantitative aspect of the overall efficiency/main label aspect. In parallel, the fluid dynamic efficiency is measured only in one point of the highest level at the best efficiency point. This FDE runs into a factor “f” which is considered within the EEI. The EEI can be “optimized” by reducing the lights brightness to simply reduce the power consumption. This has no negative effect on the sub-label of light since there, only Lux per Watt is relevant. As mentioned before, in the main part of the label - the scale - a bright appliance with a good lighting system will be punished in future. The sub label of light (icon below the energy efficiency scale on the label), based on Lux per Watt, will be not affected and could be preserved. Due to the limit of LED technology, Lux per Watt becomes a constant value. If you want to have a brighter light you need to linearly increase your power consumption. This is a tolerated mechanism in other devices, but not in our main- and sublabel. For appliances which are integrated into furniture, there is room for different interpretations regarding light and noise labelling.

Also related to the time increase factor "f", another stakeholder points out that this factor is rounded to the first decimal place in current standards calculations. However, this may have a strong influence on FDE and EEI. For instance with W_{BEP} = 100W and WL = 10W:

- - f = 0,752 is rounded to 0.8 EEI = 43.4 = A+
- - f = 0.748 is rounded to 0.7 EEI = 48.2 = A
- Their suggestion is to round f to the second decimal place.

Recirculating range hoods

Regarding range hoods, another point brought by stakeholders is the absence of a standard for recirculating (ductless) range hoods. One stakeholder indicates that since no test standard exists for the rating of range hoods that operate in recirculation mode; a test standard is needed that enables their rating and the comparison to models that operate in extraction mode. The comparison should include the evaluation of energy consumption for additional air tempering when range hoods operate in extraction mode.

Another stakeholder adds that in order to introduce efficiency measurements for recirculating range hoods, using energy consumption, air flow, odour removal, grease removal, particle removal, and eventually vapour removal should be used as input parameters. Alternatively, it can be a series of efficiencies for energy efficiency relative to air flow, odour removal (exists today), grease removal (exists partly today), eventually vapour removal.

1.2.1.7 EN 50564 Electrical and electronic household and office equipment - Measurement of low power consumption

The standby consumption of household electrical appliances is measured according to the European standard EN 50564:2011 including the common modification agreed at European level to the international IEC 62301:2011, prepared by CENELEC TC59X.

EN 50564 is intended to define requirements for the measurement of low power and:

- addresses issues associated with measuring electrical power, in particular low power (in the order of a few Watts or less), consumed by mains powered products
- describes in detail the requirements for testing single phase products with a rated input voltage in the range of 100 V a.c. to 250 V a.c. but it may, with some adaptations, also be used with three phase products (relevant from professional)

- may also be of assistance in determining the energy efficiency of products in conjunction with other, more specific, product standards.

The value of energy consumed depends on the operating mode of the product under test, for instance whether the equipment is in an off mode, in a standby mode or in an active mode. This standard does not specify these modes, instead, it provides a method of measurement with a variety of modes which are defined elsewhere. The test method is applicable to other low power modes where the mode is steady state or providing a background or secondary function (e.g. monitoring or display).

Electric ovens and electric heat plates (electric hobs) are already covered by the standby – off mode electric power consumption by the Commission Regulation (EC) No 1275/2008[5] amended by Commission Regulation (EU) No 801/2013[6]. It is required to switch into a low power mode (such as standby) after a reasonable amount of time and they must not consume more than 0.5 Watts in standby or in off mode. The power consumption in any condition providing only information or status display, or providing only a combination of reactivation function and information or status display shall not exceed 1,00 W.

1.2.1.8 EN 50643 Electrical and electronic household and office equipment - Measurement of networked standby power consumption of edge equipment

This European Standard specifies methods of measurement of electrical power consumption in networked standby and the reporting of the results for edge equipment. Power consumption in standby (other than networked standby) is covered by EN 50564, including the input voltage range. This Standard also provides a method to test power management and whether it is possible to deactivate wireless network connection(s).

1.2.2 Functional performance standards of professional cooking appliances

In terms of functional performance standards applicable to professional cooking appliances, according to a relevant stakeholder, CENELECT TC59X WG18 is currently developing a standard on professional ovens. Three cooking modes are under evaluation: convection, steam and combi. Currently, no standards are available for professional gas hobs, gas ovens, electric hobs or range hoods.

Although currently there are no European harmonized standards on commercial cooking appliances, at a national level DIN 18873 standards do cover most of the equipment available in the market:

- **DIN 18873** Methods for measuring of the energy use from equipment for commercial kitchens
  - Part 1: Convection steamers
  - Part 2: Commercial coffee machines
  - Part 3: Deep fat fryers
  - Part 4: Convection ovens
  - Part 5: Tilting frying pans and stationary frying pans
  - Part 6: Tilting pressure braising pans and stationary pressure braising pans
  - Part 7: Multiple deck ovens

[5] Available at : https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32008R1275

[6] Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R0801

– Part 8: Regenerating systems

– Part 9: Cooking zones

– Part 10: Ice machines

– Part 11: Beverage cooler

– Part 12: Ovens

– Part 13: Microwave combination oven

– Part 14: Point of use water dispenser for cooling and carbon dioxide enrichment

– Part 15: Double jacketed boiling and quick boiling pans

– Part 16: Kitchen Machinery

– Part 17: Noodle cookers

– Part 18: Wafflebaker

– Part 19: Frying and grilling appliances

– Part 20: Crepe and Poffertjes-Bakers

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1.2.3 Product safety standards indirectly addressing durability

There are some standards which are related to the safety of products and components and seem to address quality and/or durability of those components at least indirectly (**Table 5**). For example, EN 60335 addresses product safety as commented in the previous section, whereas the Part 2 of the standard is divided into specific sub-parts each containing appropriate appliance specific safety requirements.

Table 5. Safety standards and indirect requirements for quality and durability of components

Standard	Component	Requirement
Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014, Annex C	Engine	Ageing-check for engines (in device-specific parts are modifications possible)
Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014, section 25	Power supply and external cables	(In device-specific parts are modifications possible regarding the number of operating cycles)
Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014; section 23	Inner cables	The flexible part is being moved with 30 bends per minute backwards and forwards, so that the conductor is bended by the feasible biggest angle, enabled with this construction. The number of bends accounts: 10 000 for conductors, which are bended during proper use 100 for conductors, which are bended during users-maintenance

Standard	Component	Requirement
		(In device-specific parts are modifications possible, concerning the number of bends)
Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014, section 24; standard for switches: IEC 61058-1	Components: Switches	Number of operating cycles have to add up to at least 10 000
Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014, section 24; standard for Regulation- and control systems is IEC 60730-1	Components: Regulation and control systems	Minimum number of required operating cycles for example for temperature controllers: 10 000; for operating temperature limiter – 1 000 (In device-specific parts are modifications possible regarding the number of operating cycles)

1.2.4 Horizontal durability, reparability and recyclability standards

European Commission's Mandate M/518 for standardisation in the field of Waste Electrical and Electronic Equipment (WEEE)

In January 2013, the European Commission sent Mandate M/518 to the European standardisation organisations with the purpose to develop one or more European standard(s) for the treatment (including recovery, recycling and preparing for re-use) of waste electrical and electronic equipment, reflecting the state of the art. The European standard(s) requested by this mandate shall assist relevant treatment operators in fulfilling the requirements of the WEEE Directive.

EN 50625 standard series: Collection, logistics & treatment requirements for WEEE

CENELEC, through its Technical Committee 'Environment' (CLC/TC 111X), is leading the development of standards (and other deliverables) that will support the implementation of the EU Directive on Waste Electrical and Electronic Equipment. These standards cover various aspects of the treatment of electronic waste (including collection, treatment requirements, de-pollution and preparing for re-use). TC111X works on standards related to the environment and set up Working Group 6 for the EN 50625 series.

The standard on general treatment requirements includes on the one hand administrative and organisational requirements for the treatment operator and the treatment facility such as management, infrastructural pre-conditions, training and monitoring. On the other hand, technical requirements regarding the handling of WEEE, the storage of WEEE prior to treatment, the de-pollution process, the determination of recycling and recovery targets and documentation requirements. The technical specification further details different methodologies for monitoring of de-pollution.

If appliances are equipped at some point with control panels greater than 100 cm^2, also EN 50625-2-2 and TS 50625-3-3 would apply. Precious metals, for which the technical specification TS 50625-5 is planned, can be found for example in PWBs, containing palladium, silver and gold, and in permanent magnet motors of dishwashers and washing machines.

Whereas the standards and according technical specifications define requirements regarding the removal and further treatment of certain substances, mixtures and components such that they are contained as an identifiable stream or part of a stream by the end of the treatment process, they do not specify requirements for better identification or ease of dismantling of those components to facilitate the end-of-life treatment process itself.

<u>IEC/TR 62635</u> Guidelines for end-of-life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment

The Technical Report IEC/TR 62635:2012 ed1.0 provides a methodology for information exchange involving EEE manufacturers and recyclers, and for calculating the recyclability and recoverability rates to

- Provide information to recyclers to enable appropriate and optimized end-of-life treatment operations,
- Provide sufficient information to characterize activities at end-of-life treatment facilities in order to enable manufacturers to implement effective environmental conscious design (ECD),
- Evaluate the recyclability and recoverability rates based on product attributes and reflecting real end-of-life practices.

Furthermore this technical report includes:

- Criteria to describe EoL treatment scenarios;
- Criteria to determine product parts that might require removal before material separation and related information to be provided by manufacturers (location and material composition);
- A format for information describing EoL scenarios and the results of EoL treatment activities;
- A method for calculating the recyclability and recoverability rate of EEE. The calculation is limited to EoL treatment and does not cover collection. The recyclability rate is expressed as a percentage of the mass of the product that can be recycled or reused, whereas the recoverability rate in addition includes a portion derived from energy recovery. This technical report can be applied to all electrical and electronic equipment;
- Some example data corresponding to identified scenarios.

<u>IEC/TC 111 PT 62824</u> Guidance on consideration and evaluation on material efficiency of electrical and electronic products in environmentally conscious design.

Further, under the IEC Technical Committee 111, Project Team 62824 has been established to provide guidance on consideration and evaluation on material efficiency of electrical and electronic products in environmentally conscious design.

<u>ISO 11469</u> Plastics - Generic identification and marking of plastics products

This International Standard, published in 2000, specifies a system of uniform marking of products that have been fabricated from plastics materials. The marking system is intended to help identify plastics products for subsequent decisions concerning handling, waste recovery or disposal. Generic identification of the plastics is provided by the symbols and abbreviated terms given in ISO 1043, parts 1 to 4.

The standard includes requirements on the marking system and the method of marking. The marking system is subdivided into marking of products, of single-constituent products, of polymer blends or alloys, and of compositions with special additives (fillers or reinforcing agents, plasticizers, flame retardants and products with two or more components difficult to separate).

The standard is often referred to in ecolabels containing requirements on resource efficiency and end-of-life treatment of appliances.

<u>British standard BS 8887</u> Design for Manufacture, assembly, disassembly and end-of-life processing ("MADE")

The British Standards Institution has developed a design for manufacture standards series BS 8887 (Design for Manufacture, Assembly, Disassembly and End-of-life processing MADE) first in 2006. The series contains of following sub-standards:

- BS 8887-1: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – part 1: General concepts, process and requirements (01 February 2012, superseding BS 8887-1:2006)
- BS 8887-2: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – part 2: Terms and definitions (01 July 2014)
- BS 8887-220: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – part 220: The process of remanufacture – specification. It outlines the steps required to change a used product into an 'as-new' product, with at least equivalent performance and warranty of a comparable new replacement product (BSI Group [n.d.]).
- BS 8887-240: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – part 240: Reconditioning (March 2011)

According to BSI Group [n.d.],

> In 2012, BS 8887-1 was put forward to the ISO and it has been accepted onto the work programme of the ISO committee with responsibility for technical product documentation. A new working group is being set up, which will be led by the UK, and work to convert BS 8887-1 into an international standard.

The international standard BS ISO 8887-1 Design for manufacture, assembly, disassembly and end-of-life processing (MADE) Part 1: General concepts, process and requirements is currently in development, by the BSI committee TDW/4 'Technical Product Realization' being responsible.

<u>Austrian standard ONR 192102:2014</u> on durable, repair-friendly designed electrical and electronic appliances

This standard describes a label for repair-friendly designed appliances. Manufacturers of electrical and electronic equipment who intend to label their products have to test their products according to the requirements of ONR 192102 verifying compliance with a test report. According to Ricardo-AEA (2015), this standard suggests a labelling system with three levels of achievement (good, very good, excellent) based mostly upon reparability criteria. The standard includes ca. 40 criteria for white goods (such as hobs or ovens), and 53 criteria for small electronics (brown goods). The aim is to consider reparability to ensure products are not discarded sooner than is necessary as the result of a fault or inability to repair a fault.

The 40 criteria for white goods are split into mandatory criteria and other criteria for which a certain scoring can be achieved. To comply, products have to fulfil all mandatory requirements and achieve a minimum number of scores for common criteria and for service documentation.

The types of requirements include criteria such as accessibility of components, ease of disassembly, use of standard components, achievable service life (at least 10 years for white goods), availability of spare parts (at least 10 years after the last production batch), facilitation of regular maintenance, and further service information (inter alia free access for all repair facilities (not only authorized repairers) to repair-specific information). Each requirement is underpinned with some examples of realisation; however, no specific testing procedures and techniques are detailed.

British PAS 141 re-use standard

The PAS 141 specification has been developed by British Standards Institution (BSI) to increase the re-use of electrical and electronic equipment and to ensure that they are tested and repaired to a minimum level. The British non-for-profit company WRAP has developed a set of protocols based on industry experience highlighting tests and procedures to be carried out. The product protocols form a baseline for electrical product assessment and repair for re-use and can be used as a guideline to product assessment and testing.

EN standards

On a horizontal level, Mandate M/543 (European Commission 2015a) has the objective to develop generic standards, for any product group covered by Ecodesign, in support of Ecodesign requirements related to material efficiency aspects.

Standardization bodies CEN and CENELEC are developing generic methodologies and terminology related to material efficiency, such as durability, reusability, recyclability and recoverability. Related aspects, such as upgradeability, reversible disassembly time, end of life dismantling time, part mass or value, calculation of recycled and re-used content in products, or other relevant characteristics relevant for the product groups under consideration, are investigated and included if appropriate.

Up to November 2019, standards have already been published on:

- Assessment of recyclability and recoverability (EN 45555)

- Assessment of proportion of re-used components (EN 45556)

- Declaration of use of critical raw materials (EN 45558)

- Methods for providing information relating to material efficiency aspects (EN 45559)

The remaining standards under this mandate are expected to be published across 2020.

1.2.5 Emissions Standards

EN 60335-2-6 (for ovens) regarding radiation, toxicity and similar hazards

- **EN 62233** Measurement methods for electromagnetic fields of household appliances and similar apparatus with regard to human exposure
- **EN 62311** Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)

1.2.6 Safety standards

Household cooking appliances

EN 60335-1 Household and similar electrical appliances - Safety - Part 1: General requirements

- **EN 60335-2-6** Household and similar electrical appliances - Safety - Part 2-6: Particular requirements for stationary cooking ranges, hobs, ovens and similar appliances (IEC 60335-2-6:2014, modified)

- **EN 60335-2-9** Household and similar electrical appliances - Safety - Part 2-9: Particular requirements for grills, toasters and similar portable cooking appliances

- **EN 60335-2-13** Household and similar electrical appliances - Safety - Part 2-13: Particular requirements for deep fat fryers, frying pans and similar appliances

- **EN 60335-2-25** Household and similar electrical appliances - Safety - Part 2-25: Particular requirements for microwave ovens, including combination microwave ovens

- **EN 60335-2-31** Household and similar electrical appliances - Safety - Part 2-31: Particular requirements for range hoods and other cooking fume extractors

- **EN 60335-2-102** Household and similar electrical appliances - Safety - Part 2-102: Particular requirements for gas, oil and solid-fuel burning appliances having electrical connections

- **EN 30-1-1** Domestic cooking appliances burning gas - Part 1-1: Safety – General

- **EN 30-1-2** Domestic cooking appliances burning gas - Safety - Part 1-2: Appliances having forced-convection ovens and/or grills

- **EN 30-1-3** Domestic cooking appliances burning gas - Part 1-3: Safety - Appliances having a glass ceramic hotplate

- **EN 30-1-4** Domestic cooking appliances burning gas - Safety - Part 1-4: Appliances having one or more burners with an automatic burner control system

- **EN 30-2-1** Domestic cooking appliances burning gas - Part 2-1: Rational use of energy - General

- **EN 30-2-2** Domestic cooking appliances burning gas - Part 2-2: Rational use of energy; appliances having forced-convection ovens and/or grills

Professional cooking appliances

- In terms of safety standards applicable to professional cooking appliances, a relevant stakeholder indicated that Safety of gas and electric products is fully covered by the following standards, which are endorsed by the Machinery directive and Gas appliances regulation:

  - **Machinery Directive**
  - **EN 60335-1** Safety of household and similar electrical appliances - Part 1: General requirements
  - **EN 60335-2-36** Particular requirements for commercial electric cooking ranges, ovens, hobs and hob elements
  - **EN 60335-2-42** Particular requirements for commercial electric forced convection ovens, steam cookers and steam-convection ovens,
  - **EN 60335-2-99** Particular requirements for commercial electric hoods
  - **EN 60335-2-102** Household and similar electrical appliances - Safety Part 2: Particular requirements for gas, oil and solid-fuel burning appliances having electrical connections
  - **Gas Appliances Regulation**
  - **EN 203-1** Gas heated catering equipment - Part 1: General safety rules
  - **EN 203-2-1** Gas heated catering equipment - Part 2-1: Open burners and wok burners
  - **EN 203-2-2** Gas heated catering equipment - Part 2-2: Ovens

1.2.7 Noise and vibrations standards

- **EN 60704-2-13** Household and similar electrical appliances – Test code for the determination of airborne acoustical noise – Part 2-13: Particular requirements for range hoods and other cooking fume extractors
- **EN 60704-2-10** Household and similar electrical appliances – Test code for the determination of airborne acoustical noise – Part 2-10: Particular requirements for electric cooking ranges, ovens, grills, microwave ovens and any combination of these

1.2.8 Other applicable standards

- **EN 50581** Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances
- **EN 55011** Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement
- **EN 55014-1** Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 1: Emission
- **EN 55014-2** Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 2: Immunity
- **EN 55015** Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment
- **EN 61000-3-2** Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current <= 16 A per phase)
- **EN 61000-3-3** Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current <= 16 A per phase and not subject to conditional connection
- **EN 61000-3-11** Electromagnetic compatibility (EMC) - Part 3-11: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems - Equipment with rated current <= 75 A and subject to conditional connection
- **EN 61000-3-12** Electromagnetic compatibility (EMC) - Part 3-12: Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and <= 75 A per phase
- **EN 301 489-1** ElectroMagnetic Compatibility (EMC) standard for radio equipment and services - Part 1: Common technical requirements
- **EN 301 489-17** ElectroMagnetic Compatibility (EMC) standard for radio equipment and services - Part 17: Specific conditions for Broadband Data Transmission Systems
- **EN 50614** Requirements for the preparing for re-use of waste electrical and electronic equipment.

1.2.9 Third country test standards

1.2.9.1 USA

- **Household appliances**

The standard for conventional cooking products establish provisions for determining estimated annual operating costs, cooking efficiency (defined as the ratio of cooking energy output to cooking energy input), and energy factor (EF) (defined as the ratio of annual useful cooking energy output to total annual energy input)[7]. Its scope covers cooking tops both electrical and gas, a microwave ovens.

The standards were amended to include the standby and off mode power, according the consideration of IEC 62301 and IEC 62087. DOE introduced additionally a methodology to measure certain active modes such as fan-only mode for residential conventional cooking products. The inclusion of methods to measure these additional modes allows for the calculation of integrated annual energy consumption.

In 2013, DOE published an amendment proposing the measurement for testing the active mode energy consumption of induction cooling products. DOE proposed to incorporate induction cooking tops by amending the definition of conventional cooking top to include induction heating technology. Furthermore, DOE proposed to require for all cooking tops the use of test equipment compatible with induction technology. Specifically, DOE proposed to replace aluminium test blocks for cooking tops with hybrid test blocks comprising two separate pieces: an aluminium body and a stainless steel base.

In 2014, introduced another modification in which DOE proposed to specify different test equipment that would allow for measuring the energy efficiency of induction cooking tops, and would include an additional test block size for electric surface units with large diameters. DOE also proposed methods to test non-circular electric surface units, electric surface units with flexible concentric cooking zones, and full-surface induction cooking tops.

In 2016, DOE proposed to amend its standard to incorporate the relevant sections of EN 60350-2:2013 which provide a water-heating test method to measure the energy consumption of electric cooking tops. The test method specifies the quantity of water to be heated in a standardized test vessel whose size is selected based on the diameter of the surface unit under test. The test vessel specified in EN 60350-2:2013 are compatible with all cooking top technologies and surface unit diameters available on the US market.

Finally, DOE proposed to extend the test methods provided in EN 60530-2:2013 to gas cooking tops by correlating the burner input rate and test vessel diameters specified in EN 30-2-1:1998 to the test vessel diameter and water loads already included in EN 60350-2:2013. The range of gas burner input rates covered by EN 30-2-1 includes surface units with burners exceeding 14000Btu/h, and thus EN 30-2-1 provides a method to test gas surface units with high input rate burners, which previously had not been addressed in US standards.

Professional appliances

Energy Star for Commercial Food Service Equipment is based on the following American Society for Testing and Materials (ASTM) standards:

- *ASTM F2140 - 11(2019) Standard Test Method for Performance of hot food holding cabinets*

  This test method evaluates the preheat energy consumption and idle energy consumption of hot food holding cabinets. A hot food holding cabinet is described as a commercial kitchen appliance that is used to hold hot food that has been cooked in a separate appliance at a specified temperature.

  The hot food holding cabinet can be evaluated with respect to the following (where applicable):

    - Energy input rate
    - Temperature calibration
    - Preheat energy consumption and time
    - Energy consumption (idle energy rate)
    - Energy consumption with water (humidity pan) device and relative humidity (if applicable)
    - Temperature uniformity

[7] https://www.law.cornell.edu/cfr/text/10/appendix-I_to_subpart_B_of_part_430

- *ASTM F1275 - 14 Standard Test Method for Performance of Griddles*

This test method evaluates the energy consumption and cooking performance of griddles. It is applicable to thermostatically controlled, single-source (bottom) gas and electric griddles.

The griddle can be evaluated with respect to the following parameters:

  - Energy input rate
  - Temperature uniformity across the cooking surface and accuracy of the thermostats,
  - Preheat energy and time
  - Idle energy rate
  - Pilot energy rate,
  - Cooking energy rate and efficiency
  - Production capacity and cooking surface temperature recovery time

- *ASTM F1605 - 14(2019) Standard Test Method for Performance of Double-Sided Griddles*

This test method covers the energy consumption and cooking performance of double-sided griddles. It is applicable to thermostatically controlled, double-sided gas and electric (or combination gas and electric) contact griddles with separately heated top surfaces.

This test method is applicable to thermostatically controlled, double-sided gas and electric (or combination gas and electric) contact griddles with separately heated top surfaces.

The double-sided griddle can be evaluated with respect to the following (where applicable):

  - Energy input rate
  - Temperature uniformity across the cooking surface(s) and thermostats accuracy
  - Preheat energy and time
  - Idle energy rate
  - Pilot energy rate, if applicable
  - Cooking energy rate and efficiency
  - Production capacity and cooking surface temperature recovery time

- *ASTM F1496 - 13(2019) Standard Test Method for Performance of Convection Ovens*

This test method covers the energy consumption and cooking performance evaluation of convection ovens. The test method is also applicable to convection ovens with limited moisture injection. It applies to general purpose, full-size, and half-size convection ovens and bakery ovens used primarily for baking food products. It is not applicable to ovens used primarily for slow cooking and holding food product, to large roll-in rack-type ovens, or to ovens that can operate in a steam-only mode (combination ovens).

This test method is intended to be applied to convection ovens that operate close to their rated input in the dry heating mode, with the circulating fan operating at its maximum speed.

The oven's energy consumption and cooking performance are evaluated in this test method specifically with respect to the following:

  - Thermostat
  - Energy input rate and preheat energy consumption and time
  - Pilot energy rate (if applicable)
  - Idle energy rate
  - Cooking energy efficiency and production capacity

    - Cooking uniformity
    - White sheet cake browning
    - Bakery steam mode, if applicable

- *ASTM F2861 - 17 Standard Test Method for Enhanced Performance of Combination Oven in Various Modes*

This test method covers the evaluation of the energy and water consumption and the cooking performance of combination ovens that can be operated in hot air convection, steam, and the combination of both hot air convection and steam modes. The test method is also applicable to convection ovens with moisture injection. It is applicable to gas and electric combination ovens that can be operated in convection, steam and combination modes.

The combination oven can be evaluated with respect to the following (where applicable):

    - Energy input rate and thermostat calibration
    - Preheat energy consumption and time
    - Idle energy rate in convection, steam and combination modes
    - Pilot energy rate (if applicable)
    - Cooking-energy efficiency, cooking energy rate, production capacity, water consumption and condensate temperature in steam
    - Cooking-energy efficiency, cooking energy rate, and production capacity in convection mode
    - Cooking uniformity in combination mode

- *ASTM F1484 - 18 Standard Test Methods for Performance of Steam Cookers*

These test methods are applicable to the following steam cookers: high-pressure, low-pressure, pressureless and vacuum steam cookers; convection and non-convection steam cookers; steam cookers with self-contained gas-fired, electric, or steam coil steam generators, and those connected directly to an external potable steam source.

- The steam cookers will be tested for the following (where applicable):
    - Maximum energy input rate
    - Preheat energy consumption and duration
    - Idle energy rate
    - Pilot energy rate
    - Frozen green pea cooking energy efficiency
    - Frozen green pea production capacity
    - Whole potato cooking energy efficiency
    - Whole potato production capacity
    - Water consumption
    - Condensate temperature
    - Cooking uniformity

1.2.9.2 Canada

CAN/CSA-C358 (Energy Consumption Test Methods for Household Electric Ranges) applies to household electric ranges that are intended to be used on a 60 Hz ac supply with a nominal system voltage of 120/240 V. This Standard specifies the methods to be used in measuring the capacity, the energy consumption, and the energy efficiency of electrically operated ranges. It does not apply to:

(a) microwave cooking appliances;
(b) portable units designed for an electrical supply of 120 V;
(c) induction heating elements; or
(d) warming compartments or zones that are not intended for cooking

1.2.9.3 Switzerland

In the professional sector, the Swiss organism ENAK provides a certification system based on test definitions and procedures set by themselves, available for turbo-ovens, cooking hobs, cooking and frying pans, deep fryers and pasta cookers, combi-steamers, convection ovens, bain-maries and heated display cabinets

1.2.9.4 Comparative analysis for overlapping test standards on performance

In the previous sections, overlapping test standards on performance have been identified and described. Table 6 gathers the differences between these standards.

Table 6: Differences between overlapping test standards on performance

EN standard	**Overlaps with**	**Differences**
EN 60350-1 Household electric cooking appliances – Part 1: Ranges, ovens, steam ovens and grills – Methods for measuring performance	DOE 10 CFR part 430, subpart B, appendix I (USA)	US standards measures the annual energy consumption of the oven taking into account the different modes of the oven.
	CAN/CSA-C358 Energy Consumption Test Methods for Household Electric Ranges	CAN/CSA Standard sets a normal bake mode to reach 130C and then then the oven is allowed to operate a full thermostat cycle until reaching 205C. EN Standard sets a temperature rise of 55K.
EN 60350-2 Household electric cooking appliances – Part 2: Hobs – Methods for measuring performance	DOE 10 CFR part 430, subpart B, appendix I (USA)	US standards measures the annual energy consumption of the hob taking into account the stand-by and off-modes.
	CAN/CSA-C358 Energy Consumption Test Methods for Household Electric Ranges	Stardarised test vessels used are made of different combinations of materials
EN 30-2-1 Domestic gas cooking appliances – Rational use of energy	DOE 10 CFR part 430, subpart B, appendix I (USA)	No significant differences have been found. US standard incorporate relevant sections of EN standard for gas cooking appliances.. ▪

1.3 Legislation on Ecodesign, energy efficiency, performance and resource efficiency

In the following sections of this chapter, the European legislation with regard to Ecodesign, energy efficiency, performance and resource efficiency are described, followed by a compilation of international and third-country legislation.

1.3.1 EU legislation

- Table 7 provides an overview of the European legislation discussed in this section

Table 7. Overview of European legislation on Ecodesign, energy efficiency and performance

European legislation	
Ecodesign Regulation	Ecodesign regulation (EC) No 66/2014 on Ecodesign requirements for domestic ovens, hobs and range hoods.
	Ecodesign regulation (EC) No 1275/2008 for standby and off-mode
	Ecodesign regulation (EC) No 801/2013 on networked standby
	Ecodesign Regulation (EC) No 327/2011 on fans driven by motors with an electric input power between 125 W and 500 kW
	Ecodesign Regulation (EC) No 640/2009 for electric motors
	Ecodesign preparatory study on smart appliances (ENER Lot 33, ongoing)
Energy efficiency and performance	Energy Label Regulation (EC) No 65/2014 on energy label requirements for domestic ovens and range hoods.
	Low Voltage Directive (LVD) 2014/35/EU
	Electromagnetic compatibility directive (ECD) 2014/30/EU

1.3.1.1 Ecodesign regulations relevant for domestic cooking appliances

- **<u>Ecodesign regulation (EC) No 66/2014</u>**

Based on Directive 2009/125/EU with regard to Ecodesign requirements for energy-related products, the Regulation (EC) No 66/2014 with regard to Ecodesign requirements for domestic ovens, hobs and range hoods establishes general and specific requirements that all appliances need to fulfil to be distributed on the European market. General requirements include:

- for domestic ovens

  - energy efficiency requirements for the appliance performance under one standardized cycle in a conventional mode and in a fan-force mode, if available

  - the provision of obligatory information in the booklet

- for domestic hobs

  - maximum energy consumption for domestic electric hobs

  - energy efficiency of gas burners for domestic gas hobs

  - the provision of obligatory information in the booklet

- for domestic range hoods

  - minimum energy efficiency and minimum fluid dynamic efficiency requirements for the appliance performance under standardized cycle.

- maximum air flow that shall revert to an air flow lower or equal to 650m^3/h in a specified time at the best efficiency point

- maximum energy consumption of the low power modes off-mode and standby modes

- minimum average illumination of the lighting system

- the provision of obligatory information in the booklet

The specific requirements prescribe the minimum limits for energy efficiency or the maximum energy consumption according to the Energy Efficiency Index (EEI), as seen in Table 8.

Table 8. Ecodesign requirements in REG 66/2014

Appliance	Due date	Specific requirements
Domestic ovens	February 2015	EEI_{cavity} <146
	February 2016	EEI_{cavity} <121
	February 2019	EEI_{cavity} <96
Electric domestic hobs	February 2015	$EC_{elect\ hob}$<210 Wh/kg
	February 2017	$EC_{electhob}$<200 Wh/kg
	February 2019	$EC_{elect\ hob}$<195 Wh/kg
Gas-fired domestic hobs	February 2015	$EE_{gas\ hob}$>53 %
	February 2017	$EE_{gas\ hob}$>54 %
	February 2019	$EE_{gas\ hob}$>55 %
Domestic range hoods	February 2015	EEI_{hood}<120 FDE_{hood} >3
	February 2017	EEI_{hood}<110 FDE_{hood} >5
	February 2019	EEI_{hood}<100 FDE_{hood} >8
	February 2015	Air flow ≤ 650m3/h
	February 2015	E_{middle} > 40 lux

Regulation (EC) No 66/2014 prescribes formulas for the calculation of EEI, EC, EE or FDE and the respective energy consumption, theoretic minimum required energy or annual energy consumption. These equations are taken over in the Energy Label Regulation (EC) No 65/2014, when appropriate.

In addition, the Ecodesing regulation sets minimum requirements for the low power modes of range hoods. From September 2017 the following requirements applied:

– the power consumption of any off mode condition shall not exceed 0.50W

– the power consumption in any condition providing only a reactivation function, or providing only a reactivation function and information or status display shall not exceed 1.00W

– when domestic range hoods are not providing the main functions or when other energy-using product(s) are not dependent on its functions, equipment shall, unless inappropriate for the intended use, offer a power management function, or a similar function, that switches equipment after the shortest possible period of time appropriate for the intended use of the equipment, automatically into standby mode or off mode or another condition which does not exceed the applicable power consumption requirements for off more and/or standby mode when the equipment is connected to the mains power source

The power management function shall be activated before delivery.

For range hoods with automatically functioning mode during the cooking period and fully automatic range hoods, the delay time after which the product switches automatically into the modes and conditions as referred to in the previous point shall be one minute after the motor and lighting have both been switched off either automatically or manually.

Additionally for the verification process tolerances for all measures values are given, as well as reference values of the most efficient appliances (electric and gas fed) available on the market at that time.

- **Ecodesign regulation (EC) No 1275/2008 for standby and off mode**

Regulation (EC) No 1275/2008 is implementing the Directive 2005/32/EC with regard to Ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment (European Commission 2008). According to Annex I of Regulation, electric ovens, electric hot plates and other appliances for cooking are covered by this Regulation. Range hoods are not included in the list of products within Annex I of this regulation, and in this case, stand-by and off mode requirements are set by the Ecodesing regulation, as explained above.

Currently, stage 2 is applicable for products placed on the market from 7 January 2013, with the following requirements regarding power consumption of standby- and off-mode, as well as power management or similar functions.

- power consumption in standby modes

    - the power consumption of equipment in any condition providing only a reactivation function, or providing only a reactivation function and a mere indication of enabled reactivation function, shall not exceed 0.50 W

    - the power consumption of equipment in any condition providing only information or status display, or providing only a combination of reaction function and information status display shall not exceed 1.00 W

- power consumption in off-mode: power consumption of equipment in any off-mode conditions shall not exceed 0.5 W

- availability of off mode and/or standby mode: equipment shall, except where this is inappropriate for the intended use, provide off mode and/or standby mode, and/or another condition which does not exceed the applicable power consumption requirements for off mode and/or standby mode when the equipment is connected to the mains power source

- power management: when equipment is not providing the main function, or when other energy-using product(s) are not dependent on its functions, equipment shall, unless inappropriate for the intended use, offer a power management function, or a similar function, that switches equipment after the shortest possible period of time appropriate for the intended use of the equipment, automatically into:

    - standby mode, or off mode, or another condition which does not exceed the applicable power consumption requirements for off mode and/or standby mode when the equipment is connected to the mains power source. The power management function shall be activated before delivery

- **Ecodesign Regulation (EC) No 801/2013 on networked standby**

Regulation (EC) No 801/2013 (European Commission 2013b) is an amendment to regulation (EC) No 1275/2008 for standby and off mode, expanding this by Ecodesign requirements related to networked standby electric power consumption for the placing on the market of electrical and electronic household and office equipment.

In this context, “networked standby” means a condition in which the equipment is able to resume function throughout a remotely initiated trigger from a network connection, i.e. a signal that comes from outside the equipment via a network. Thus, the Regulation applies to all domestic ovens, hobs and range hoods that can be connected to a network. In the networked standby, the equipment is inactive (not performing a main function but in a condition allowing it to be reactivated via an external network signal).

While Ecodesign Regulation (EC) No 1275/2008 for standby and off mode requires power management for all equipment other than networked equipment put on the market since 2013, as of 1 January 2015 the following requirements apply to networked equipment:

- possibility of deactivating wireless network connection(s): any networked equipment that can be connected to a wireless network shall offer the user the possibility to deactivate the wireless network connection(s). This requirement does not apply to products which rely on a single wireless network connection for intended use and have no wired network connection

- power management for networked equipment: equipment shall, unless unappropriated of the intended use, offer a power management function or a similar function. When the equipment is not providing a main function, and other energy-using product(s) are not dependent on its functions, the power management function shall switch equipment after the shortest possible period of time appropriate for the intended use of the equipment, automatically into a conditions having networked standby. In a condition providing networked standby, the power management function may switch equipment automatically into standby mode or off mode or another condition which does not exceed the applicable power consumption requirements for standby and/or off mode as specified in Regulation (EC) No 1275/2088. The power management function, or a similar function, shall be available for all network ports of the networked equipment. The power management function, or a similar function, shall be activated, unless all network ports are deactivated. In that latter case the power management function, or a similar function, shall be activated if any of the network ports is activated. The default period of time after which the power management function, or a similar function, switches the equipment automatically into a condition providing networked standby shall not exceed 20 minutes.

- networked equipment that has one or more standby modes shall comply with the requirements for these standby mode(s)

- when all network ports are deactivated (since 1 January 2015)
- when all wired network ports are disconnected and when all wireless network ports are deactivated (1 January 2017)

- networked equipment other than HiNA equipment (high network availability equipment) shall comply with the provisions of "power management for all equipment other than networked equipment"

- when all network ports are deactivated (since 1 January 2015)
- when all wired network ports are disconnected and when all wireless network ports are deactivated (1 January 2017)

- the power consumption of "other" network equipment (i.e. not HiNA equipment or equipment with HiNA functionality) in a condition providing networked standby into which the equipment is switched by the power management function, or similar function:

- shall not exceed 6.00 W (since 1 January 2015)
- shall not exceed 3.00 W (since 1 January 2017)
- shall not exceed 2.00 W (since 1 January 2019

- **<u>Ecodesign Regulation (EC) No 327/2011 on fans driven by motors with an electric input power between 125 W and 500 kW</u>**

Regulation (EC) No 327/2011 covers fans that are integrated in other products without being separately placed on the market or put into service as long as they are between 125 W and 500kW.

This regulation however does not apply to the fan integrated into kitchen hoods < 280W total maximum electrical input attributable to the fan(s). A specific case can be found where the total maximum electrical power attributable to the fan is above 280 W but the input power in the optimum efficiency point is below. In this case, as the exclusion is made based on total maximum electrical input power, the fan must comply with the Regulation.

Most of the domestic range hoods will then be excluded from this eco-design regulation as most of them have a maximum electrical input lower than 280W.

If any of them are above this limit, as commented in the example before, then the definition applied in this regulation is that, a *fan is defined as a rotatory bladed machine that is used to maintain a continuous flow of gas, typically air, passing through it and whose work per unit mass does not exceed 25kJ/kg and which:*

1 is designed for use with or equipped with an electrical motor with an electric input power between 125W and 500kW (≥125W and ≤500kW) to drive the impeller at tis optimum energy efficiency point

2 is an axial fan, cross flow or mixed flowed fan

3 may or may not be equipped with a motor when placed on the market or put into service.

The requirements of this regulation refer to minimum energy efficiency requirements and information requirements In addition, the regulation requires the provision of information related to the technical characteristics of the fan in the free access websites of the manufacturers of fans, related to the year of manufacture and details of the manufacturers. In addition, the regulation requires information relevant for facilitating disassembly, recycling or disposal at the end-of-life, to minimise impact on the environment and ensure optimal life expectancy as regards installation, use and maintenance of the fan and description of additional items used when determining the fan energy efficiency, such as ducts, that are not described in the measurement category and not supplied with the fan. Finally, manufacturers should provide information in the manual of instructions on specific precautions to be taken when fans are assembled, installed or maintained as well as the details of the characteristics of the variable speed drive (VSD) that must be installed with the fan, if needed, to ensure optimal use after assembly.

- **Ecodesign Regulation (EC) No 640/2009 for electric motors**

Regulation (EC) No 640/2009 (European Commission 2009) set Ecodesign requirements for electric motors included in other products. The regulation, however, does not cover all motor types being on the market. Motors are not an essential part of ovens and are only used in those ovens that include forced air function.

- **Ecodesign regulation 1253/2014 on ecodesign requirements for ventilation**

Regulation (EC) No 1253/2014 set ecodesign requirements for ventilation units for their placing on the market or putting into service.

This regulation establishes requirements in terms of Specific Energy Consumption (SEC), noise, multi-speed/variable speed drives, thermal by-pass facilities and filters (among other parameters).

1.3.1.2 Energy efficiency regulations relevant for domestic cooking appliances

- **Energy Label Regulation (EC) No 65/2014 on energy label requirements for domestic ovens and range hoods**

Based on Directive 2010/30/EU with regard to labelling of energy related products, the Regulation (EC) No 65/2014 with regard to energy label of domestic ovens and range hoods came into force in January 2015. It describes the uniform design and content of the new energy label that shall be used for the declaration of performance characteristics.

Current energy label has a multilingual design, displays energy efficiency from classes A+++ to D. In the case of the domestic ovens, further information display on the label refers to the capacity and the energy consumption for the heating function conventional and if available the forced air convection. In the case of range hoods, information refers to energy consumption, fluid dynamic efficiency, lighting efficiency, grease filtering efficiency and noise.

Sizes and colours for all elements and declarations are prescribed in detail, as well as formulas to calculate annual consumptions, efficiency indices and tables that indicate minimum and maximum values for energy efficiency classes.

Domestic ovens

The energy efficiency classes of domestic ovens shall be determined separately for each cavity in accordance with values as set out in Table 9.

Table 9. Energy efficiency classes and energy efficiency index in ovens

Energy efficiency class	**Energy efficiency index (EEI_{cavity})**
A+++ (most efficient)	$EEI_{cavity} < 45$
A++	$45 \leq EEI_{cavity} < 62$
A+	$62 \leq EEI_{cavity} < 82$
A	$82 \leq EEI_{cavity} < 107$
B	$107 \leq EEI_{cavity} < 132$
C	$132 \leq EEI_{cavity} < 159$
D (least efficient)	$EEI_{cavity} < 159$

EEI is calculated according to following equations:

- for domestic electric ovens:

$$EEI_{cavity} = \frac{EC_{electric\ cavity}}{SEC_{electric\ cavity}}\ x\ 100$$

$$SEC_{electric\ cavity} = 0.0042\ x\ V + 0.55\ (in\ kWh)$$

- for domestic gas ovens:

$$EEI_{cavity} = \frac{EC_{gas\ cavity}}{SEC_{gas\ cavity}}\ x\ 100$$

$$SEC_{gas\ cavity} = 0.044\ x\ V + 3.53\ (in\ MJ)$$

Where:

EEI_{cavity} is the energy efficiency index for each cavity of a domestic oven, in % rounded to the first decimal place

$SEC_{electric\ cavity}$ is standard energy consumption (electricity) required to heat a standardized load in a cavity of an electric heated domestic oven during a cycle, expressed in kWh, rounded to the second decimal place

▪ $SEC_{gas\ cavity}$ is standard energy consumption (electricity) required to heat a standardized load in a cavity of a gas heated domestic oven during a cycle, expressed in kWh, rounded to the second decimal place

$EC_{electric\ cavity}$ is energy consumption required to heat a standardized load in a cavity of an electric heated domestic oven during a cycle, expressed in kWh, rounded to the second decimal place

$EC_{gas\ cavity}$ is energy consumption required to heat a standardized load in a cavity of a gas heated domestic oven during a cycle, expressed in kWh, rounded to the second decimal place

Domestic range hoods

The energy efficiency classes for domestic range hoods shall be determined in accordance with values as set out in Table 10.

Table 10. Energy efficiency classes and energy efficiency index in range hoods

Energy efficiency class	Energy efficiency index (EEI_{hood})			
	Label 1	**Label 2**	**Label 3**	**Label 4**
A^{+++} (most efficient)				$EEI_{hood} < 30$
A^{++}			$EEI_{hood} < 37$	$30 \leq EEI_{hood} < 37$
A^{+}		$EEI_{hood} < 45$	$37 \leq EEI_{hood} < 45$	$37 \leq EEI_{hood} < 45$
A	$EEI_{hood} < 55$	$45 \leq EEI_{hood} < 55$	$45 \leq EEI_{hood} < 55$	$45 \leq EEI_{hood} < 55$
B	$55 \leq EEI_{hood} < 70$	$55 \leq EEI_{hood} < 70$	$55 \leq EEI_{hood} < 70$	$55 \leq EEI_{hood} < 70$
C	$70 \leq EEI_{hood} < 85$	$70 \leq EEI_{hood} < 85$	$70 \leq EEI_{hood} < 85$	$70 \leq EEI_{hood} < 85$
D	$85 \leq EEI_{hood} < 100$	$85 \leq EEI_{hood} < 100$	$85 \leq EEI_{hood} < 100$	$EEI_{hood} \geq 85$
E	$100 \leq EEI_{hood} < 110$	$100 \leq EEI_{hood} < 110$	$EEI_{hood} \geq 100$	
F	$110 \leq EEI_{hood} < 120$	$EEI_{hood} \geq 110$		
G (Least efficient)	$EEI_{hood} \geq 120$			

EEI is calculated according to following equations:

$$EEI_{hood} = \frac{AEC_{hood}}{SAEC_{hood}} \, x \, 100$$

$$SAEC_{hood} = 0.55 \, x \, (W_{BEP} + W_L) + 15.3$$

Where:

EEI_{hood} is the energy efficiency index for a hood, rounded to the first decimal place

$SAEC_{hood}$ is standard annual energy consumption of the domestic range hood in kWh/a, rounded to the first decimal place

AEC_{hood} is the annual energy consumption of the domestic range hood in kWh/a, rounded to the second decimal place

W_{BEP} is the electric power input of the domestic range hood at the best efficiency point in Watt, rounded to the first decimal place

W_L is the nominal electric power input of the lighting system of the domestic range hood on the cooking surface in Watt, rounded to the first decimal place

The AEC_{hood} of a domestic range hood is calculated as:

i) for the fully automatic domestic range hoods

$$AEC_{hood} = \left[\frac{(W_{BEP} \, x \, t_H \, x \, f) + (W_L \, x \, t_L)}{60 + 1000} + \frac{P_0 \, x \, (1440 - t_H \, x \, f)}{2 \, x \, 60 \, x \, 1000} + \frac{P_S \, x \, (1440 - t_H \, x \, f)}{2 \, x \, 60 \, x \, 1000}\right] x \, 365$$

ii) for all other domestic range hoods:

$$AEC_{hood} = \left[\frac{(W_{BEP} \, x \, t_H \, x \, f) + (W_L \, x \, t_L)}{60 + 1000}\right] x \, 365$$

Where:

t_L is the average lighting time per day, in minutes (tL = 120)

t_H is the average running time per day for domestic range hoods, in minutes (tH = 60)

P_0 is the electric power input in off mode of the domestic range hood, in Watt and rounded to the second decimal place

P_s is the electric power input in standby mode of the domestic range hood, in Watt and rounded to the seond decimal place

f is the time increase factor, calculated and rounded to the first decimal place as

$$f = 2 - \frac{(FDE_{hood}\ x\ 3.6)}{100}$$

The FED_{hood} is the fluid dynamic efficiency and it is calculated at the best efficiency point by the following formula, and is rounded to the first decimal place

$$FDE_{hood} = \frac{Q_{BEP}\ x\ P_{BEP}}{3600\ x\ W_{BEP}}\ x\ 100$$

Where:

Q_{BEP} is the flow rate of the domestic range hood at best efficiency point, expressed in m3/h and rounded to the first decimal point

P_{BEP} is the static pressure difference of the domestic range hood at best efficiency point, expressed in Pa and rounded to the nearest integer

W_{BEP} is the electric power input of the domestic range hood at the best efficiency point, expressed in Watt and rounded to the first decimal place.

Further annexes prescribe obligatory information for product fiche, technical documentation, distribution and marketing.

1.3.1.3 Potential issues of current Ecodesign and Energy labelling regulations on domestic cooking appliances

Real-life representativeness

According to stakeholders, current indexes may not be reflecting real life usage in the case of range hoods, since the energy efficiency rating is based on a measurement at the best efficiency point (BEP). The BEP is defined by the highest value of flow rate times pressure divided by power input. The BEP is usually at pressures that are much higher than pressures in real applications. The change in efficiency from high to low pressures can differ between models. Therefore, the energy efficiency rating should be based on measurements at lower pressures which resemble an average scenario in households. This is supported by several stakeholders, who also indicated that the actual Energy Label and Ecodesign Regulation pushed manufacturers to increase more and more the energy efficiency of the product with the focus on maximum available speed (even in boosted mode) because the measurement of Annual Energy Consumption (AEC) and EEI take into consideration just this setting; the result is that the energy efficiency of the other available speeds is rather low. Market analysis, on the contrary, shows that the product is used at all available speeds and in particular at minimum and maximum not boosted speeds, and that the boost setting is activated few times, just in situations with high level of fumes and vapour, because of the noise generated by the hood itself that increase with the speed. For this reasons, they suggest to review the method for the calculation of AEC and EEI in the direction to be more and more consistent with user behaviours and so taking into consideration all the speeds declared in the actual product fiche and not just the maximum even in boosted (if any).

Stakeholders recommend to change the measurement of efficiency from best efficiency point to typical uses, with a typical pressure drop over the exhaust piping. In the current standard the fluid dynamic efficiency (FDE) is determined in the best efficiency point, defined as the point where FDE is the highest. However, in practice, the range hood is seldom operating in the best efficiency point, thus the FDE results in an efficiency which is different from a normal working point of the appliance. Therefore, to allow the evaluation of efficiency of range hoods in typical working conditions, it is proposed to develop a pressure – airflow curve and the corresponding electric power curve for the minimum and maximum continuous modes and for the boost mode, and to include these in the test reports together with the efficiencies calculated based on the measurements. Then, it will be possible to base ecodesign regulation and energy labelling on energy efficiency requirements at a typical working point for the fume extractors.

Verification tolerances

In terms of verification tolerances in range hoods, several comments have been made by stakeholders. One of them indicates that Q_{BEP}, P_{BEP} and W_{BEP} have a verification tolerance of 5 %. However, the best efficiency point is the maximum of a curve that can have a small slope (long horizontal line) around the maximum. For such a curve the values of the determined Q_{BEP}, P_{BEP} and W_{BEP} vary greatly with just small disturbing factors in the measurement. Furthermore, the test standard does not restrict the air density in the test room. A change in air density causes a change in two or sometimes all three parameters. Laboratories at different altitudes will test in different air densities. A round robin test in five laboratories on two range hoods conducted by the Federal Institute for Materials Research and Testing in Germany gave relative standard deviations of: 8.2 % for Q_{BEP}, 6.0 % for P_{BEP} and 6.1 % for W_{BEP}. Deviations between parameters partially compensated when calculating the fluid dynamic efficiency (FDE) which had a relative standard deviation of 5.0 %. For example, when a laboratory had the same Q_{BEP} but a higher P_{BEP} then it also measured a higher W_{BEP}. Therefore, it is suggested that the verification tolerance is set for the FDE instead of Q_{BEP}, P_{BEP} and W_{BEP}.

The same stakeholder adds that in the round robin test the grease filtering efficiency had a relative standard deviation of 5.2 %. Thus, a verification tolerance of 5 % is too restrictive. Small improvements are possible by a more thorough description in the standardization. However, no major leaps in an improved reproducibility are expected. A verification tolerance of 8 % might be justified.

Finally, they argue that lighting with LEDs demands low power inputs. A tested range hood on the market had a declared value of WL = 3.3 W. For this case the verification tolerance of 5 % relates to an absolute tolerance of 0.165 W. This accuracy is difficult to achieve for interlaboratory comparisons. A minimum absolute tolerance of 0.3 W could be added to the relative tolerance of 5 %.

Another stakeholder recommends not to define verification tolerances on Q_{BEP}, P_{BEP} and W_{BEP}, but to define a verification tolerance on FDE (e.g. 8%), which is the consumer relevant parameter. FDE is also less sensitive to measurement uncertainties.

They add that currently the verification tolerance on sound power level (LwA) is 0%. As a consequence, reported sound levels are higher than actual sound levels. Use an absolute verification tolerance of 2dB (A). Differences below 3dB (A) can hardly be heard by non-professionals.

1.3.2 EU safety legislation

- **<u>Low voltage Directive (LVD) 2014/35/EU</u>**

The purpose of the LVD Directive (European Parliament 2014) is to ensure that electrical equipment on the market fulfils the requirements providing a high level of protection of health and safety of persons and of domestic animals and property, while guaranteeing the functioning of the internal market. The directive applies to electrical equipment designed for use with a voltage rating of between 50 and 1000 V for alternating current and between 75 and 1500 V for direct current, which is new to the union market when it is placed on the market (for example, a new electrical equipment made by a manufacturer established in EU-27 or new or second-hand imported from a third country).

Manufacturers of electrical equipment covered by Directive are obliged to carry out the conformity assessment procedure. The Conformité Européene (CE) marking, indicating the conformity of electrical equipment, is the visible consequence of a whole process comprising the conformity assessment.

- **Electromagnetic compatibility Directive (ECD) 2014/30/EU**

ECD 2014/30/EU (European Parliament 2014) aims to ensure the functioning of the internal market by requiring equipment to comply with an adequate level of electromagnetic compatibility, i.e. the ability of equipment function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to other equipment in that environment.

Equipment shall be so designed and manufactured, having regard to the state of art, as to ensure that:

- the electromagnetic disturbance generated does not exceed the level above which radio and telecommunications equipment or other equipment cannot operate as intended;
- it has a level of immunity to the electromagnetic disturbance to be expected in this intended use which allows it to operate without unacceptable degradation of its intended use

Manufacturers of equipment covered by this Directive are obliged to carry out the conformity assessment procedure. The CE marking, indicating the conformity of apparatus, is the visible consequence of a whole process comprising conformity assessment. Equipment shall be accompanied by information on any specific precautions that must be taken when the apparatus is assembled, installed, maintained or used, in order to ensure that, when put into service, the apparatus is in conformity with the essential requirements set out in the directive.

1.3.3 EU legislation on substances, material and resource efficiency and end-of-life

In Annex I, part 1.3 the Ecodesign Directive 2009/125/EC defines parameters which must be used, as appropriate, and supplemented by others, where necessary, for evaluating the potential for improving the environmental aspects of products. According to the Directive 2009/125/EC (European Parliament 2009a), this includes

- *Ease for reuse and recycling as expressed through: number of materials and components used, use of standard components, time necessary for disassembly, complexity of tools necessary for disassembly, use of component and material coding standards for the identification of components and materials suitable for reuse and recycling (including making of plastic parts in accordance with ISO standards), use of easily recyclable materials, easy access to valuable and other recyclable components and materials; easy access to components and materials containing hazardous substances*
- *Incorporating of used components;*
- *Avoidance of technical solutions detrimental to reuse and recycling of components and whole appliances*

This section identifies and provides an overview of legislation in the EU for the products in scope with focus on resources use and material efficiency.

- **EU RoHS Directive 2011/65/EU**

The Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (commonly referred to as RoHS 2) restricts the use of certain hazardous substances in electrical and electronic equipment to be sold in the EU and repeals Directive 2002/95/EC from 3rd of January 2013 (European Parliament 2011)

The RoHS-Directive restricts the presence of the substances listed in Annex II of the Directive, currently including the following substances: lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ether (PDBE).

The RoHS-Directive limits the presence of these substances in electrical and electronic equipment to be placed on the EU market, to concentrations not exceeding 0.1% by weight of homogenous material. For cadmium the threshold level is at 0.01%.

Exemptions from these provisions are only possible, provided that the availability of an exemption does not weaken the environmental and health protection afforded by Regulation (EC) No 1907/2006, and that at least one of the following conditions is fulfilled:

- Substitution is not possible from a scientific and technical point of view;
- The reliability of substitutes is not ensured;
- The negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the benefits;

Decisions on exemptions and on their duration may also take into consideration the following aspects, though it is understood that these do not suffice on their own to justify an exemption:

- The availability of substitutes;
- Socio-economic impacts of substitution;
- Impacts on innovation; and
- Life-cycle thinking on the overall impact of an exemption;

Applications for granting, renewing or revoking exemptions have to be submitted to the European Commission in accordance with Annex V of the Directive, and are required to include among others a justification including comprehensive information on the substance-application and possible substitutes. All applications undergo a technical analysis as well as a stakeholder consultation.

In general, applications exempted from the restriction are listed in Annex III of the RoHS Directive. As most of the exemptions are very specific, it is not possible to generalise certain topics for household appliances. Possible exemptions might be for example lead in various alloys (steal, copper, aluminium) probably being relevant for housings, though depending on the applied housing materials, as well as other components for which such alloys are in use. Theoretically, another example of exemptions might be Compact Fluorescent Light (CFL) backlight systems if still being used in displays, although it is assumed that most displays have been shifted to LED backlight systems.

- **EU WEEE Directive 2012/19/EU**

The Directive 2012/19/EU (European Parliament 2012a) on waste electrical and electronic equipment (commonly referred to as WEEE-Directive) regulates the separate collection, treatment and recycling of end-of-life electrical and electronic equipment. Directive 2012/19/EU requires Member States to achieve quantitative collection targets (e.g. 65% of the average weight of EEE placed on the market in the three preceding years). It also requires Member States to ensure that producers provide for the financing of the collection, treatment, recovery and environmentally sound disposal of WEEE (Article 12).

The WEEE-Directive classifies EEE in various categories. From 15 August 2018 the domestic ovens, hobs and range hoods might not be classified in one single category, as before into the “large household appliances”, but instead they fall under the following new categories:

- Category 1: Temperature exchange equipment; in the case of domestic ovens;
- Category 2: Screens, monitors, and equipment containing screens having a surface greater than 100 cm^2; this category might apply to domestic ovens in case of having a large control panel.

- Category 4: Large equipment (any external dimension more than 50 cm); this category will mainly apply to household ovens

Annex V of the Directive also contains minimum targets for recovery and recycling. For the initial category 1 equipment (large household appliances), these targets are 85% for recovery and 80% for re-use and recycling. Furthermore, Annex VII of the Directive specifies substances, mixtures and components that have to be removed from any collected WEEE for selective treatment. However, different interpretations by recyclers can be found: removal before or after shredding.

- **EU REACH Regulation 1907/2006/EC**

The Registration, Evaluation, Authorisation and Restriction of Chemicals regulation (also known as REACH Regulation (European Parliament 2006b)) entered into force 1 June 2007. Under the REACH Regulation, certain substances that may have serious and often irreversible effects on human health and the environment can be identified as Substances of Very High Concern (SVHCs). If identified, the substance is added to the Candidate List, which includes candidate substances for possible inclusion in the Authorisation List (Annex XIV). Those SVHC which are included in Annex XIV become finally subject to authorisation. By this procedure REACH aims at ensuring that the risks resulting from the use of SVHCs are controlled and that the substances are replaced where possible.

In this regard, REACH also introduced new obligations concerning general information requirements on substances in articles. Producers and importers of articles that contain SVHC included in the candidate list, will be required to notify these to the European Chemicals Agency (ECHA) if both of the following conditions are met:

- The substance is present in those articles in quantities totalling over 1 t/y per producer or importer;
- The substance is present in those articles above a concentration of 0.1% weight by weight (w/w).

Notification will not be required in case the SVHC has already been registered for this use by any other registrant (Article 7(6)), or exposure to humans or environment can be excluded (Article 7(3)).

In addition, Article 33(1) requires producers and importers of articles containing more than 0.1% w/w of an SVHC included in the candidate list, to provide sufficient information to allow safe handling and use of the article to its recipients. As a minimum, the name of the substance is to be communicated.

The provisions of Article 33(1) apply regardless of the total amount of the SVHC used by that actor (no tonnage threshold) and regardless of a registration of that use. Furthermore, this information has to be communicated to consumers, on request, free of charge and within 45 days (Article 33(2)).

The above mentioned Candidate list is updated regularly (two to three times a year). At July 2019, 201 substances are on the list. Several of these substances can be present in ovens, hobs or range hoods, e.g. plasticisers in seals.

- **EU CLP Regulation 1272/2008/EC**

The Classification, Labelling and Packaging regulation (also known as CLP Regulation (European Parliament 2008)) entered into force 20 January 2009. The purpose of the CLP Regulation is to identify hazardous chemicals and to inform their users about particular threats with the help of standard symbols and phrases on the packaging labels and through safety data sheets. The purpose of the globally harmonised system (UN-GHS) is to make the level of protection of human health and the environment more uniform, transparent and comparable as well as to simplify free movement of chemical substances, mixtures and certain specific articles within the EU.

Substances had to be classified until 1 December 2010 pursuant to Directive 67/548/EEC and mixtures until 1 June 2015 pursuant to Directive 1999/45/EC. Differing from this provision, the classification, labelling and packaging of substances and preparation may already be used before 1 December 2010 and 1 June 2015 in accordance with the provisions of the CLP/GHS-Regulation. After these dates the provisions of the CLP-Regulation are mandatory. The REACH-Regulation is complemented by the CLP Regulation.

1.3.4 Third country regulation

USA

- The National appliance energy conservation act of 1978, amended the Energy Policy and Conservation Act (EPCA) to establish prescriptive standards for gas cooking products requiring gas ranges and ovens with an electrical supply cord that are manufactured on or after January 1990 not to be equipped with a constant burning pilot light.
- DOE undertook a study and concluded in 1998 that no standards were justified for conventional electric cooking products at that time. In addition, partially due to the difficulty of conclusively demonstrating that elimination of standing pilots for conventional gas cooking products without an electrical supply cord was economically justified, DOE did not include amended standards for conventional gas cooking products in the final rule.
- In 2009 DOE published a rule amending the energy conservation standard for conventional cooking products to prohibit constant burning pilots for all gas cooking products (i.e. gas cooking products either with or without an electrical supply cord) manufactured on or after April 2012. DOE decided to not adopt energy conservation standards pertaining to the cooking efficiency of conventional electric cooking products because it determined that such standards would not be technologically feasible and economically justified at that time. This rule was requested to be revised not later than 6 years after its issuance.
- ENERGY STAR, the voluntary labelling program managed by the U.S. Environmental Protection Agency (EPA), sets compliance thresholds of energy efficiency for the certification of professional kitchen appliances. It is based on the ASTM standards and their parameters, which are described in section 1.2.2.

Brazil

Domestic gas ovens

In Brazil, energy labelling is already implemented in a voluntary or mandatory mode for gas cooking appliances. The oven gas consumption index is calculated as follows:

$$I_c\,(\%) = 100\,\frac{(measured\ gas\ consumption\ for\ oven\ 210C\ temp\ maintenance)}{(max\ admissible\ gas\ consumption\ for\ oven\ temp\ maintenance\ calculated\ by\ the\ standard)}$$

In the particular case of natural gas ovens, the gas consumption is the following:

$$I_c\,(\%) = 100\,\frac{\left(\frac{C}{0.0903}\right)}{(0.93 + 0.035 * V)}$$

Where C is the gas consumption in kg/h and V the volume in litres

Domestic gas hobs

In Brazil, energy label is implemented for gas hobs appliances. The cooking table burner individual energy efficiency is defined as the ratio between the measured heat absorbed by the water in a standard pan and the thermal energy theoretically available to be transferred to water on the gas fuel burn due to its calorific power. The cooking table efficiency index is defined by dividing the sum of the individual efficiencies by the number of burners.

Canada

All residential cooking appliances are subject to Canada's *Energy Efficiency Regulations*, which set a performance standard for their energy consumption. This helps keep the least efficient products off the Canadian market. In addition, they must have an EnerGuide label that informs how much energy a model uses (except from the gas ranges).

The Canadian regulation does not include an energy label or an energy star specification to qualify the cooking appliances because the energy consumption between different models is small. The minimum energy performance standards applied to household ranges that are:

- Free-standing appliances equipped with one or more surface elements and one or more ovens
- Built-in appliances equipped with one or more surface elements and one or more ovens
- Built-in appliances equipped with one or more ovens and no surface elements
- Wall-mounted appliances equipped with one or more ovens and no surface elements
- Counter-mounted appliances equipped with one or more surface elements and no ovens

The Canadian MEPS do not cover the following

- Appliances designed for an electrical supply of 120 volts
- Household appliances with one or more tungsten-halogen heating elements.

The EnerGuide (Figure 4) informs about the energy consumption of an appliance and allows comparison between the model and the rest of the models on the market. The EnerGuide label is a mandatory for all cooking appliances except gas ranges. It must be easy to see on the outside or inside the product. The label shows the product type, the model number and average energy consumption in kWh/year. A scale shows how the model performs in comparison with other models: the lower the number, the more energy efficient the product.

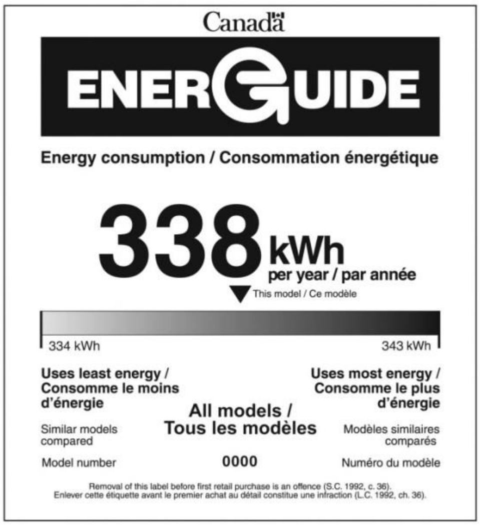


Figure 4. EnerGuide for cooking appliances in Canada

Regarding the energy efficiency regulation in Canada, there are two regulations that apply to gas range and electric range respectively.

A) Gas range

A gas range, according to the regulation, is a household propane or natural gas range that has an electrical power source, and is used for food preparation and provides one of the following functions: surface cooking, oven cooking, or broiling. This applies to appliance manufacturer on or after February 1995. There is no a testing standard associated with this regulation.

The energy efficiency requirement sets up that it must not have a continuously burning pilot light.

In addition to the minimum energy efficiency requirements, the regulation indicates that the following energy efficiency report requirements should be delivered;

- Name of the product
- Brand name
- Model number
- Manufacturer
- Volume of usable oven space in liters
- Whether the range is built-in or free standing
- Whether the broilers are open or closed
- Whether a mathematical model as defined in the regulations was used to generate any of the information provided.

B) Electric range

Electric range, is defined in this regulation as, *a household electric range. It does not include a portable range that is designed for an electrical supply of 120 V or a microwave oven.* The regulation is in force since 2013 and refers to the testing standard CAN/CSA-C358-03.

The minimum energy efficiency performance (in kWh/year) depends on the type of product (range, cooktop or oven) and is related to cavity volume in the case of ranges and ovens.

China

China set minimum allowable values of energy efficiency and energy efficiency grades for household induction hobs. This mandatory programme specifies the minimum allowable values of energy efficiency, evaluating values of energy conservation, energy efficiency grades, test methods and inspection rules of household induction hobs. It applies to household induction hobs with one or multiple heating units and the rating power of one heating unit is from 700 to 2800W. Commercial induction hobs, power frequency induction hobs and concave induction hobs are not included in the scope of this standard.

Japan

“Top Runner” is a Japanese programme in which energy consumption of domestic gas cooking appliances is tacked. Top Runner is mandatory but is not a MEPS. Manufacturers and importers are under the obligation to comply with the standards by Energy conservation law. Enforcement within the Top Runner Programme relies on ‘blame and shame’ that works well in Japan. The following information shall appear on the label:

- Fiscal year of the label
- Manufacturer and model
- Expected annual electricity bill with the concerned device
- Rating system

▪ In case of non-compliance, the name of the company and fine are made publicly available.

Russia

The Gosurdarstvennyy Standart (GOST) R 51388-99 lays down the rules for delivering the information about energy performance of domestic electric appliances to consumers. The standard determines the general requirements, the rules and the amount of information to be given to consumers as well as energy performance classes, indices of saved energy costs, and other parameters of appliances.

Electric cooking ranges and ovens are in the list of domestic electric appliances which require a labelling scheme. Information about efficiency performance is delivered by providing an energy performance label, which contains indicators of energy efficiency and data on compliance of these indicators with requirements of respective standards. Energy labels are assigned to the appliances for a period of three years at most. The indicators of energy performance of appliances are described in GOST R 51541-99. GOST 14919-83 sets energy performance requirements of domestic electric cooking ranges, cooking plates and cooking ovens. An average consumed power can be calculated according to the formula that includes the size, the number of cycles and the time.

Costa Rica

Costa Rica has a programme of labels that must be placed on products prior to leaving the factory or customs. Non-compliance results in a fine of 25% of the product sale price. The label displays the products energy consumption and the required MEPS level for that compliance.

▪

1.4 Recommendations

1.4.1 Preliminary product scope

In Section 1.1 of Task 1, a review has been completed on domestic cooking appliances regarding definitions and scope. Preliminary recommendations on these two aspects are summarized below.

Definitions

The definitions of domestic cooking appliances making use of data from Eurostat (NACE Rev2 database) is not straightforward. First, there are several product codes which could be interpreted as falling within the scope of this study, as presented in Table 4. Although there is a high level of granularity in the data available in NACE Rev2 database for domestic cooking appliances, the definitions of ovens and hobs are not obvious, since there are overlaps between these two product types. As it can be seen in Section 1.1.2.2 of this report, certain product categories refer to only one of those type of appliances (such as 27.51.28.70: *"Domestic electric ovens for building-in"*), whereas other categories refer to appliances which include both (27.51.28.10: *"Domestic electric cookers with at least an oven and a hob"*).. For this reason, in Task 2 of this Review Study, a differentiation will be made between "standalone ovens", "standalone hobs" and "ovens with hobs" (also known as cookers or ranges). On the contrary, the definition of domestic range hoods is simple in NACE Rev2 database, making the analysis of data for this appliance easier and straightforward.

In the case of commercial and professional appliances, Eurostat does not provide a high level of granularity, as only three categories are available: bakery/biscuit ovens, infra-red radiation ovens and equipment for cooking/heating food. Using this product classification, there is no clear differentiation between ovens, hobs and range hoods. No detailed data is provided either regarding energy source of commercial and professional cooking appliances.

Product definitions are clearer in Regulation (EU) No 65/2014 on Energy labelling and Regulation (EU) No 66/2014 on Ecodesign. Ovens, hobs and range hoods are clearly distinguished and further product category definitions are provided for each of them (for instance, definitions are provided for *small*, *portable* and *microwave* ovens). In addition to that, regulation defines its scope as "*domestic ovens (including when incorporated in cookers), domestic hobs and domestic electric range hoods, including when sold for non-domestic purposes*". Therefore, current legislation seems to acknowledge the possibility of using these appliances outside the household sphere.

Some modifications were suggested by stakeholders that are taken into account in this preliminary scope proposal. Based on the information available, the following changes on the definitions of domestic cooking appliances covered by current legislation are recommended:

- In order to include the filtration function and recirculation systems: in the definition of range hoods and to align the definitions with the IEC 61591

  Range hood means an appliance installed over a hob and through which the air is passed to remove contaminants from the room. It covers the following categories:

  - *Recirculating air range hood: range hood containing filters to remove contaminants after which the cleaned air is discharged back into the room*
  - *Air-extraction range hood: range hood which discharges the collected air to the outside of the building by means of ducting*

  Down-draft system: means a cooking fume extractor intended for installation adjacent to household cooking ranges, hobs and similar cooking appliances that draws vapour down into an internal / exhaust duct. The filtered air may be discharged back into the room or ducted away

- In order to better reflect induction technologies in the definition of electric hobs:

  Electric hob means an application or part of an appliance which incorporates one or more cooking zones and/or cooking areas including a control unit and which is ~~heated~~ supplied with electricity"

- In order to evaluate the current exclusion of small appliances:

Gas hob means an appliance or part of an appliance which incorporates one or more cooking zones including a control unit and which is heated by gas burner"

Other definitions suggested by stakeholders are aimed to improve the performance tests and limit the leeway allowed to manufacturers to choose the settings. In particular, the following definitions were proposed for ovens:

The standardised cycle to be tested is the most basic mode that allows baking or roasting all kind of foods on one or more oven levels at the same time with or without fan.

Ecomode is the mode that allows save energy compared to the standardised cycle. It should be defined in the user manual what it allows to cook, what are its limits.

Scope

Domestic appliances such as ovens or hobs using energy sources beyond electricity or gas, microwaves, portable ovens, small ovens, outdoor cooking appliances, among others, are not included within the scope of the current regulations. There are divergent views among stakeholders about their inclusion in the scope of this review. There is broad agreement regarding some specific products, which should be covered by the scope according to stakeholders:

- Combi steam oven
- Gas-cooking appliances designed for use only with LPG.
- Range hoods without lights
- Range hoods with mood lights

There is no similar agreement regarding the exclusion of the following products proposed by some stakeholders:

- Ovens with microwave function and solo microwave ovens
- Steam ovens
- Grills and grill ovens
- Only recirculation hood
- Hoods without integrated fan for use with a central fan.

The latter appliances are proposed to be incorporated in this preliminary scope in order to evaluate along the review process whether their current exclusion is still valid. For example, the exclusion of *ovens which offer 'microwave heating'* function needs to be reviewed since this microwave heating function may be becoming a standard feature. In any case, the reasons provided from stakeholders for their exclusion (i.e. low frequency of use, small market share, lack of performance test method) will be part of this review process.

Appropriateness of including professional cooking appliances within the project scope

A relevant topic at this point is the potential inclusion of professional cooking appliances under the project scope. In Article 7, ecodesign regulation 66/2014 indicates that:

> *The review of the regulation shall assess, amongst others, the inclusion of professional and commercial appliances.*

On this topic, two aspects need to be addressed, as summarised in **Figure 5**.

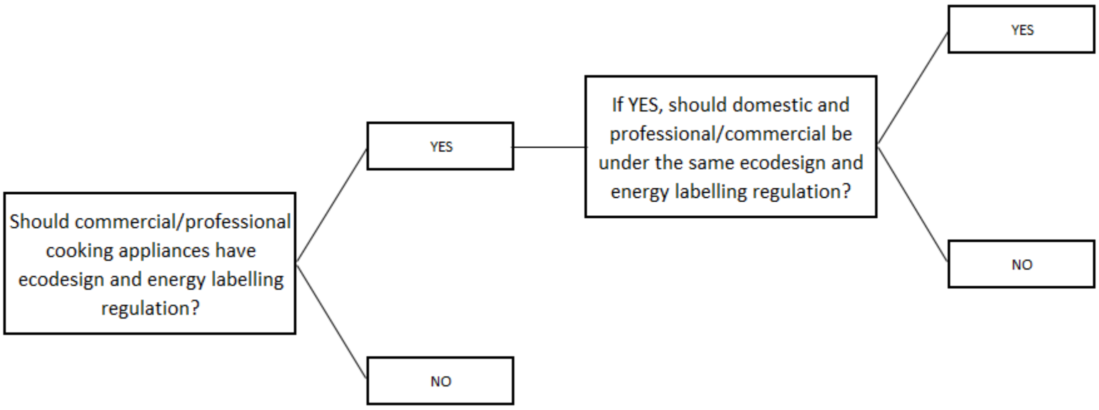


Figure 5. The potential inclusion of commercial cooking appliances within project scope

First of the aspects to consider is whether commercial and/or professional cooking appliances should have ecodesign and energy labelling regulation. Consulted on this aspect, stakeholders have mixed opinions.

Against the development of regulation, three main arguments are provided.

- Users of commercial and professional cooking appliances have very different needs to the users of domestic appliances. This leads to significantly different intensity of use, cooking options, temperature settings as well as performance and durability requirements.
- Commercial and professional products have a much wider variability than domestic products, making it more difficult to standardize requirements
- Commercial and professional products are often conceived as part of a system, with modular designed in combination with other appliances in the kitchen

In favour of developing regulation two main arguments are provided:

- The commercial and professional sector is potentially a high impact sector from the energy consumption point of view (initial exploratory calculations indicate it might be around half the energy consumption of the domestic market, with a significantly lower market share).
- Having ecodesign regulation could be a relevant driver to energy efficiency in the commercial/professional sector.

If regulation is developed for commercial and professional cooking appliances, stakeholders also have mixed opinions whether they should be covered under the same regulation as domestic appliances, or whether they should have their own specific regulation.

In favour of having the same regulation for domestic and commercial/professional cooking appliances, two main arguments are provided:

- The function of domestic and commercial/professional cooking appliances is essentially the same (cooking food), therefore they should be covered under the same ecodesign/energy labelling regulation.

- Separating the review of domestic cooking appliances regulation from the development of new regulation for commercial/professional appliances would delay the adoption of measures in this sector

In favour of having two different regulations (one for domestic and a new one for commercial/professional), two main arguments are provided:

- Different user needs and significant product variability would make it particularly difficult to establish requirements which are satisfactory for all product types. Incompatibilities of definitions, formulas and energy categories are expected if domestic and commercial/professional are included under the same regulation

- The lack of harmonized European standards for commercial/professional products complicates the fair comparison between products and the definition of minimum requirements and energy categories (availability of standards will be covered in detail in Section 1.2 of this report)

Considering the reasoning above provided by relevant stakeholders, it has been concluded that regulation for commercial/professional cooking appliances is necessary, since it is potentially a high impact energy consumption sector with possibilities for improvement. Regulation in the commercial/professional sector could boost innovation and be a driver for efficiency.

In order to provide appropriate ecodesign requirements, the regulation for commercial/professional cooking appliances is proposed to be specific and separated from the domestic cooking appliances regulation. This will ensure that every requirement and energy labelling category defined are suitable and meaningful, considering sector-specific user needs.

1.4.2 Tests and methodologies

Ovens

- In current version of the regulation, manufacturers declare energy consumption based on their best performing energy mode. Manufacturers may use so called "ecomodes" for energy consumption declaration, modes which might differ greatly between similar products in terms of temperature profiles and that might not be able to cook a wide range of recipes. Some stakeholders indicate that, in order to ensure fair comparisons between products and that energy consumption declaration reflects a common use of the appliance, energy consumption declaration of domestic ovens should be based on a standard heating function, present in every oven in the market, representative of real-life use of ovens across the EU, able to cook a wide range of dishes. During the development of this preparatory study, the benefits and disadvantages of using a common standard heating mode for energy consumption declaration of domestic ovens will be discussed.
- In current version of the regulation, energy consumption declaration is based on the energy consumption observed using different heating functions (3 for electric and 2 for gas) and temperature settings (3 in both types of ovens). However, if the highest of these temperatures cannot be reached by the oven, the standard requires using the maximum reachable value by the appliance. Also, it has been observed that in some occasions, this temperature is only reached at the beginning of the test cycle, decreasing after that in order to obtain lower energy consumption declarations. In the next version of the regulation, it should be ensured that energy consumption declarations are based on the same temperature settings for every oven, both in terms of maximum temperature and duration of the cycle with this temperature.

- The volume of the oven cavity is used to calculate the Energy Efficiency Index. With the current definition of the EEI calculation, larger cavity volumes lead to better EEI results. EN-60350-1 allows to conduct the measurement of the oven cavity after removing "not essential removable items". This may lead to higher declared volumes compared to real-life usage of the ovens, in order to obtain better EEI values. However, one might argue that this additional volume being declared after removing these items is still a usable volume from the cavity (used for circulation of heated air). Moreover, there is currently no evidence that the benefit in terms of EEI being obtained by declaring cavity volumes in this way is not reflecting appropriately the real life usage of ovens. Therefore, unless evidence is found showing that manufacturers are declaring significantly better EEI values by measuring larger cavity volumes, in next version of the regulation it appears reasonable to continue with the way in which the cavity volume of the oven is measured today. If evidence becomes available during the development of this preparatory study, the possibility of restricting the amount and type of components that can be removed at measuring may be evaluated.
- In current version of the regulation, energy consumption declaration is based on EN-60350-1, making use of a standard load (a brick). It has been argued that using a brick to declare energy consumption is not appropriate, as this load is not able to compare cooking performance of different ovens (for instance in terms of doneness or browning). Test methods based on the cooking of a standard meal (a standard cake) are currently under investigation. Against this proposal, it has been argued that measuring energy consumption with real food is not possible, as food can only be standardized to very limited extent, leading to high uncertainties, as well as repeatability and reproducibility issues. Currently there is not significant evidence proving that the brick method test does not represent appropriately a standard meal, and investigations to define a measuring method with real food are still ongoing. If repeatable and reproducible methods to measure energy consumption of domestic ovens using real food become available during the development of this preparatory study, the possibility of replacing the brick method may be evaluated.
- In current version of the regulation, ovens which are heated with steam as primary function are not included in the scope. Therefore, energy declarations of solo-steam ovens or steam heating functions in combi-steam ovens are not required. Market and user behaviour analysis are needed in order to determine whether the use of steam heating functions has a significant role in the overall energy consumption in Europe. If the use of these heating modes results to be significant, the possibility of including them in the next version of the regulation may be evaluated. In that case, a specific standard test would need to be defined for these heating functions, in order to be able to measure the amount of steam being used in each product.
- Similarly, in current version of the regulation, ovens which offer microwave heating function are not included in the scope. Therefore, energy declarations of solo-microwave ovens or microwave heating functions in "combi" ovens are not required. Market and user behaviour analysis are needed in order to determine whether the use of microwave heating functions has a significant role in the overall energy consumption in Europe. If the use of these heating modes results to be significant, the possibility of including them in the next version of the regulation may be evaluated. In that case, a specific standard test would need to be defined for these heating functions, as the brick method is not suitable for microwave ovens.
- Pre-heating the oven is a widespread practice among consumers with a potentially significant energy impact. However, this practice is only required for a limited amount of recipes and is not considered an energy efficient user behaviour. Declaring energy consumption of the pre-heating phase could send a misleading message regarding the appropriateness of this activity. If results from the user behaviour study indicate that overall energy consumption of pre-heating is significant, different options to address this issue may be evaluated in this preparatory study.
- Self-cleaning systems such as pyrolysis are widespread feature in current domestic ovens that incur in large energy consumptions due to high temperatures required. Declaring energy consumption of self-cleaning systems is however difficult since currently there is no subjective

method to evaluate level of cleanliness of ovens, making the comparison of the performance of this feature not feasible. If repeatable and reproducible methods to measure energy consumption of self-cleaning systems in domestic ovens become available during the development of this preparatory study, the possibility of including energy consumption declaration of this feature will be evaluated.

Gas hobs

- Small (auxiliary) burners with a nominal heat input under 1,16 kW are not covered by the current standard, since the test procedure is not optimal for them (they are not normally used for boiling big amounts of water). If small burners are to be included in the scope of Ecodesign, a test should be developed
- The intermediate rounding of the energy efficiency of gas hobs should be removed to enable the repeatability of results.

Range hoods

- Real-life representativeness

The best efficiency point (BEP) defined by the highest value of flow rate times pressure divided by power input. The BEP is not the usual mode that range hoods operate in real life. Therefore, the energy efficiency rating should be based on measurements at lower pressures which resemble an average scenario in households.

It is recommended to follow the suggestions from stakeholders, and shifting the measurement of efficiency from best efficiency point to typical uses, with a typical pressure drop over the exhaust piping. To allow for this, stakeholders proposed to develop a pressure – airflow curve and the corresponding electric power curve for the minimum and maximum continuous modes and for the boost mode, and to include these in the test reports together with the efficiencies calculated based on the measurements. Then, it will be possible to base ecodesign regulation and energy labelling on energy efficiency requirements at a typical working point for the fume extractors.

- Odour reduction and recirculation hoods

There is a debate about whether the regulation should be based on the primary function of a range hood, instead of energy efficiency in relation to airflow and pressure. Those in favour of including the primary function performance in terms of odour reduction argue that current ecodesign and energy labelling regulations push manufacturers towards high air flow products, instead of optimal products.

This discussion is linked to the absence of a standard for recirculating (ductless) range hoods. In the view of some stakeholders, this prevents the comparison to models that operate in extraction mode. Recirculating hood would perform lower fluid-dynamic efficiencies due to the odour filter, but there would be a certain trade-off derived from the energy saved for space heating, since no air replacement would occur.

Following this reasoning, some stakeholders recommend that regulations should be based on a calculation which considers the aspects below:

- efficiency of capture cooking odour
- energy consumption of heating or cooling of replaced air
- energy consumption of range hood

According to this proposal, the central ventilation configuration would be the most efficient, resulting in annual energy consumptions one order the magnitude lower than range hoods equipped with an electric motor.

Stakeholders against this proposal argue that the energy efficiency of a product should not depend on external factors, such as heating or cooling systems or ventilation systems, since it would discourage any technological progress within the reach of manufacturers and product designers. Besides, moisture, grease and pollutants from cooking need to be eliminated and, in many cases, the most efficient way is ducting the fumes out of the building.

It is acknowledged that this discussion spins around the type of installation of the range hood, which depends on external factors related to the features of the building. However, the odour reduction performance is a topic that requires to be addressed in this revision of the Ecodesign regulation. It is also essential if the definition of range hoods is to include ductless configurations, since the performance will depend on the capacity to reduce odours, i.e. the performance of the odour filtration. In this regard, EN 61591 contains a test method for the odour reduction with the substance MEK. Although, this method may have a margin for improvement, it can be consider a good starting point.

2 Task 2: Markets

The purpose of this task is to present the economic and market analysis related to the domestic and commercial ovens, hobs and range hoods within the scope of the revision regulations on Ecodesign and Energy Label. The aim of this section is, firstly, to place these product groups within the context of EU industry and trade policy.

Secondly, this section provides market and cost inputs for the assessment of EU-wide environmental impacts of the product group.

Thirdly, it aims at providing insights into the latest market trends in order to identify market structures and ongoing trends in product design. This market data will serve as an input for subsequent tasks such as the base-case analysis and improvement potential (task 5 and task 7 respectively).

Finally, the data on consumer prices and rates is to be used later in the study of the life-cycle-costs (LCC) calculations.

2.1 Generic economic data: analysis of Eurostat data

This section presents an economic analysis based on official European statistics provided by Eurostat[8] concerning production and trade data. For this section, the PRODCOM Annual Data on manufactured goods were extracted for the years 2008 – 2018. The PRODCOM statistics have the advantage of being the official EU-source that is also used and referenced in other EU policy documents regarding trade and economic policy, thus guaranteeing EU consistency.

PRODCOM data is based on products whose definitions are standardised across the European Member States and thus allow comparability between the Member State data. However, as mentioned in Task 1 under product definition, PRODCOM classification is not detailed enough to cover all the products identified in task 1 as there is no specific category for cooking appliances specifically in the PRODCOM database. However, there are several product categories that can be considered (Table 11).

Table 11. PRODCOM product categories related to cooking appliances

Product category	Description
27511580	Ventilating or recycling hoods incorporating a fan, with a maximum horizontal side = 120 cm
27521115	Iron or steel gas domestic cooking appliances and plate warmers
27521190	Other domestic cooking appliances and plate warmers, of iron or steel or of copper, non-electric
27512833	Domestic electric hobs for building-in
27512835	Domestic electric cooking plates, boiling rings & hobs (excluding hobs for building-in)
27512870	Domestic electric ovens for building-in
27512890	Domestic electric ovens (excluding those for building-in, microwave ovens)
27521113	Iron or steel gas domestic cooking appliances and plate warmers, with an oven
27512810	Domestic electric cookers with at least an oven and a hob (including combined gas-electric appliances)
28211330	Electric bakery and biscuit ovens
28211357	Electric infra-red radiation ovens
28931580	Non-domestic equipment for cooking or heating food

[8] https://ec.europa.eu/eurostat/web/prodcom/data/database

The above product categories have been divided in the first place between Domestic Appliances and Commercial Appliances. This document covers the analysis only for Domestic Appliances. Data will be presented graphically to establish differences between specific appliances, as explained below and in Figure 6.

Range hoods are a relatively independent category from the rest and needs no aggregation with other categories:

- Appliances under PRODCOM category 27511580 *"Ventilating or recycling hoods incorporating a fan, with a maximum horizontal side = 120 cm*2" will be considered a "**range hood**"

In the case of hobs (hobs which are sold isolated, without an oven), the below PRODCOM categories have been aggregated:

- Appliances under PRODCOM category 27521115 *"Iron or steel gas domestic cooking appliances and plate warmers"* will be considered a "**gas hob**"
- Appliances under PRODCOM category 27512833 *"Domestic electric hobs for building-in''* and every appliance under PRODCOM category '27512835 *"Domestic electric cooking plates, boiling rings & hobs (excluding hobs for building-in)"*, will be both considered as "**electric hobs**"
- Appliances under PRODCOM category 27521190 *"Other domestic cooking appliances and plate warmers, of iron or steel or of copper, non-electric"*, will be considered a "**non-electric hob**"

Under domestic ovens, a distinction has been made between ovens and cookers (ovens with hobs together). In the case of **ovens**, PRODCOM database only contains electric ovens:

- Appliances under PRODCOM category 27512870 *"Domestic electric ovens for building-in*" and 27512890 *"Domestic electric ovens (excluding those for building-in, microwave ovens)*" will be considered an "**electric oven**". The first of those categories refers to what is also known in the industry as a 'wall oven', or an oven which is installed directly on a wall. The second of these categories refers to what is also known in the industry as a 'slide-in' oven or 'drop-in' oven. As it is not explicitly stated in the dataset titled, it is assumed that ovens under 27512890 do not include a hob on top of them.

In the case of **cookers**, PRODCOM database contains gas and electric ovens:

- Appliances under PRODCOM category 27521113 *"Iron or steel gas domestic cooking appliances and plate warmers, with an oven"* will be considered a "**gas cooker**".
- Appliances under PRODCOM category 27512810 *"Domestic electric cookers with at least an oven and a hob (including combined gas-electric appliances)*" will be considered a "**electric cooker**".

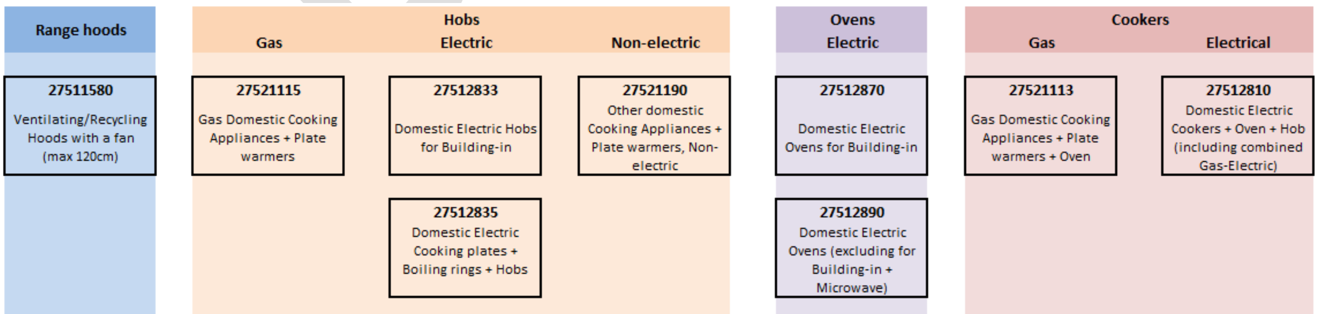


Figure 6. Categorisation for Domestic Appliances

2.1.1 Domestic Cooking Appliances EU28 Production

As it can be observed in Table 12, more than 21.5 million units of cooking appliances were produced in the EU in 2018. The countries with the largest production volume in that year were Italy, Poland (both with more than 7 million units each) and Germany (3 million units). Other significant producers were Spain, France, Portugal and Romania, all of them with over half a million units produced in 2018.

Table 12. Domestic Cooking Appliances – EU28 Production

	Production (Units)									
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
EU28	36,211,659	37,495,114	28,386,050	22,937,009	23,568,566	23,279,865	23,012,964	25,110,192	25,923,847	21,590,706
Austria	0	0	3,964	0	0	0	0	0	0	0
Belgium	0	68,205	67,942	0	0	0	79,123	73,472	66,209	0
Bulgaria	29,791	29,153	22,291	23,714	128,608	33,784	230,084	327,527	219,606	25,887
Croatia	62,282	70,913	58,242	49,869	32,847	22,689	24,036	23,916	24,957	20,306
Cyprus	0	0	0	0	0	0	0	0	0	0
Czech Republic	0	0	0	0	1,250	0	148,276	0	0	0
Denmark	401	986	301	0	0	0	0	1,045	1,642	450
Estonia	104,936	134,103	115,953	107,316	123,722	131,265	113,302	99,189	124,158	151,977
Finland	65,749	84,240	87,781	32,013	15,794	15,580	16,967	17,626	17,383	13,877
France	1,311,238	1,537,643	946,062	832,346	404,640	245,572	271,494	637,048	685,056	531,308
Germany	5,628,908	6,178,750	2,423,548	2,276,133	2,169,888	3,543,068	3,604,799	3,894,092	2,085,104	3,093,057
Greece	86,518	299,786	148,309	56,001	50,058	664	171,758	139,523	3,086	2,479
Hungary	0	0	0	0	0	0	154,840	177,390	9,588	9,065
Ireland	0	0	0	0	0	0	0	0	0	0
Italy	20,688,931	19,952,378	17,071,434	12,206,058	12,530,833	11,025,180	9,650,898	9,617,671	12,240,142	7,788,821
Latvia	0	0	0	0	0	0	0	0	0	0
Lithuania	451	5,068	5,291	4,850	4,328	3,294	2,850	2,482	2,412	2,100
Luxemburg	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0
Netherlands	6,763	7,013	0	0	0	0	0	0	0	0
Poland	4,297,596	5,725,437	5,888,203	6,144,129	6,016,750	6,611,936	6,703,084	7,206,468	7,554,915	7,402,950
Portugal	164,200	169,144	157,987	193,599	496,737	580,569	599,189	506,087	569,910	603,935
Romania	588,457	1,972	8,880	5,037	5,759	558,097	568,407	281,270	563,417	518,145
Slovakia	110,301	149,915	112,975	97,415	81,735	76,179	153,239	358,720	366,237	361,528
Slovenia	0	0	0	0	0	0	28,265	0	0	0
Spain	2,642,891	2,607,929	857,781	647,609	1,147,958	431,988	484,802	1,051,111	983,381	923,547
Sweden	0	0	0	93,058	192,892	0	0	0	0	0
United Kingdom	422,246	472,479	409,106	167,862	164,767	0	7,551	695,555	406,644	141,274

Figure 7 shows the evolution of production volume between 2009 and 2018, by country. It can be seen that total volume in EU28 has decreased from over 35 million units in 2010 to 21.5 million in 2018. The largest decrease is observed in Italy, where 20 million units were produced in 2009, going down to 7.8 million in 2018. Production has also decreased significantly in Spain (from 2.6 million in 2009 up to 0.9 in 2018) and in Germany (from 5.6 to 3.1 million). On the contrary, production has grown in Poland over the period 2009-2018: from 4.3 to 7.4 million. It is difficult to determine whether this overall decrease is real or it is more related to issues with data quality, since there are significant data gaps in the PRODCOM database. For instance, there is no data available on electric hobs (PRODCOM categories 27512833 and

27512835) after 2011 for any of the EU28 countries. It seems likely that the decrease in production observed from 2012 onwards is related to this lack of data on electric hobs.

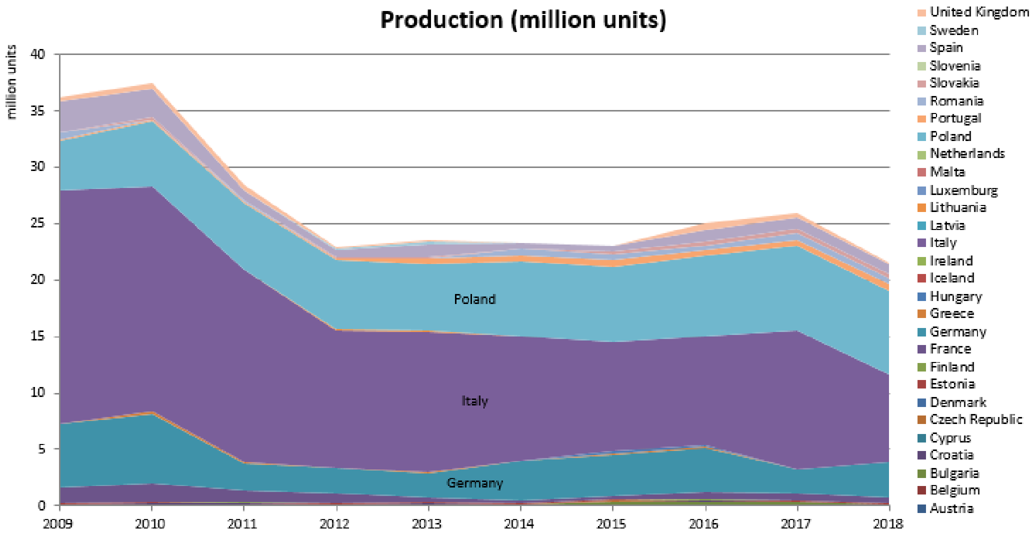


Figure 7. Production volume in units 2009-2018, per country

Figure 8 provides a breakdown of production per type of appliance. As it can be seen, more than 40% of units produced in 2018 were range hoods, followed by electric ovens (29%). This proportion has remained stable in EU28 for the past 6-7 years, being significantly different at the beginning of the period studied, when 25% of units produced were hobs and 13% ovens (range hoods and cookers remained similar as today). As it can be observed, production of electric hobs seems to fall considerably in 2011, although this drop might be related to the lack of data on production of electric hobs after that year.

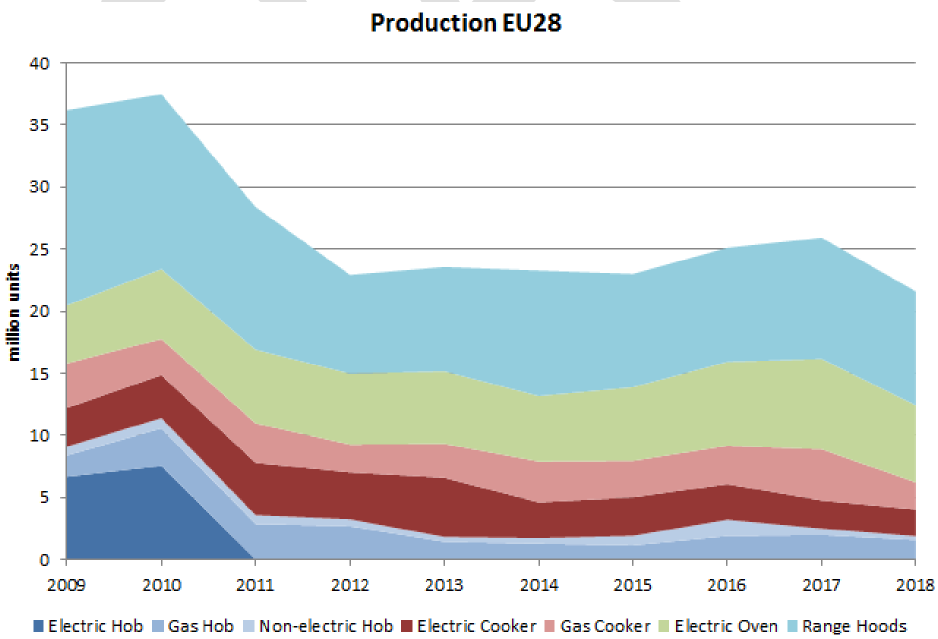


Figure 8. Production volume in units 2009-2018, per type of appliance

In order to evaluate which is the most common **energy source** of the appliances produced in EU28, an in-depth analysis has been carried out in Figure 9 (cookers data for 2009-2018). Over the past 10 years, production numbers have been oscillating without significant differences between them. In 2018, the share of electric and gas was equal. From this data, it appears that for cookers consumers seem to prefer equally electricity and gas. Consistent data from EUROSTAT was not available for hobs.

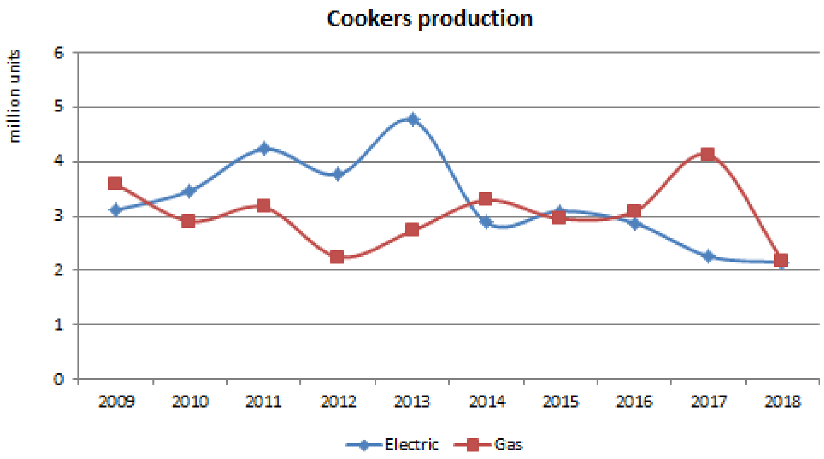


Figure 9. Cookers - Production

In terms of value, domestic cooking appliances market represented a total of 3,659 million Euros in the EU28. This is a 24% decrease when compared to 2009, where the value of this sector was 4,837 million Euros (Table 13).

Table 13. Domestic Cooking Appliances – EU28 Production

	Production (Million Euros)									
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
EU28	4,837.36	5,270.35	4,310.39	3,573.39	3,559.78	3,514.64	3,669.85	3,913.16	4,263.70	3,659.51
Austria	0.00	0.00	6.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Belgium	0.00	36.39	37.77	0.00	0.00	0.00	44.04	43.92	41.79	0.00
Bulgaria	2.97	2.83	3.14	3.29	3.88	4.84	5.89	6.33	6.99	5.97
Croatia	10.47	12.09	11.14	10.89	7.56	5.38	5.90	5.76	6.02	5.62
Cyprus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Czech Republic	1.89	0.00	0.00	0.00	0.00	0.00	17.03	0.00	0.00	0.00
Denmark	0.68	1.66	0.45	0.00	0.00	0.00	0.00	0.02	0.01	0.44
Estonia	1.44	1.85	1.82	1.69	1.84	2.35	2.71	2.22	2.32	2.66
Finland	20.77	29.67	27.56	11.50	5.12	4.58	4.76	4.85	4.66	4.24
France	357.17	371.86	271.76	250.57	173.31	62.68	90.72	164.82	164.80	172.90
Germany	1,646.86	1,715.80	1,154.76	1,063.38	1,082.68	1,124.31	1,173.10	1,394.70	1,290.13	1,172.14
Greece	4.90	10.67	4.51	1.00	1.61	0.19	30.44	27.26	1.72	1.61
Hungary	0.00	0.00	0.00	0.00	0.00	0.00	1.80	1.90	0.08	0.07
Ireland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Italy	1,463.25	1,616.59	1,685.99	1,334.28	1,234.66	1,364.73	1,299.99	1,272.54	1,553.27	1,262.98
Latvia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lithuania	0.10	1.90	2.17	1.98	2.24	1.36	1.19	1.13	1.02	0.94
Luxemburg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Malta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Netherlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poland	530.84	658.53	673.98	703.88	694.69	696.90	743.56	690.58	804.33	735.33
Portugal	25.82	28.93	27.54	33.17	49.23	55.29	55.13	41.46	45.93	47.87
Romania	64.30	0.14	0.83	0.62	0.68	65.72	67.66	27.57	62.23	62.36
Slovakia	16.27	17.88	16.48	15.08	13.95	13.61	12.46	0.00	0.00	0.00
Slovenia	0.00	0.00	0.00	0.00	0.00	0.00	1.48	0.00	0.00	0.00
Spain	393.50	401.28	77.88	48.74	177.02	42.78	47.22	112.48	115.83	107.55
Sweden	0.00	0.00	0.00	20.33	35.47	0.00	0.00	0.00	0.00	0.00
United Kingdom	296.13	362.27	306.22	72.99	75.86	69.92	64.77	115.62	162.57	76.82

As it happens in volume production in units, the countries with the largest production value are Italy, Germany and Poland (Figure 10). In a similar way, the most significant decreases in the 2009-2018 period have been observed in Germany (29%) and Italy (14%). Poland has increased the value of their production in 39% in the same period (from 531 to 735 million Euro).

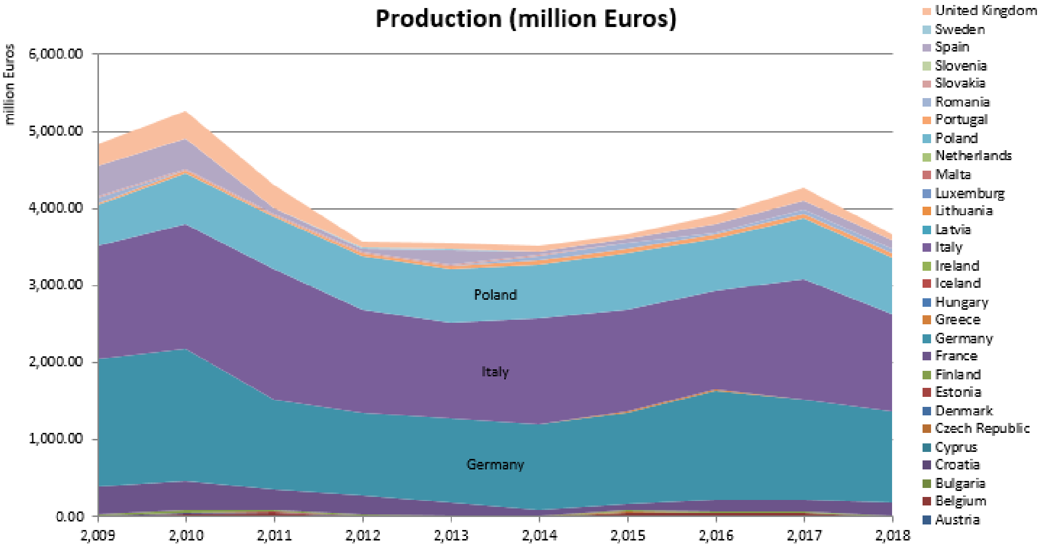


Figure 10. Production value, per country

Analysing value per type of appliance (Figure 11), most of the value in 2018 comes from electric ovens with almost 1,500 million Euro (41% of total), followed by range hoods (28%).

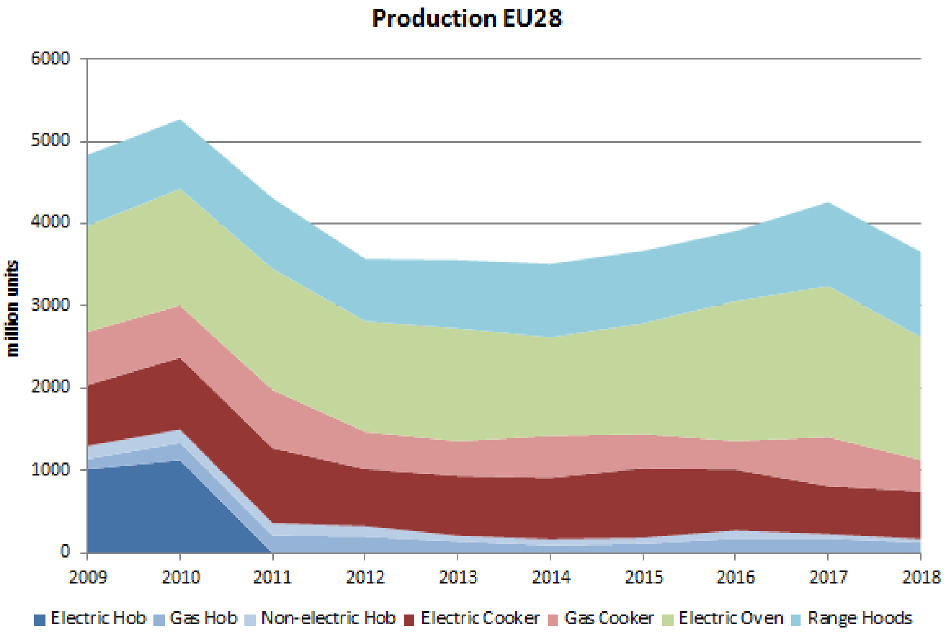


Figure 11. Production value, per type of appliance

Focusing on energy source, in Figure 12 the analysis is conducted on production value in Euros of cookers. The total value oscillates between 2009-2018, generally with considerable higher value of electric ones. Consistent data from EUROSTAT was not available for hobs.

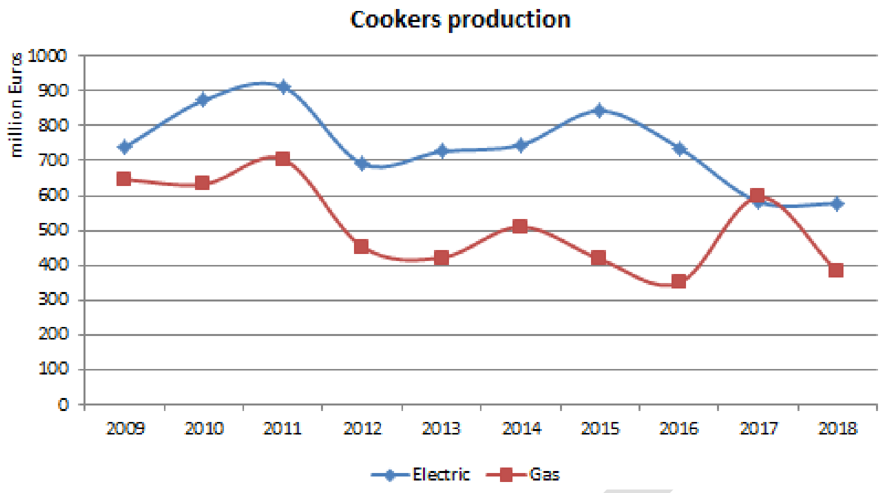


Figure 12. Cookers – Production value

2.1.2 Domestic Cooking Appliances EU28 Import-Export

Table 14 contains data regarding imports and exports in the EU28 for the year 2018, in units and in million Euros. In terms of units, the EU28 is a net importer of cooking appliances: 38 million difference, which is more than double imports than exports. In terms of value, the EU28 appears as a net importer, although the difference is much smaller in this case (4% bigger).

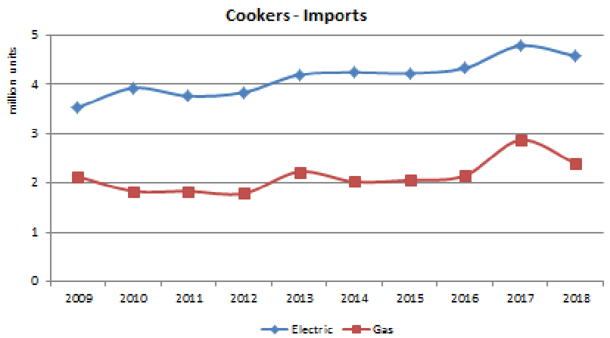
Table 14. Domestic Cooking Appliances – EU28 Import-Export (Units/Million Euros)

	2018 Units		2018 Million Euros	
	Imports	Exports	Imports	Exports
EU28	72,954,454	34,512,531	5,091.87	4,879.79
Austria	1,017,633	520,411	140.15	67.39
Belgium	2,362,485	1,538,027	195.68	90.12
Bulgaria	641,978	47,342	39.91	6.44
Croatia	353,644	61,612	32.49	10.85
Cyprus	88,004	203	8.70	0.19
Czech Republic	16,256,575	1,106,738	102.54	96.08
Denmark	915,319	285,677	154.45	65.82
Estonia	114,375	18,212	15.15	4.41
Finland	409,155	68,974	62.46	5.58
France	8,058,286	1,356,312	652.87	141.58
Germany	7,953,664	4,584,380	912.10	1,279.96
Greece	837,321	299,173	70.19	33.52
Hungary	793,864	97,217	59.28	7.20
Ireland	743,552	51,769	67.05	8.95
Italy	3,874,440	7,323,330	253.72	1,122.12
Latvia	111,027	23,865	11.26	4.35
Lithuania	306,287	113,014	27.70	12.62
Luxemburg	62,585	9,120	17.17	3.56
Malta	50,853	699	6.23	0.96
Netherlands	4,393,885	2,628,905	422.36	247.04
Poland	2,867,573	7,858,365	232.00	851.28
Portugal	747,100	637,973	70.01	47.77
Romania	1,666,554	655,017	112.34	64.84
Slovakia	1,007,804	409,258	64.62	34.11
Slovenia	532,521	922,516	41.76	142.44
Spain	4,974,821	2,201,287	274.04	256.87

Sweden	1,424,249	596,303	231.94	142.41
United Kingdom	10,388,900	1,096,832	813.69	131.35

The largest number of imports in 2018 appear to be in the Czech Republic. However, this number needs to be taken with caution, since it seems too big considering their population (16 million imports for less than 11 million people in that year) and number of imports in previous years in that country (just over 1 million in 2016 and 2017). Countries with a large number of imports are United Kingdom, France, Germany, Spain and Italy. Considering balance import-export, most of EU28 countries are net importers of cooking appliances, with the exception of Poland, Italy and Slovenia.

Focusing on energy source, a clear trend is observed in terms when looking at cookers. Both import and export numbers show a clear preference for electric cookers during the period 2009-2018. Consistent data from EUROSTAT was not available for hobs.



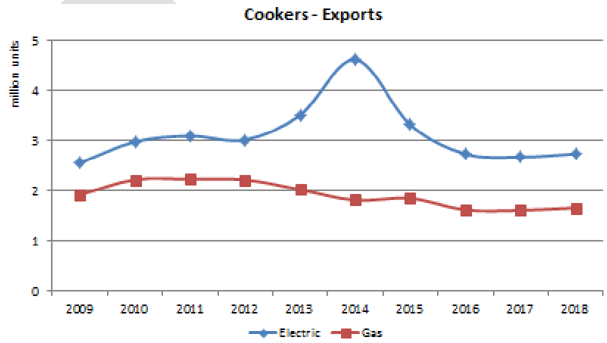


Figure 13. Cookers - Imports/Exports

2.1.3 Average value of Domestic Cooking Appliances

Table 15 provides information regarding the average value per unit of cooking appliances in the EU28. The numbers have been obtained dividing the value of total production in Euros by the number of total units produced, for each year.

Table 15. Domestic Cooking Appliances Average Value (Euro/Unit)

	Average Production (Euro/Unit)									
Product	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Range Hoods	55	60	75	95	99	88	96	93	104	113
Hobs - Electric	153	150	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hob - Gas	72	69	74	75	99	74	98	94	91	81
Oven - Electric - building-in	281	253	249	235	235	227	229	253	253	240
Oven - Electric - non-building-in	132	206	193	249	218	285	n/a	107	118	n/a
Cooker - Electric	237	252	215	183	152	258	272	256	257	269
Cooker - Gas	180	217	223	201	155	155	141	113	144	175

As it can be seen in Figure 14, the average production value of Electric Ovens for building-in (in blue) has remained relatively constant between 275 and 240 Euros between 2009-2018. Electric cookers (in green) has changed significantly between that period, with a lowest average value of 150 Euros in 2013 and a highest of 265 in 2018. Data gaps prevent from providing values for certain years in the case of Electric ovens for non-building-in (120 Euros in 2017). Finally, Gas cookers have average production values that range between 225 Euros in 2011 to 115 Euros in 2016.

In the case of hobs (Figure 15), data gaps prevent from making a full comparison between gas and electric. The production value seems to be considerably higher in the case of electric hobs in 2009 and 2010 (years when there is data available for both energy sources), with values of 150 Euros for electricity and 70 Euros for gas. Range hoods appear to be increasing their production value in the analysed period, with 55 Euros per unit on 2009, up to 115 Euros per unit in 2018.

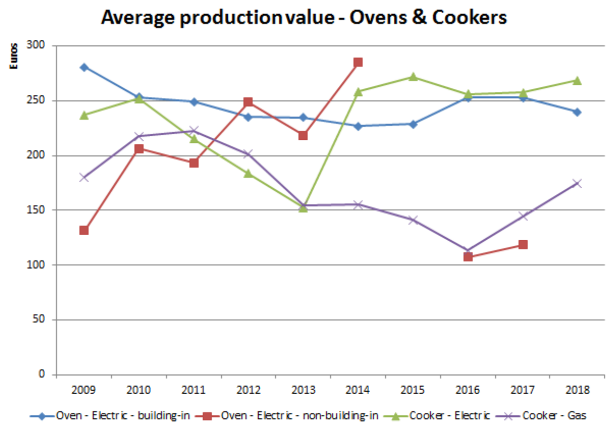


Figure 14. Ovens – Average production value

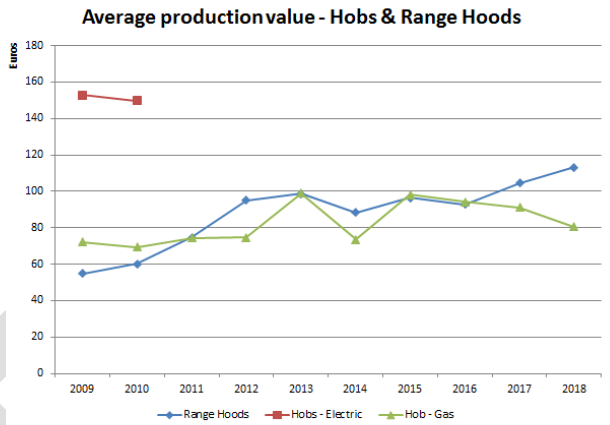


Figure 15. Hobs and range hoods – Average production value

2.1.4 Domestic Cooking Appliances EU28 Apparent Consumption

Apparent consumption is calculated as follows:

Apparent consumption= Production + Imports – Exports

Table 16 shows Apparent consumption for EU28. As it can be observed, most of the values in Table 6 are not available (n/a). This is related to both data gaps and inconsistencies in the PRODCOM database. Most of the data gaps are in Production numbers, since for many member states the databases are incomplete or empty (the clearest example of data inconsistencies found is production numbers which are lower than export numbers).

When such inconsistencies are detected, it is considered that data is either not available or not correct, and then presented as n/a in Table 6. Having data gaps and inconsistencies in mind, the largest apparent consumption in 2018 is observed in Italy (3.4 million), Poland (2 million), Germany (1.9 million) and France (1.7 million).

Table 16. Domestic Cooking Appliances – EU28 Apparent Consumption

	Apparent Consumption (Units)									
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
EU28	28,178,600	26,989,477	19,436,810	13,791,221	14,620,713	13,567,822	12,445,173	14,050,307	16,610,576	11,385,502
Austria	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Belgium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Bulgaria	138,010	137,866	88,142	88,744	87,118	109,533	98,727	104,765	102,165	103,565
Croatia	69,777	85,038	44,941	33,036	27,340	30,525	35,135	38,997	40,882	n/a
Cyprus	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Czech	n/a	n/a	n/a	n/a	n/a	n/a	188,397	n/a	n/a	n/a

Republic										
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Estonia	110,765	142,743	121,259	113,683	132,840	139,823	123,423	109,222	134,758	163,370
Finland	95,725	175,479	211,917	49,227	n/a	n/a	n/a	n/a	n/a	n/a
France	4,288,037	4,577,002	3,825,056	3,364,045	2,779,312	n/a	n/a	1,716,860	3,344,613	1,745,760
Germany	4,341,010	4,596,131	2,102,528	2,163,340	1,201,676	3,075,909	2,999,308	2,337,726	n/a	n/a
Greece	385,969	801,795	207,210	132,330	211,133	n/a	72,320	n/a	n/a	n/a
Hungary	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ireland	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	12,314,850	11,201,852	10,081,036	5,510,996	7,272,428	6,338,180	4,936,129	5,476,890	7,968,893	3,442,724
Latvia	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Luxemburg	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Poland	2,237,386	1,726,734	1,859,280	1,692,256	1,418,051	1,769,750	1,848,946	2,448,254	2,781,206	1,952,010
Portugal	214,316	171,457	140,154	164,131	380,537	543,923	493,341	502,719	263,935	392,404
Romania	549,041	n/a	n/a	n/a	n/a	680,082	686,674	434,739	721,725	679,934
Slovakia	n/a	n/a	n/a	n/a	n/a	n/a	148,693	375,781	417,857	398,524
Slovenia	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Spain	2,639,331	2,611,436	n/a	n/a	321,026	880,097	814,080	n/a	n/a	n/a
Sweden	n/a	n/a	n/a	n/a	284,655	n/a	n/a	n/a	n/a	n/a
United Kingdom	794,383	761,944	755,287	479,433	504,597	n/a	n/a	504,354	834,542	599,885

Table 17 provides value of Apparent Consumption of Domestic Cooking Appliances in the EU28, in million Euros. With the same caution in the analysis as for production units, the largest apparent consumption in 2018 was in Germany (552 million), followed by France (535 million) and Italy (454 million). Significant apparent consumption is also observed in Spain (110 million) and UK (108 million).

Table 17. Domestic Cooking Appliances – EU28 Apparent Consumption

	Apparent Consumption (Million Euros)									
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
EU28	3,380.7	3,684.4	3,090.8	2,192.3	2,149.3	2,015.7	1,923.9	2,385.4	2,609.1	2,004.5
Austria	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Belgium	n/a	49.3	49.6	n/a	n/a	n/a	53.3	52.2	47.5	n/a
Bulgaria	14.3	11.7	10.6	10.6	10.8	14.3	15.0	17.2	17.3	16.7
Croatia	12.8	14.7	12.1	10.3	9.2	10.4	10.3	11.6	10.3	4.2
Cyprus	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	3.7	n/a	n/a	n/a	n/a	n/a	10.5	n/a	n/a	n/a
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Estonia	1.8	2.2	2.0	1.9	2.1	2.5	3.0	2.6	2.9	3.3
Finland	21.4	62.4	63.6	32.6	9.8	4.1	5.8	10.6	4.4	4.3
France	709.2	749.1	620.2	586.2	507.1	184.8	114.0	399.8	472.6	535.3
Germany	1,079.0	1,171.9	733.0	717.0	728.0	769.8	683.3	875.3	641.5	552.2
Greece	12.1	15.2	10.6	n/a	n/a	n/a	13.0	5.5	6.4	6.3
Hungary	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ireland	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Italy	426.2	471.7	736.0	405.2	401.3	493.7	442.5	425.4	729.6	454.9
Latvia	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Lithuania	n/a	1.4	1.5	0.8	n/a	n/a	n/a	n/a	n/a	n/a
Luxemburg	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Poland	154.4	218.0	198.4	162.8	144.3	145.3	155.0	218.4	277.2	82.6
Portugal	38.2	21.2	17.4	32.7	43.6	29.7	43.4	50.3	36.6	43.6
Romania	62.7	3.0	3.6	2.8	2.4	71.2	78.4	46.6	80.4	81.8
Slovakia	15.0	8.5	16.7	15.1	14.3	14.7	14.6	n/a	n/a	n/a
Slovenia	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Spain	377.9	354.6	84.8	77.4	129.6	79.4	83.9	80.1	85.5	110.5
Sweden	n/a	n/a	n/a	27.6	37.7	n/a	n/a	n/a	n/a	n/a
United Kingdom	451.9	529.6	530.8	109.2	109.3	195.9	197.7	189.8	196.8	108.9

For the reasons explained above, it is considered that data quality regarding apparent consumption is not enough to provide meaningful graphical results. Therefore, no further analysis will be provided for apparent consumption.

2.1.5 Extra-EU-28 trade

Table 18 gathers the figures of extra-EU-28 trade with selected countries which represent more than 75% of extra-EU-28 exports and more than 95% of extra-EU-28 imports.

The product groups correspond to the following HS codes:

- 851660: Electric ovens, cookers, cooking plates and boiling rings, electric grillers and roasters, for domestic use (excl. Space-heating stoves and microwave ovens)
- 732111: Appliances for baking, frying, grilling and cooking and plate warmers, for domestic use, of iron or steel, for gas fuel or for both gas and other fuels (excl. Large cooking appliances)

In the case of electric appliances, China and Turkey are by far the largest exporters to the EU-28 (49% and 40% of extra-EU-28 imports respectively). On the other hand, the main destinations of European exports are Russia, Australia, China and the United States.

Table 18. Value of extra-EU-28 trade of electric appliances with some countries in 2018 (Eurostat)

Country	Imports	Exports
China	634 245 921	100 612 573
Turkey	528 046 707	27 319 133
Malaysia	86 811 178	3 732 298
United States	12 234 335	94 270 879
Hong Kong	5 709 010	15 202 327
Serbia	2 011 992	14 867 477
Taiwan	1 988 155	6 373 825
South Korea	1 820 304	27 570 792
Singapore	1 704 045	8 361 531
Ukraine	1 404 234	34 610 528
Thailand	1 270 861	9 206 151
Norway	1 083 978	121 453 708
Indonesia	625 169	1 547 069

Japan	624 994	3 929 680
Canada	240 717	19 073 013
Australia	193 683	125 150 724
Vietnam	74 864	21 355 794
Russian Federation (Russia)	69 092	230 004 617
United Arab Emirates	47 331	12 310 116
Israel	33 537	43 618 547
New Zealand	20 339	20 508 739
South Africa	15 841	19 478 573
Saudi Arabia	1 127	17 168 763

Note: the countries are order from the largest to the smallest value of imports to EU.

In the case of non-electric appliances, China is by far the largest exporter to the EU-28 (68% extra-EU-28 imports), followed by Turkey (20% extra-EU-28 imports). On the other hand, the main destinations of European exports are United States, Australia, Russia and Saudi Arabia.

Table 19. Value of extra-EU-28 trade of non-electric appliances with some countries in 2018 (Eurostat)

Country	**Imports**	**Exports**
China	375 092 998	12 600 823
Turkey	116 123 262	8 182 856
United States	29 894 370	55 343 557
Canada	14 169 773	6 686 856
Ukraine	3 979 038	10 061 102
Hong Kong	2 956 594	4 083 356
Taiwan	2 382 764	835 605
Vietnam	1 369 793	531 532
South Korea	939 235	154 542
Thailand	819 822	661 570
Indonesia	765 870	1 815 000
India	360 229	2 228 625
Japan	339 541	491 556
South Africa	318 414	5 314 808
Serbia	192 561	370 685
Iran, Islamic Republic Of	142 961	1 557 326
Norway	139 960	9 230 970
United Arab Emirates	122 227	13 001 264
Australia	118 927	53 997 405
Egypt	71 381	10 247 344
Singapore	30 616	1 978 795
Israel	21 009	13 550 473
Brazil	18 343	2 735 220
Russian Federation (Russia)	15 899	35 122 692
Lebanon	6 181	8 307 626
Saudi Arabia	4 290	28 409 321

New Zealand	0	3 783 106

Note: the countries are order from the largest to the smallest value of imports to EU.

2.1.6 Conclusions from analysis of Eurostat data

EUROSTAT data represents the official EU source and provides valuable qualitative information about the roles played by each country in this sector. However, as it has already been pointed out in this section, the data needs to be interpreted with caution as there are significant gaps for some countries which prevent from completing a robust analysis.

Moreover, the level of detail provided by EUROSTAT data is not sufficient to conduct a relevant environmental and economic impact analysis. For instance, it does not provide information regarding sales of appliances with different energy efficiency categories, which is essential to understand the benefits provided by ecodesign regulation. Also, the product classification does not differentiate clearly between relevant technologies in each product type (gas, radiant and induction hobs, for instance).

In order to estimate the total energy consumption of the product groups under study, it is necessary to calculate the total stocks of each of them in the EU. An essential piece of information to calculate the stocks are the annual sales, data which is also not available within EUROSTAT database.

Because of these reasons, the subsequent modelling tasks of the preparatory study will not be based on EUROSTAT data. In order to overcome this, relevant data will be obtained from trusted sources with significant expertise in the market of the different product groups. This data will be presented in section 2.2.

2.2 Market, stocks and trends of domestic cooking appliances

2.2.1 Data sources for environmental and economic impact modelling

Alternative data sources to EUROSTAT will be used in subsequent sections of this preparatory study. These data sources are:

- Previous Preparatory study for Ecodesign requirements for domestic cooking appliances (Mudgal et al, 2011)
- EUROMONITOR data for market high level analysis
- GfK data for market in-detail analysis: disaggregated data for five EU countries that represent 58% of EU27 population.

2.2.2 Ecodesign Impact Accounting

The European commission has identified a need to systematically monitor and report on the impact of Ecodesign, energy label and tyre labelling measures, including potentially new forthcoming actions, with a view to improve its understanding of the impacts over time as well as forecasting and reporting capacity.

With contract No. ENER/C3/412-2010/FV575-012/12/SI2.657835, DG Energy contracted Van Holstteijn en Kemna B.V. (VHK) to undertake this exercise. The accounting method developed in this study provides a practical tool to achieve those goals. The accounting covers projections for the period 2010-2050, with inputs going as far back as 1990 and earlier. Studies of 33 product groups (including lots 22 and 23 on domestic and commercial ovens and domestic and commercial hobs and range hoods) with over 180 base case products were harmonized and completed to fit the methodology.

Projections use two scenarios 'business as usual' (BAU) scenario, which represents what was perceived to be the baseline without measures at the moment of decision making and an ECO scenario that is derived from the policy scenario in the studies which come closest to the measure taken. Data used and results obtained in this study regarding domestic cooking appliances are presented in this section.

In terms of sales, gas hobs and ovens were expected to decrease their sales between the period 1990-2050. On the other hand, electric ovens and hobs, as well as range hoods, were expected to grow sales in the same period (Figure 16).

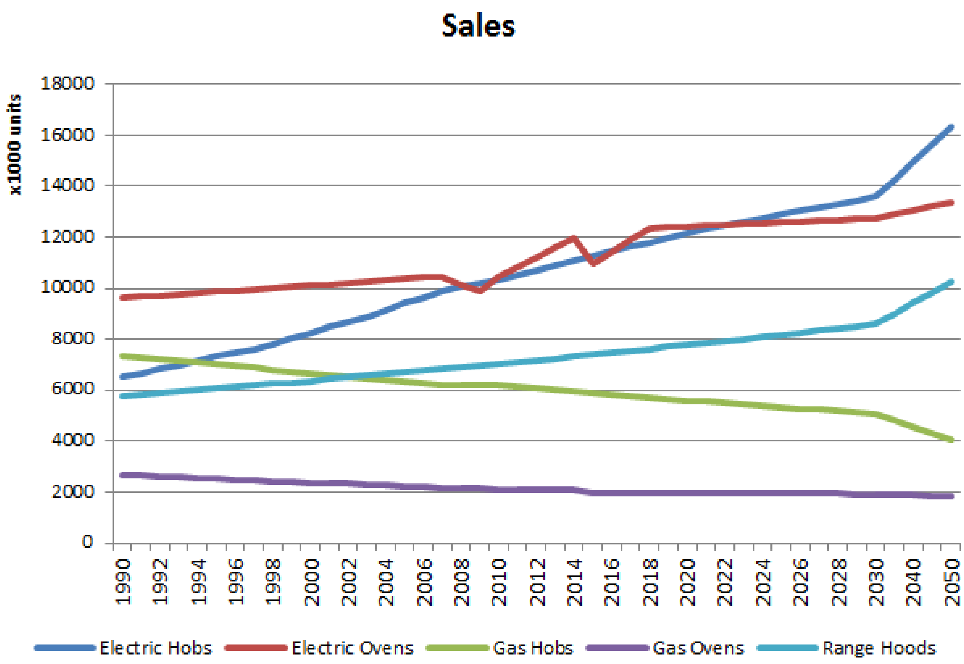


Figure 16. Sales of domestic cooking appliances (VHK, 2014)

Based on yearly sales and on fixed lifetime values for each type of appliance, stock of domestic cooking appliances was also estimated (Figure 17). A significant increase in the stock of electric hobs and ovens was expected for the analysed period, along with range hoods. The total number of gas ovens and hobs present in EU28 households was expected to decrease.

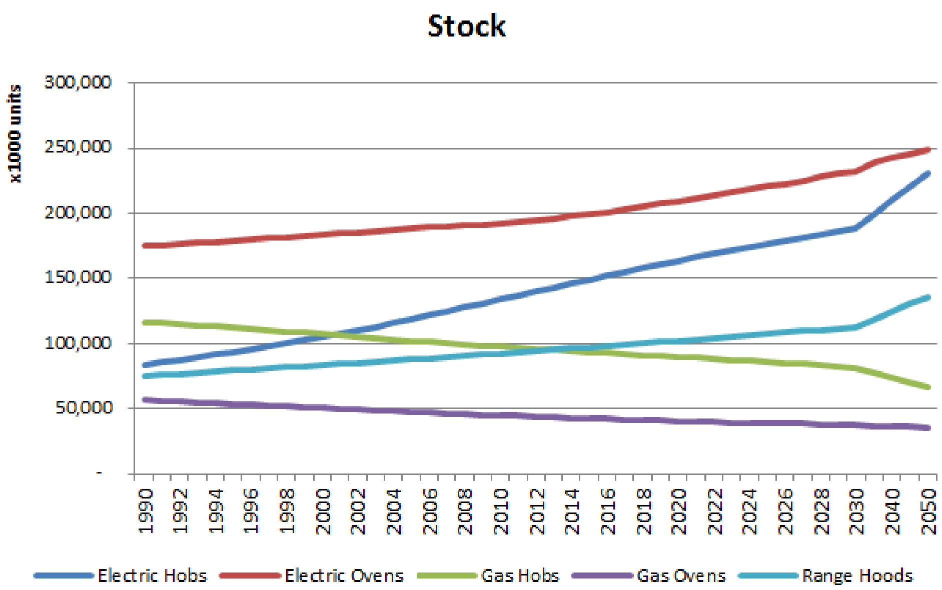


Figure 17. Stock of domestic cooking appliances (VHK, 2014)

Considering technology developments in each product type, energy consumption improvements were estimated for electric hobs, gas hobs, electric ovens, gas ovens and range hoods. These energy consumption improvements were considered in the ECO scenario. Finally, taking into account all the data presented below (sales, stocks, potential improvements), total primary energy consumption was estimated to BAU and ECO scenarios (Figure 18).

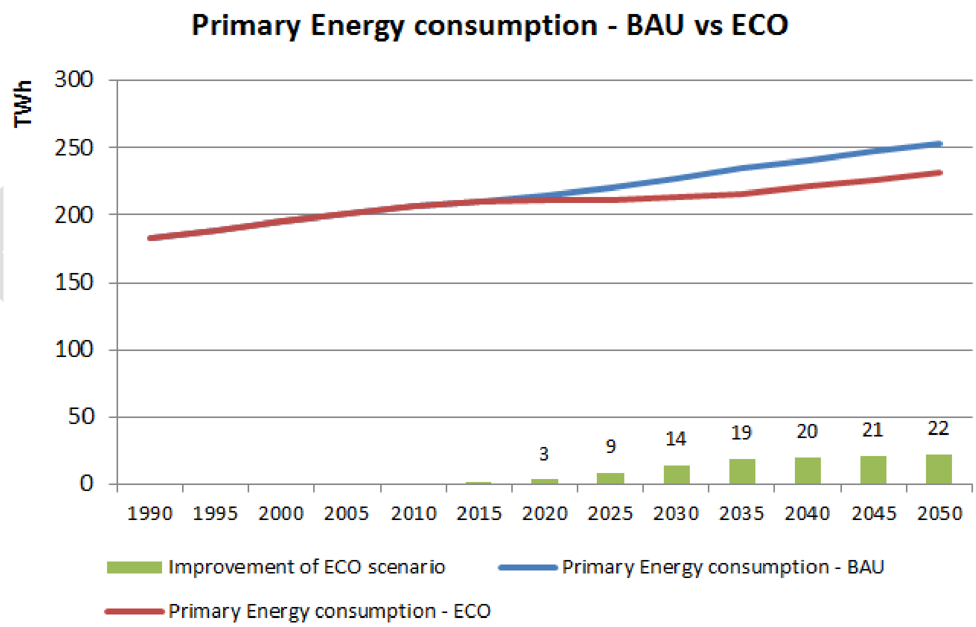


Figure 18. Improvement potential of ECO scenario vs BAU (VHK, 2014)

As it can be seen, technology improvements in domestic cooking appliances start providing a reduction of 3 TWh of primary energy consumption in 2020. By the year 2050, the expected energy consumption reduction of the ECO scenario is of approximately 22 TWh.

2.2.3 Sales of domestic cooking appliances

In this section, data regarding sales of the different product groups is presented. Sources of information are Euromonitor (2019) and GfK (2019).

2.2.3.1 Ovens

Over the period 2015-2018, oven sales have been growing steadily, from nearly 6.5 million units sold in 2015 to slightly over 7 million units in 2018 (Figure 19). The vast majority of ovens sold over that period were electrically heated (sales of gas ovens are so small that they are not visible in the graph).

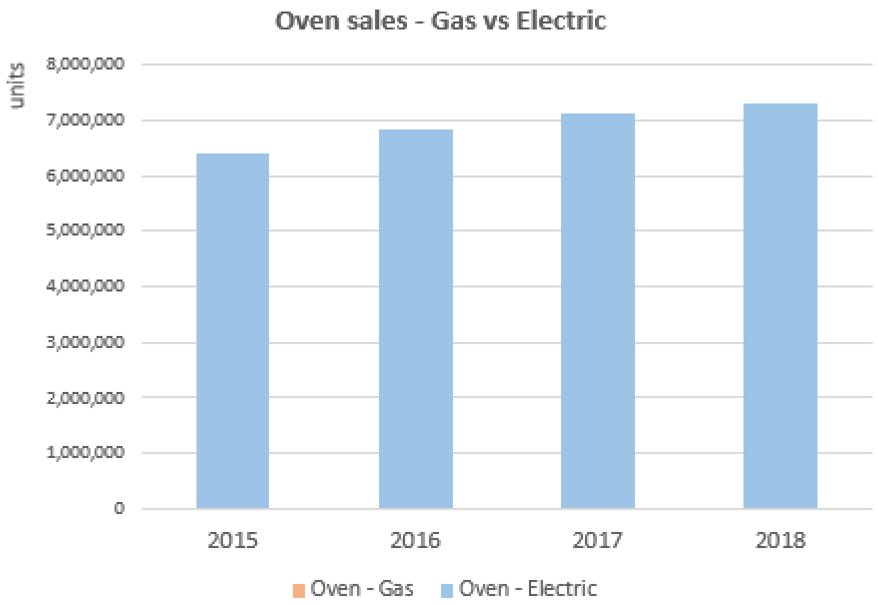


Figure 19. Oven sales 2015-2018

Ovens in the market are currently being offered with a wide variety of modes, including steam-assisted and microwave-assisted heating functions. In Figure 20, data is shown regarding five representative EU countries. As can be seen, steam-assisted ovens tend to be growing over the past years, reaching 200,000 units in these five countries in 2018, with microwave-assisted ovens relatively stable at around 30,000 units. If these numbers are compared with the total market of ovens in those countries, it can be observed that these functions still represent a very low percentage of the market.

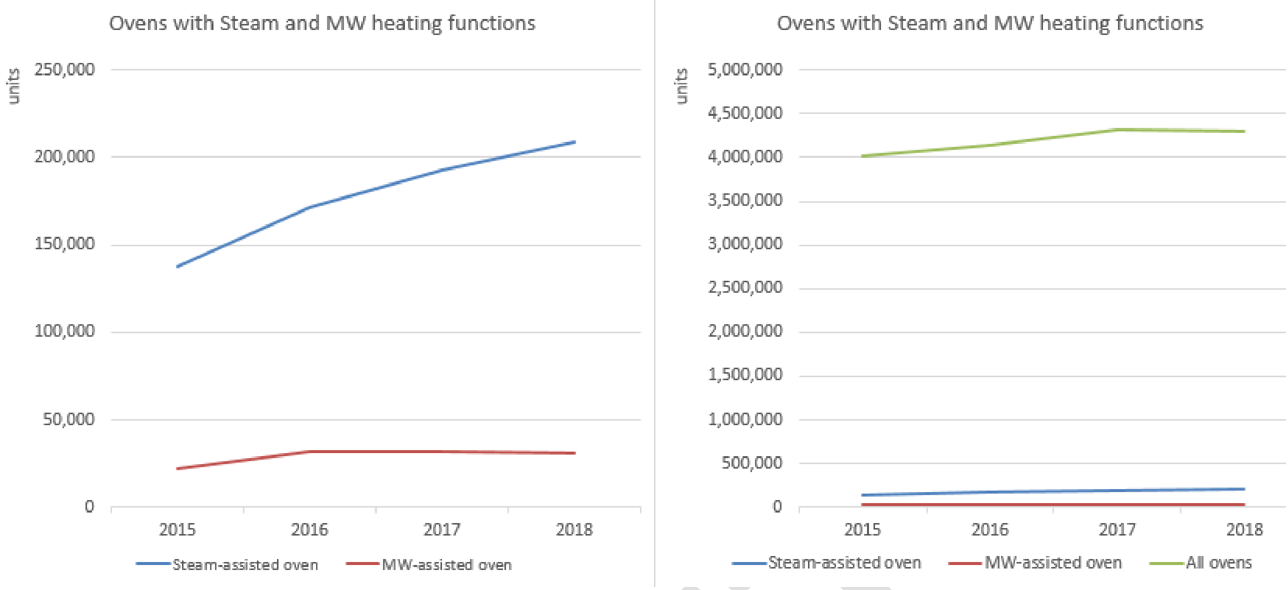


Figure 20. Ovens with steam and microwave heating functions

In terms of cavity volume, there is a growing trend for larger cavity ovens (Figure 21). In 2015, the most popular choice were 55-60 l. ovens, whereas in 2018, the cavity volume with the highest sales was 70-75 l.

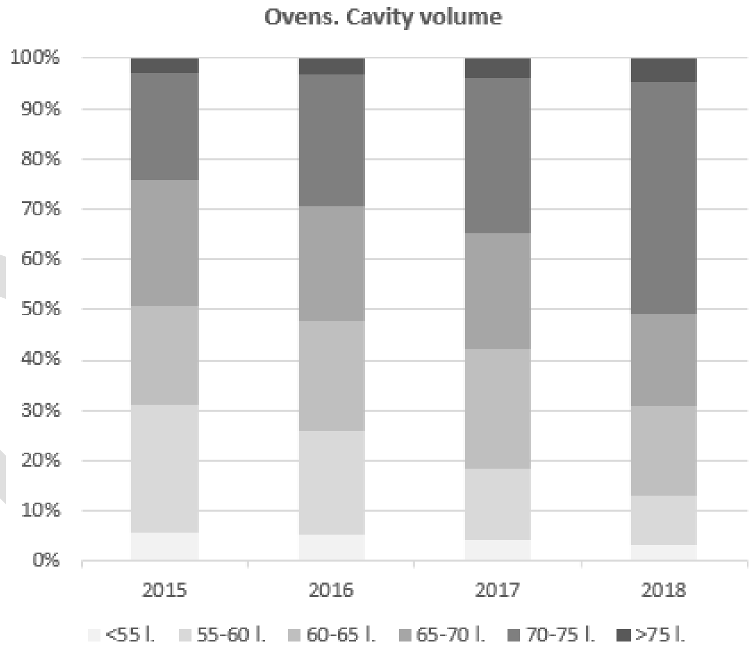


Figure 21. Oven sales - Cavity volume

With the onset of home automation and the Internet of Things, cooking appliances are increasingly equipped with connectivity features. In the recent years, consumers have shown an interest in connected ovens (Figure 22).

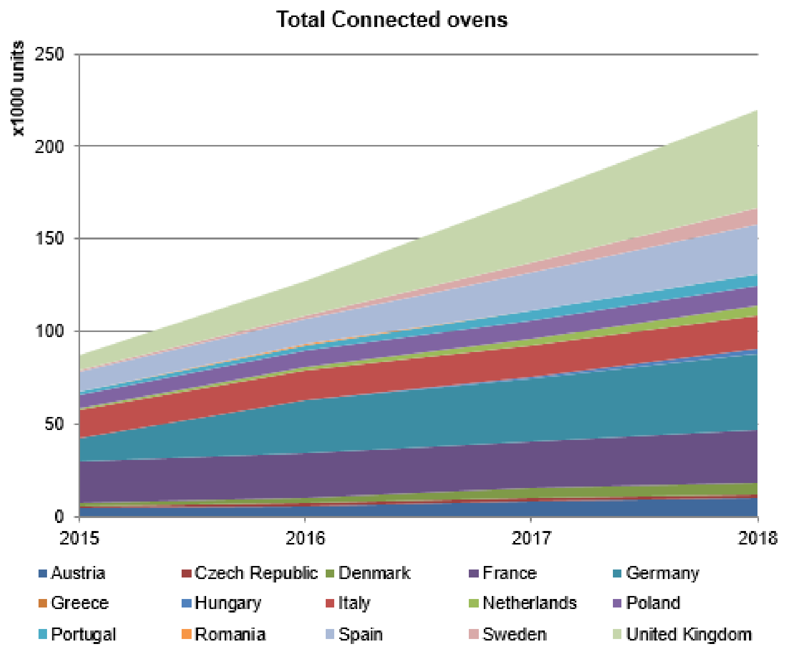


Figure 22. Connected ovens sold in 2018 in 15 EU countries (Euromonitor International, Consumer Appliances, 2019)

As it can be observed, the amount of connected ovens sold in EU28 in 2018 was four times higher than in 2014. The countries where the most units were sold are United Kingdom, Spain, Italy, Germany and France. However, it must be taken into account that in terms of proportion, only 3% of ovens sold in 2018 had connectivity features.

2.2.3.2 Cookers

In terms of cookers, sales decreased slightly over the period 2015-2018, with approximately 2.2 million units sold in 2018 (Figure 23). In contrast with ovens, the proportion of gas heated cookers is 21%, with electricity still being the most popular choice.

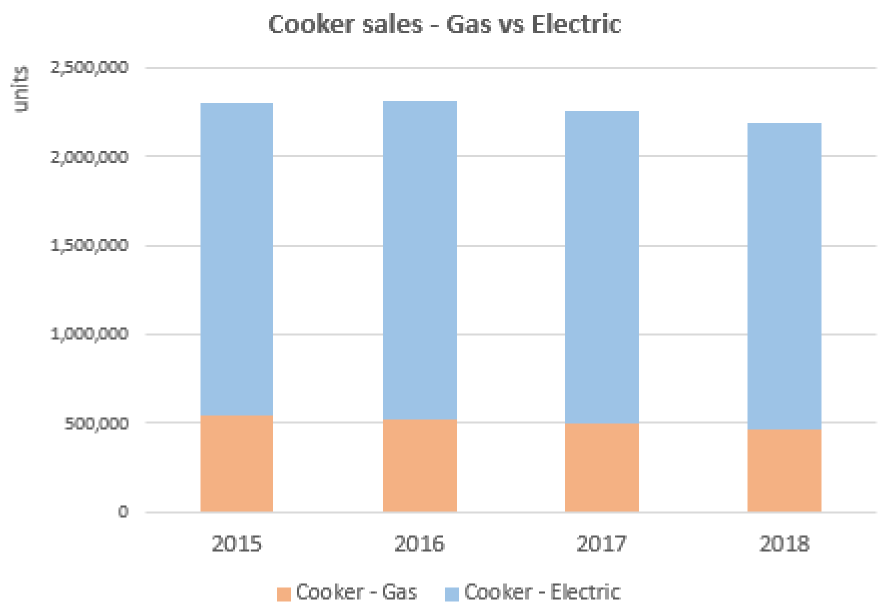


Figure 23. Cooker sales 2015-2018

2.2.3.3 Hobs

In terms of hobs, sales have been growing steadily over the period 2015-2018, from 8.2 million to 9.0 million in 2018. The technology that has been growing the most has been induction: 41% of units sold in 2018 were induction.

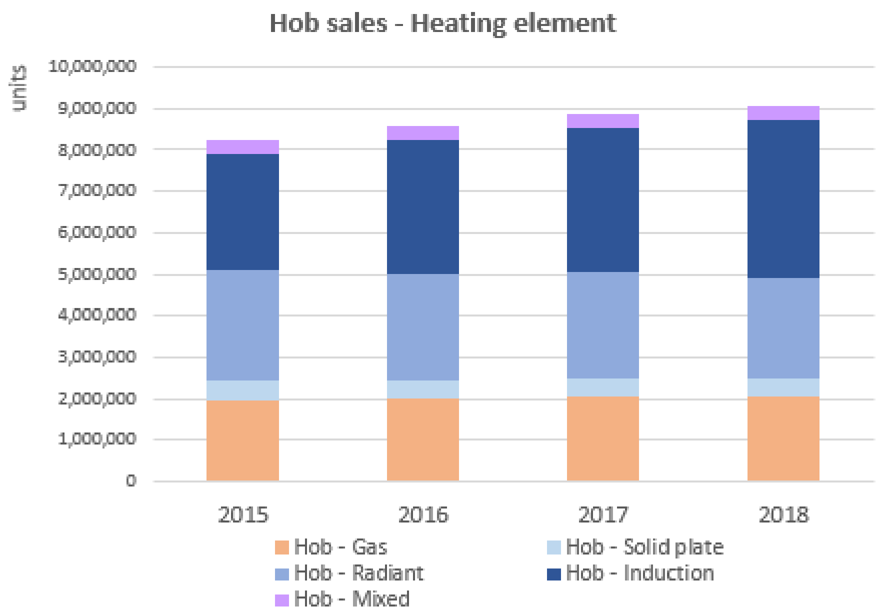


Figure 24. Hob sales 2015-2018

However, significant differences can be observed between different countries and regions (Figure 25).

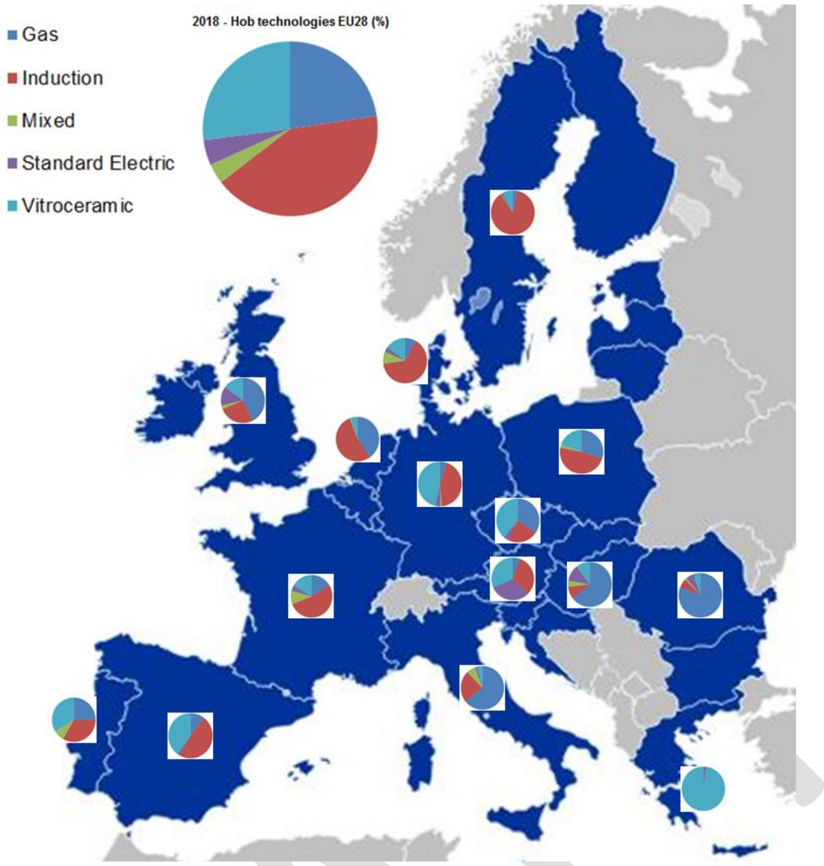


Figure 25. Share of hob technologies in 2018 in 15 EU countries (Euromonitor International, Consumer Appliances, 2019)

In Sweden and Denmark, a remarkable dominance in sales was observed in the case of induction hobs (87% and 65%, respectively). This technology was the choice for most of the consumers as well in Poland, Netherlands, France and Spain. On the opposite side, most of the consumers in United Kingdom, Hungary, Italy and Romania preferred a gas hob in 2018. Finally, the only countries where the most sold hob technology was radiant were Austria, Germany and Czech Republic.

2.2.3.4 Range hoods

Finally, in terms of range hoods, sales have grown from 6.4 million in 2015 to nearly 7 million units in 2018 (Figure 26).

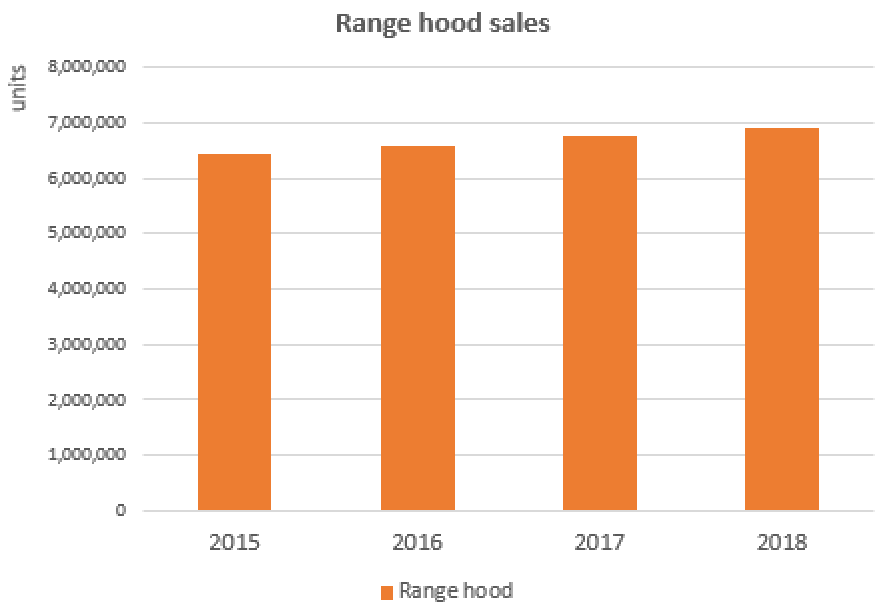


Figure 26. Range hood sales 2015-2018

2.2.4 Energy efficiency classes of domestic cooking appliances

In this section, an analysis is conducted on the distribution of energy classes for the different product groups applicable (ovens, cookers and range hood). Source is GFK market data for five representative European countries, which account for 58 % of the EU27 population. Every graph in this section represents percentages of units sold.

2.2.4.1 Ovens

Figure 27 shows the distribution of energy classes for domestic ovens sold over the period 2015-2018.

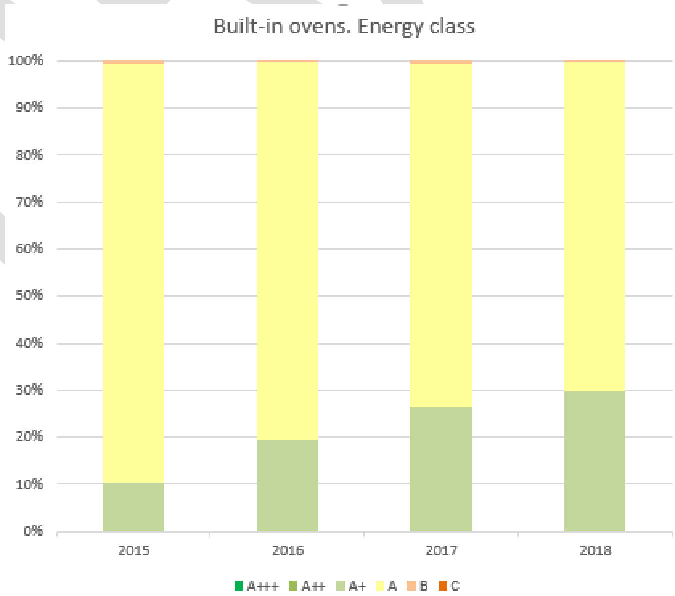


Figure 27. Built-in ovens. Energy class

The most significant points that can be extracted are summarized below:

- There are no A+++ ovens and only 0.06% are A++ (top energy classes)
- A+ category has been growing up to a 29% in 2018
- The vast majority of ovens are either A or A+ (mid energy classes)
- Nearly 70% of ovens in 2018 are A (minimum possible class after 2020)
- 0.24% of ovens in 2018 are either B or C (banned after 2020)
- There are no ovens in the lowest energy class (D)

From the graph, it can be inferred that industry has found it very difficult to reach the top energy classes (A++ or A+++). Less than a third of the ovens in the sample are A+. It appears that with currently available technology, the oven most commonly available in the market is in the A energy class.

An oven characteristic that might have an effect on energy efficiency class is cavity volume. As already seen in Figure 21, consumers are moving from smaller to higher cavity volumes: in 2015, the most popular choice was 55-65 litres, whereas in 2018, the most common was 70-75 litres. To understand whether this shift in cavity volume is having an effect on overall energy consumption, an analysis is conducted on Figure 28, to see whether there is a relationship between cavity volumes and energy efficiency class.

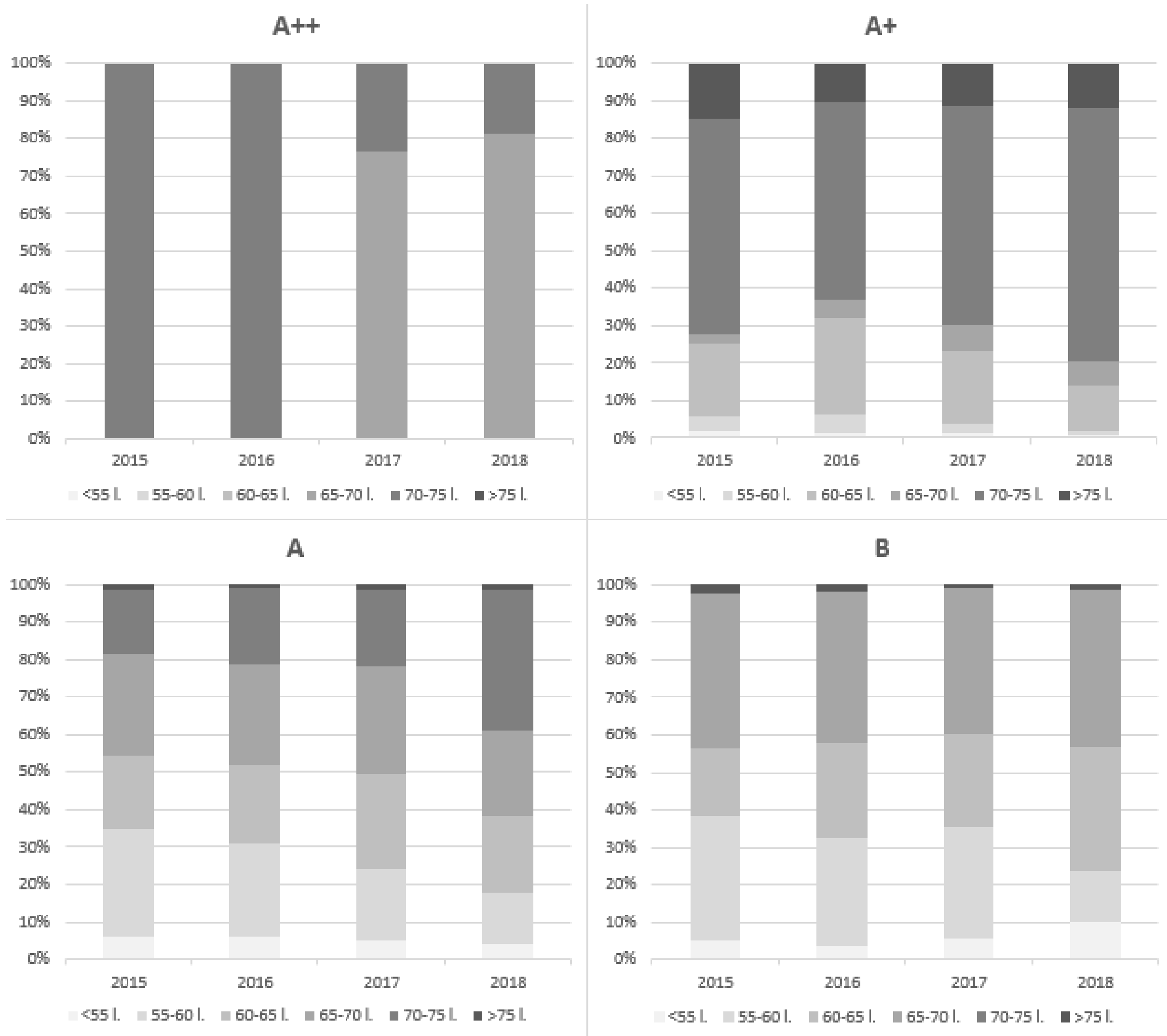


Figure 28. Built-in ovens. The effect of cavity volume on Energy class

A slight trend can be observed from the interpretation of Figure 28. It appears that there is a bigger proportion of larger cavity volumes in the top energy classes (A++ and A+) than in the low energy classes (A and B). There is no clear explanation for this trend at this point. Either it is technically more difficult to achieve higher energy classes with small cavity volumes, or either bigger cavity volumes are considered "high-end" and therefore are equipped with better insulation and energy conservation features which allow them to achieve A+ and A++ classes.

This trend is confirmed when comparing the largest and smallest cavity volumes available in the data sample (Figure 29). Most of the ovens with cavity volume smaller than 55 litres are A, whereas most of the ovens with a cavity volume larger than 75 litres are A+.

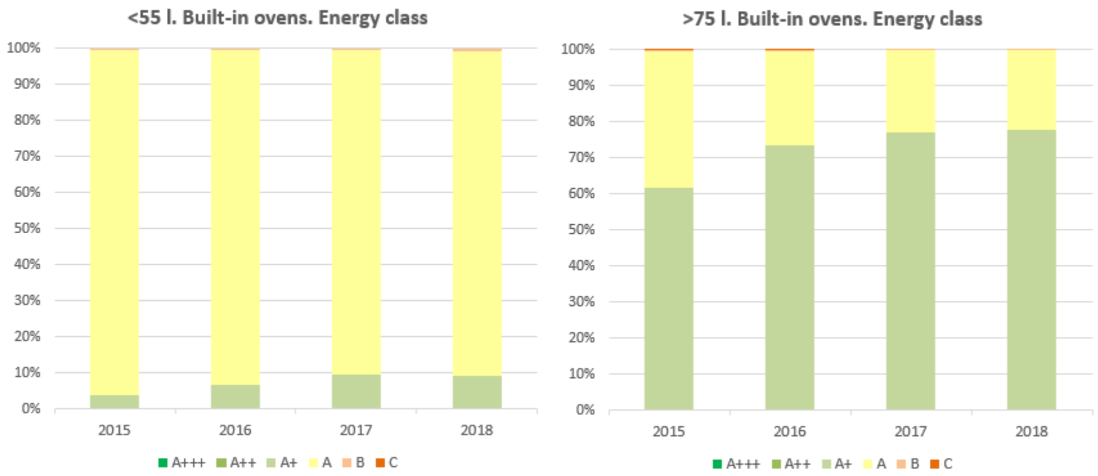


Figure 29. Built-in ovens. Small and big cavity volumes. Energy class

Another oven characteristic that might have an effect on energy efficiency class is the presence of a steam heating function supporting the convective heating process. An analysis is conducted in Figure 30.

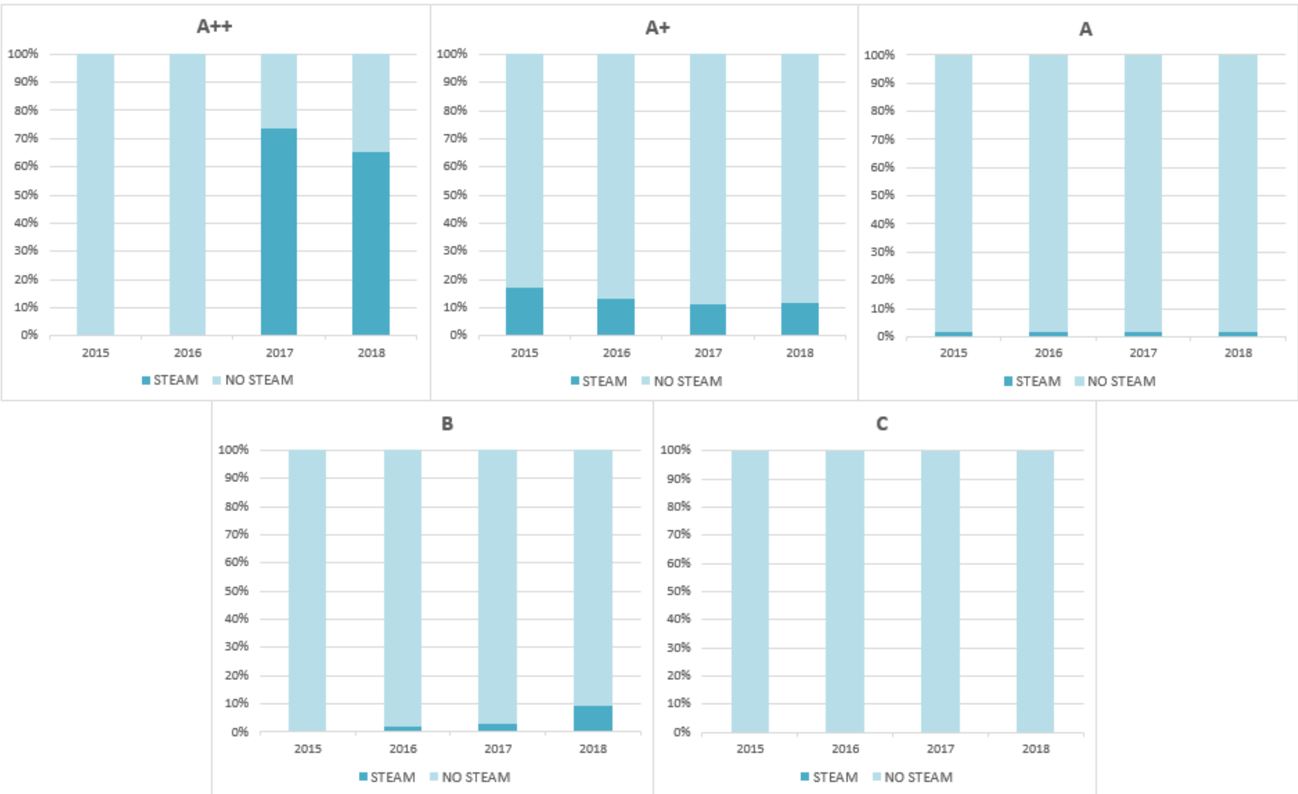


Figure 30. Built-in ovens. The effect of steam heating function

From the interpretation of Figure 30, it appears that there is bigger proportion of ovens with steam heating function in the top energy classes. In fact, nearly 70% of A++ ovens in 2018 had a steam heating function. On the contrary, none of the ovens in C class had this feature. From this graph, it can be inferred that it seems easier to reach top energy classes when the oven has a steam heating function supporting the convective function.

2.2.4.2 Cookers

A similar analysis to the one conducted for ovens is presented for cookers in this section. Figure 31 shows the distribution of energy classes for domestic cookers sold over the period 2015-2018.

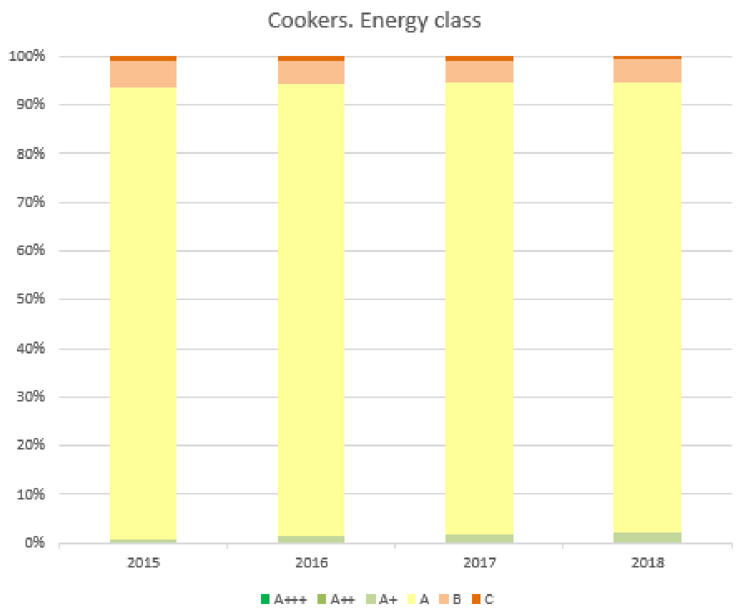


Figure 31. Cookers. Energy class

The most significant points that can be extracted are summarized below:

- There are no A+++ or A++ cookers (top energy classes)
- A+ category has been growing very slowly up to a 2% in 2018
- The vast majority (79%) of cookers are A (minimum energy class after 2020)
- 4.5% of cookers in 2018 are either B or C (banned after 2020)
- There are no cookers in the lowest energy class (D)

From the graph, it can be inferred that industry has found it even more difficult to achieve top energy classes in cookers. Only a residual percentage of these appliances (2%) has reached the A+ class. It could be interpreted that cookers are 2-in-1 appliances (oven + hob) with lower energy efficiency than their individual counterparts.

As in the case of ovens, in Figure 32, the distribution of cavity volumes sold in the five representative European countries are presented. For easier interpretation, darker colours represent larger cavity volumes.

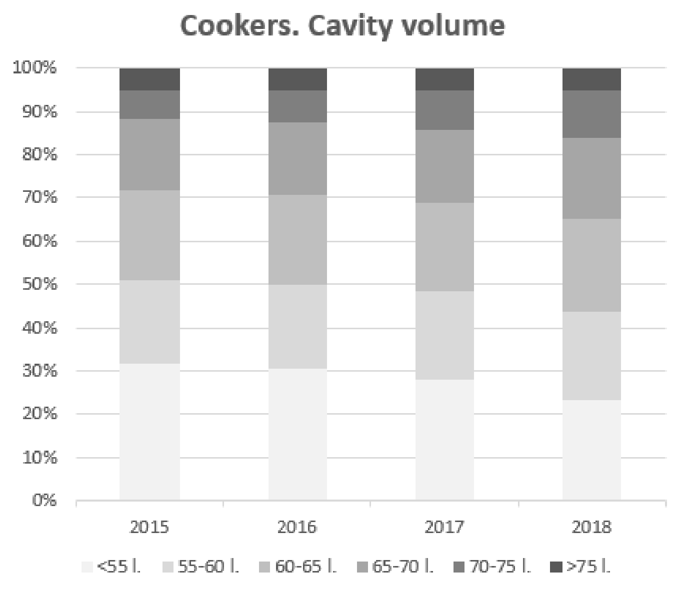


Figure 32. Cookers. Cavity volumes

In contrast to ovens, cavity volumes of cookers appear to be more stable over the period 2015-2018. In fact, in 2018, sales were almost equally distributed between <55 litres, 55-60 litres and 60-65 litres. The most popular choice for ovens (70-75 litres) is less common in cookers. To understand if cooker cavity volume has an influence on the energy class of the appliance, an analysis is conducted in Figure 33.

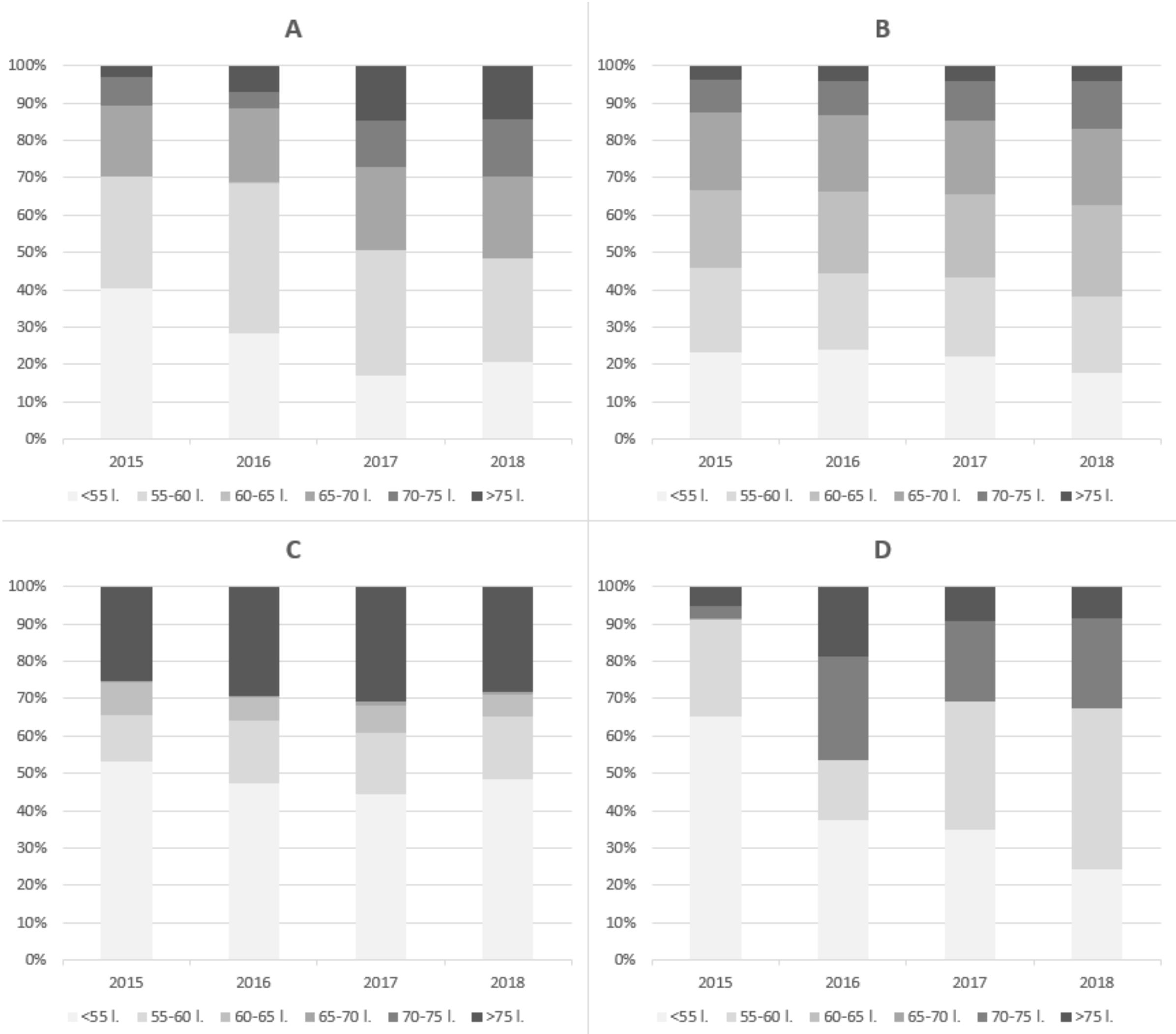


Figure 33. Cookers. The effect of cavity volumes on Energy class

The trend observed in the case of ovens is less apparent in cookers. However, looking at 2018, it can be seen that nearly 70% of cookers in the lowest class (D) have small cavities (less than 60 litres), whereas only 40% of the cookers in the highest class (A) have them. Again, it appears to be more difficult to reach top energy classes with a small cavity.

This trend can be confirmed with the analysis of Figure 34, when comparing the smallest and biggest cavities available in the data sample. It can be seen that only 2% of the small cookers reach A+ class, whereas up to 5% of the largest ovens reach it.

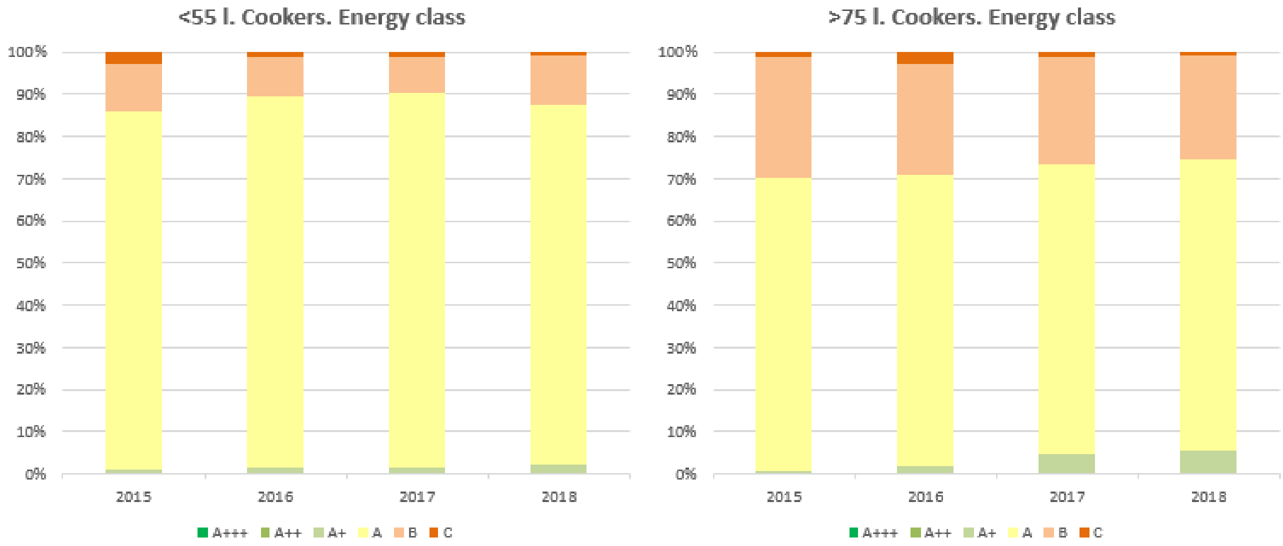


Figure 34. Cookers. Small and big cavity volumes. Energy class

In terms of the influence of steam heating functions on the energy classes of domestic cookers, the analysis is not meaningful since only 0.01% of cookers in the data sample have steam function. This feature appears to be only available in built-in ovens.

2.2.4.3 Range hoods

Figure 35 shows the distribution of energy classes for domestic range hoods sold over the period 2015-2018.

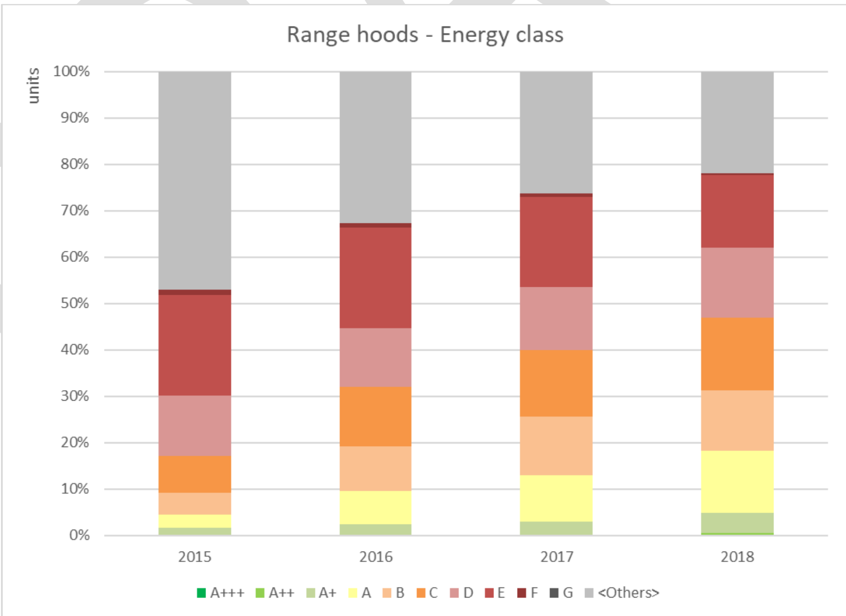


Figure 35. Evolution of range hoods sales in five EU countries per energy classes

As can be observed, the energy classes of range hoods have improved along the period, leading to a quite even composition among energy classes A to E. The penetration of A+ has increased significantly from 2015 to 2018, mainly due to the sales of ceiling hoods and worktop vent hoods, as it is shown in Figure 36:

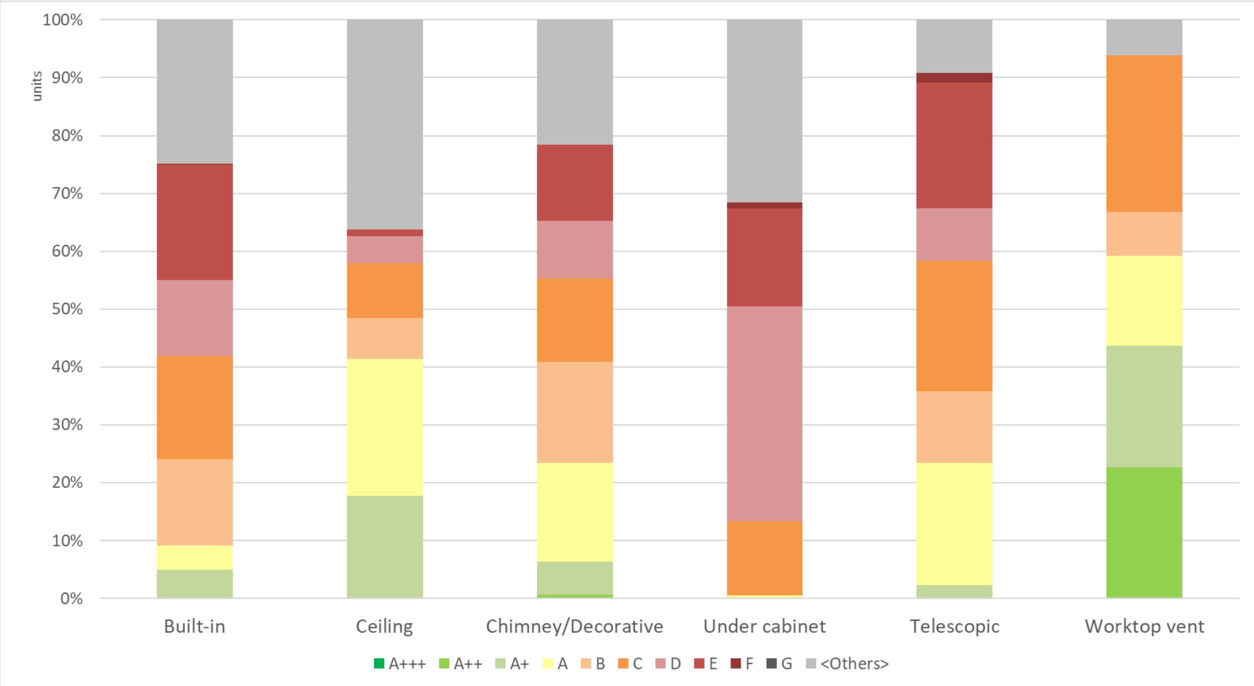


Figure 36. Composition of types of range hood in terms of energy classes in 2018 in five EU countries

In particular, worktop vent range hoods have reached A++ energy class, though their market share is still very low. More common types of range hoods, such as under cabinet, have stagnated in C class and lower classes, which may be related to their typical sizes and flows. Figure 37 offers a better insight on this matter, showing the distribution of sales by energy classes and airflows. The area of the bubble represents the sales in units, differentiated by energy class (colour) and airflow in m^3 per hour (vertical axe, i.e. the higher the bubble is located the bigger its flow is).

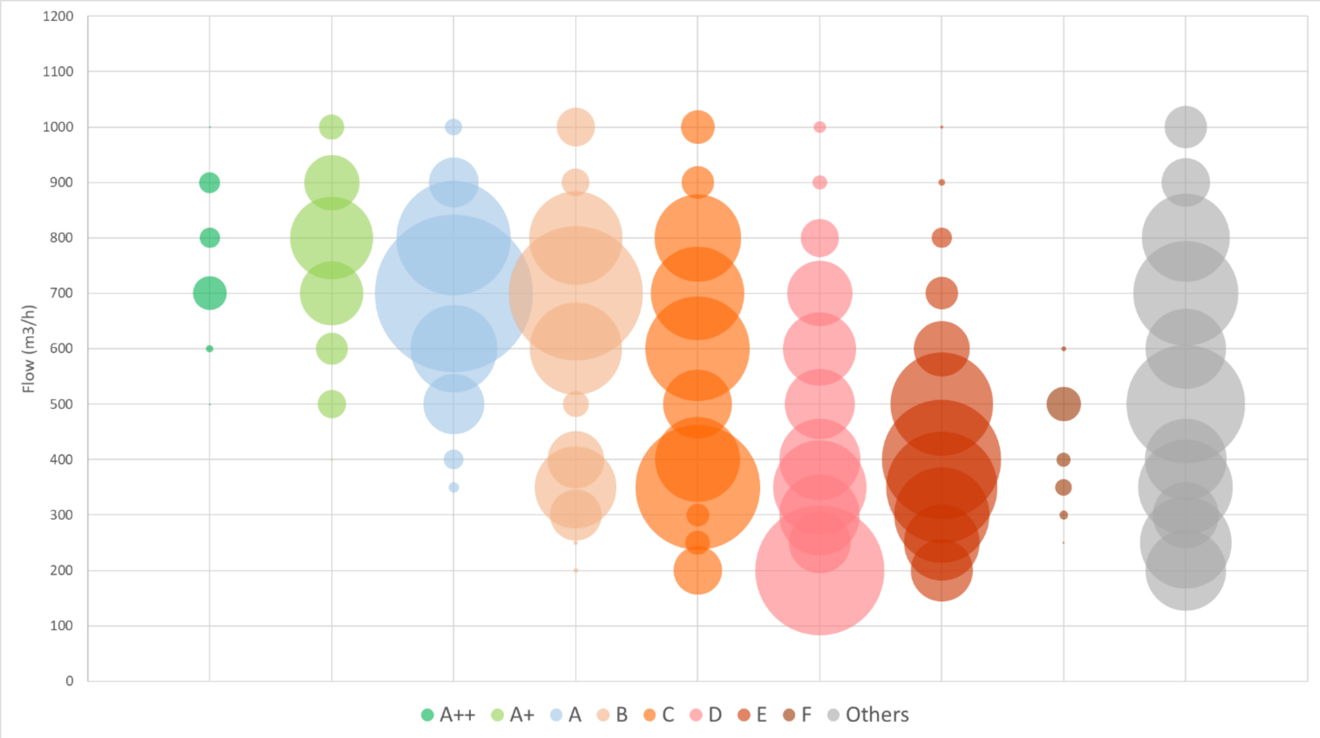


Figure 37. Unit sales (bubble area) per energy class and airflow in five EU countries (2018)

As can be observed, the largest sales of energy classes A or better are more apparent in range hoods of airflow above 600 m^3/h. On the other side, the sales of energy classes C or worse are larger in range hoods below 400 m^3/h.

The volumes of the range hood sold vary significantly among countries, since it is limited by the kitchen furniture and the space available in the kitchen. This variation can be observed in Figure 38 and Figure 39:

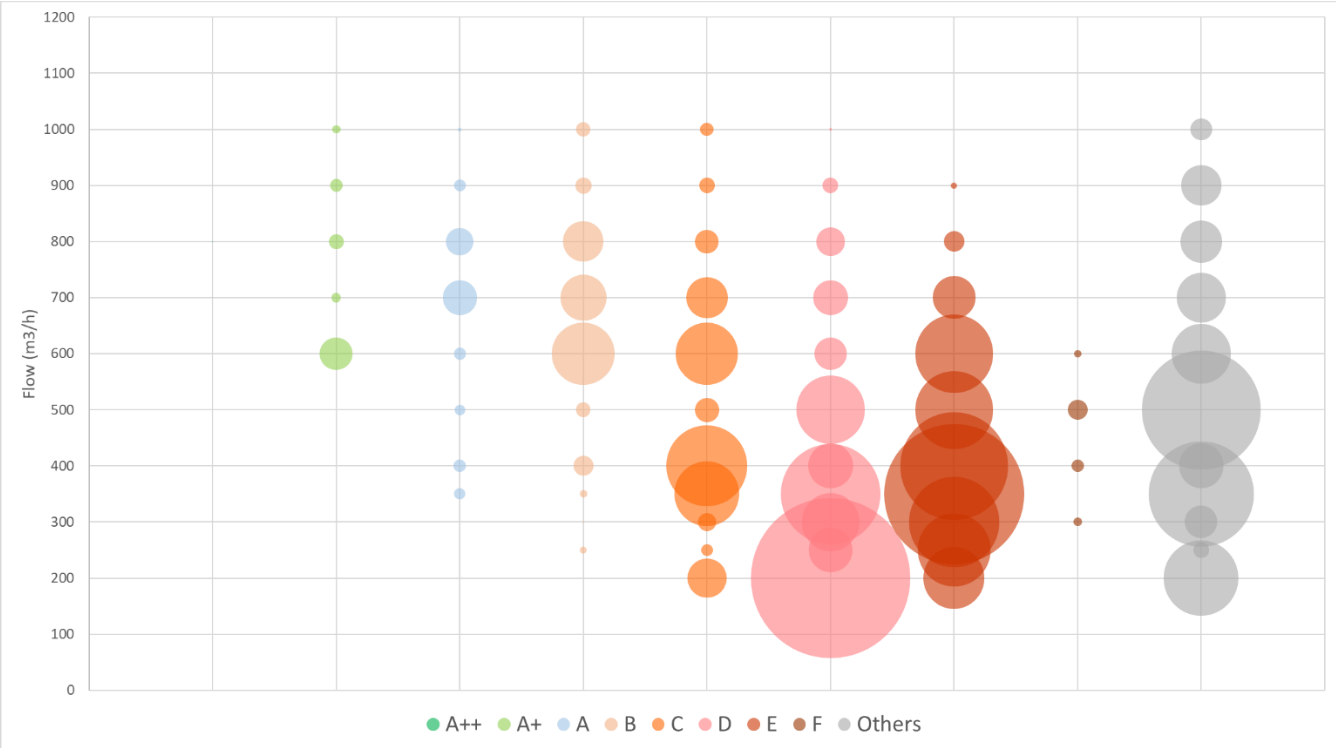


Figure 38. Unit sales (bubble area) per energy class and airflow in Poland (2018)

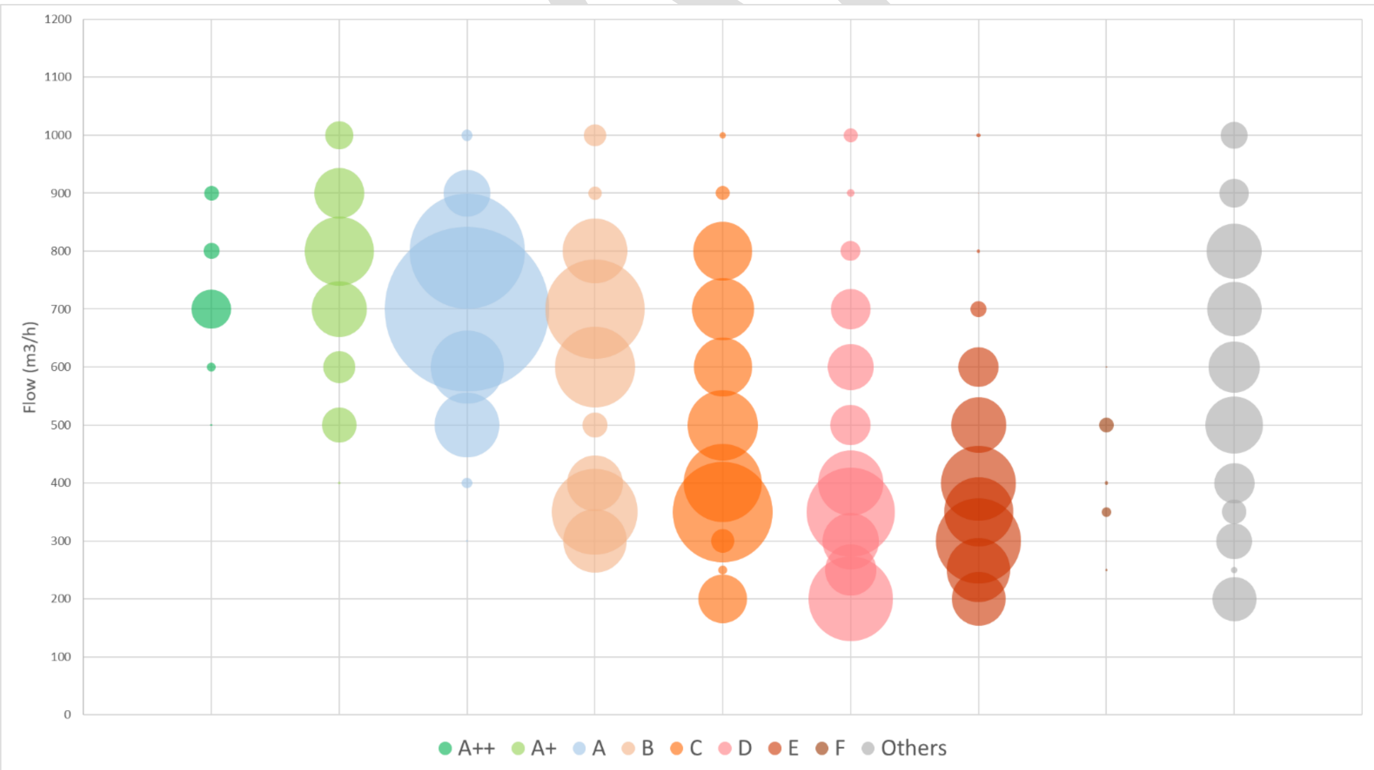


Figure 39. Unit sales (bubble area) per energy class and airflow in Germany (2018)

Poland and Germany clearly differ on the airflow of range hoods typically sold in their national markets. In Poland, lower airflow range hoods are more common, and as can be observed, the energy classes are concentrated in D and E. The contrary occurs in Germany, where the range hoods sold are typically larger airflow and also reach better energy classes. As indicated before, there seems to be a relation between airflow and energy class, which will be further explored in Task 4.

2.2.5 Trends of domestic cooking appliances

In this section, trends on domestic cooking appliances in terms of growth are presented. Figure 40 shows annual growth forecast for ovens over the period 2018-2023. Most of the countries in the EU will see a growth in oven sales over that period, with maximum growth expected in Austria at nearly 6%. On the other side, Belgium, Denmark, Finland, Germany, Netherlands and Portugal will observe slow decreases in sales over that period.

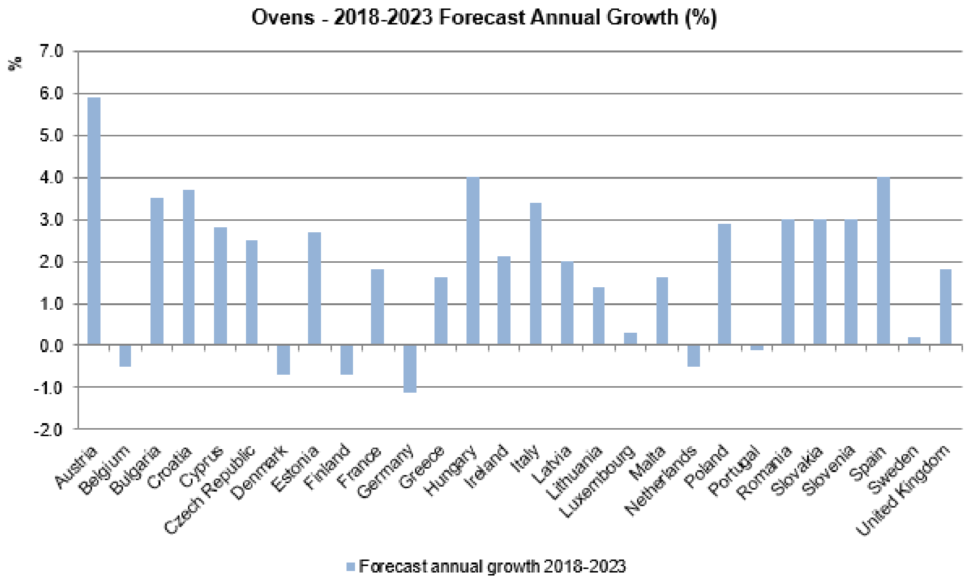


Figure 40. Ovens sales. Annual growth forecast (Euromonitor International, Consumer Appliances, 2019)

Figure 41 shows annual growth forecast for hobs over the period 2018-2023. Again, most of the countries in the EU will see a growth in hob sales over that period, with maximum growth expected in Austria at nearly 7%. On the other side, only Denmark will observe a decrease in sales over that period.

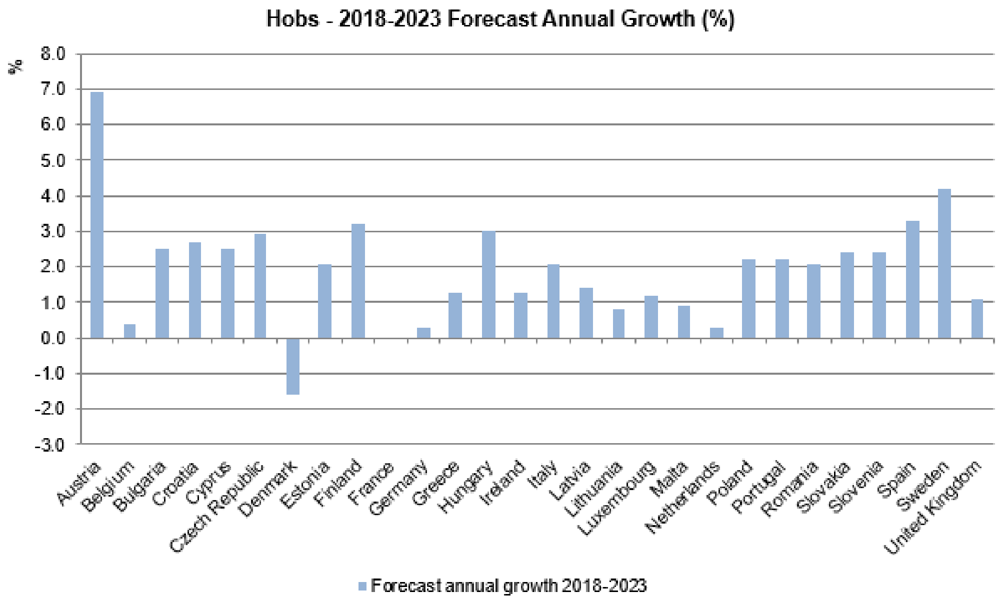


Figure 41. Hobs sales. Annual growth forecast (Euromonitor International, Consumer Appliances, 2019)

Figure 42 shows annual growth forecast for range hoods over the period 2018-2023. Again, most of the countries in the EU will see a growth in range hood sales over that period, with maximum growth expected in Hungary at 3%. On the other side, only Denmark and Germany will observe a decrease in sales over that period.

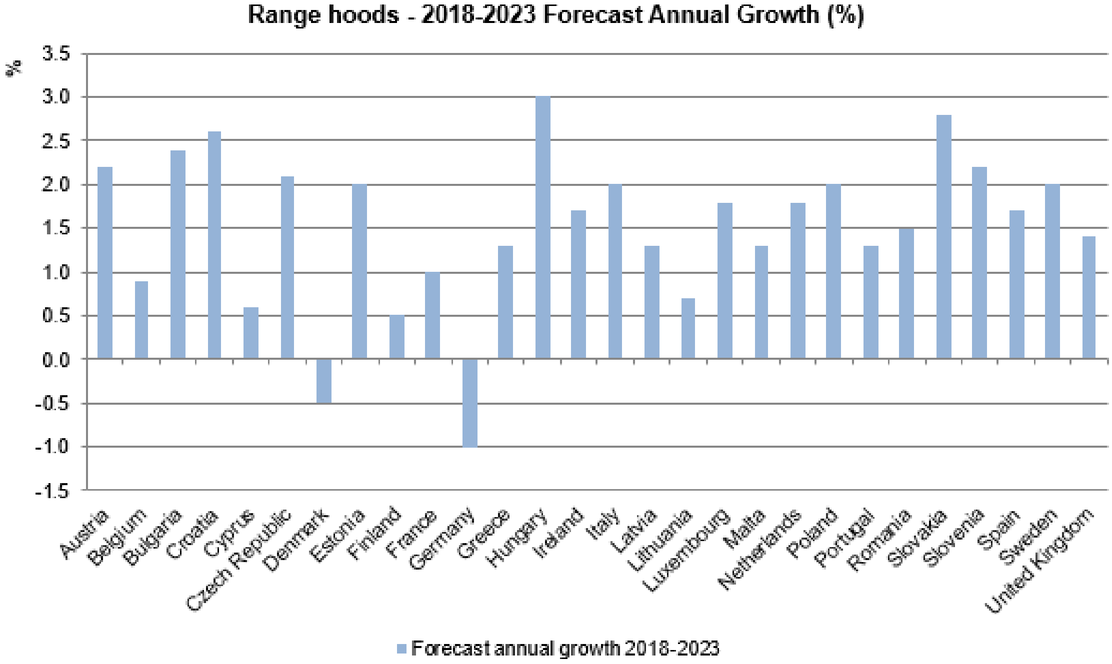


Figure 42. Range hoods sales. Annual growth forecast (Euromonitor International, Consumer Appliances, 2019)

Based on the above annual growth forecast, it is possible to estimate sales for the period 2018-2023 for the different product groups. As it can be seen in Figure 43, oven sales may grow up to nearly 8 million units in 2023, with the vast majority of products being electrically heated.

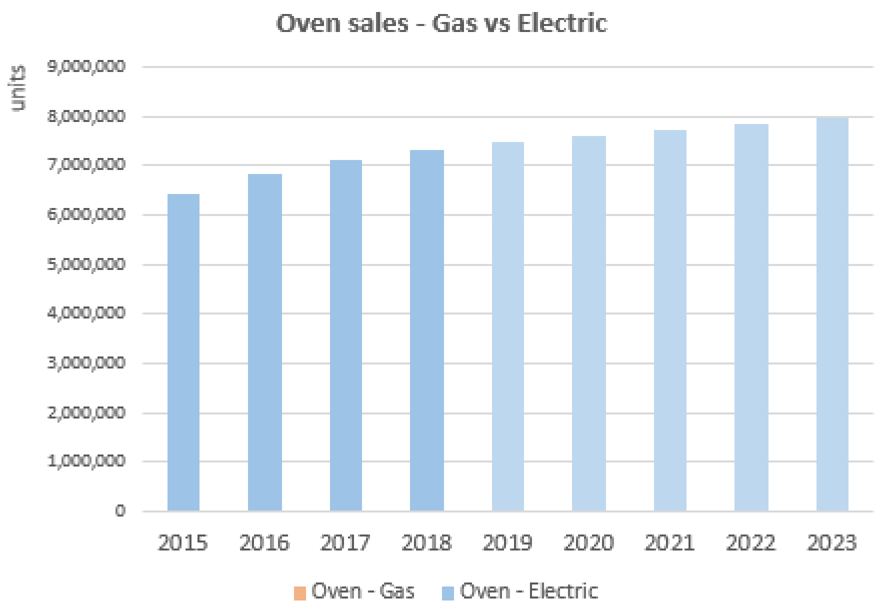


Figure 43. Oven sales trends

Cooker sales may see a slow decrease over the period 2018-2023, reaching slightly above 2 million units in 2023 (Figure 44). In this product group, less than half a million correspond to gas heated appliances.

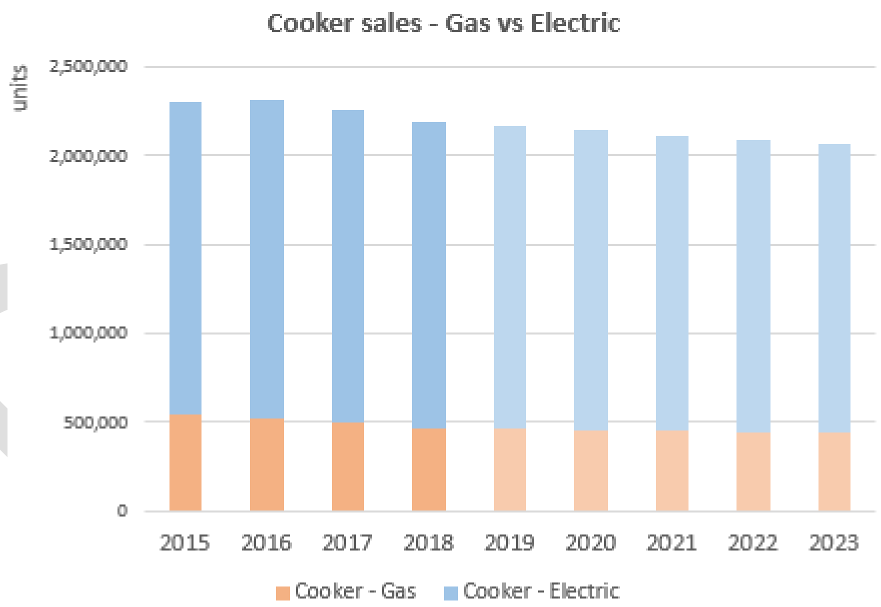


Figure 44. Cooker sales trends

In terms of hobs, sales are expected to grow up to nearly 10 million units in 2023, with most of the sales being on that year of induction appliances (Figure 45).

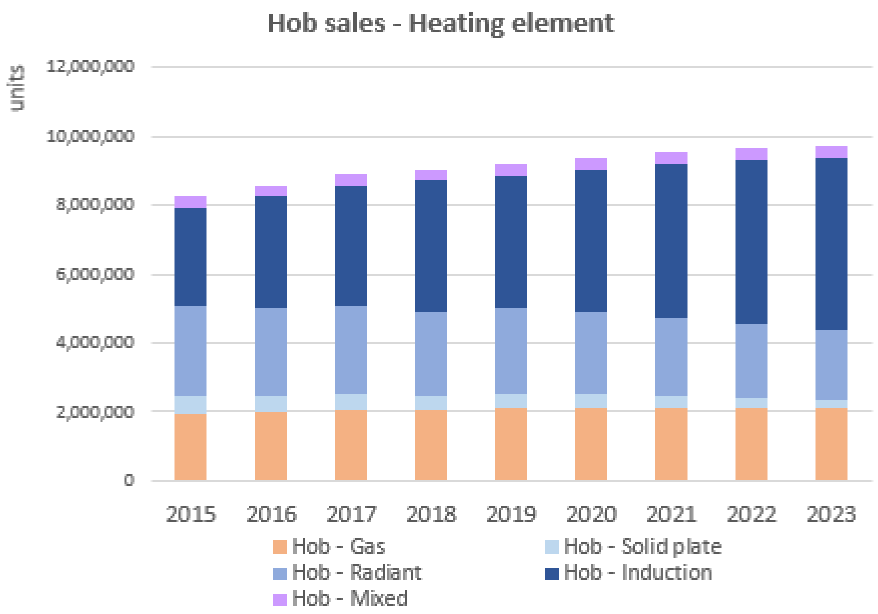


Figure 45. Hob sales trends

Finally, range hoods are expected to grow over the same period, reaching slightly over 7 million units sold in 2023 (Figure 46).

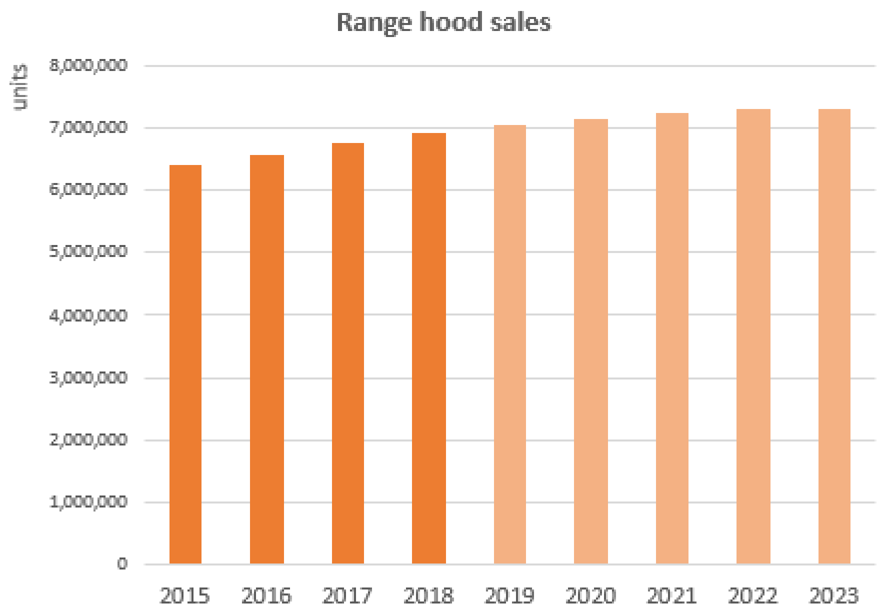


Figure 46. Hobs sales trend

Looking specifically at technology trends for the different product groups (Figure 47), it can be seen in the first instance that electric ovens are expected to keep on dominating the market over the next years (sales of gas ovens are so small that the red line appears almost flat in the graph)

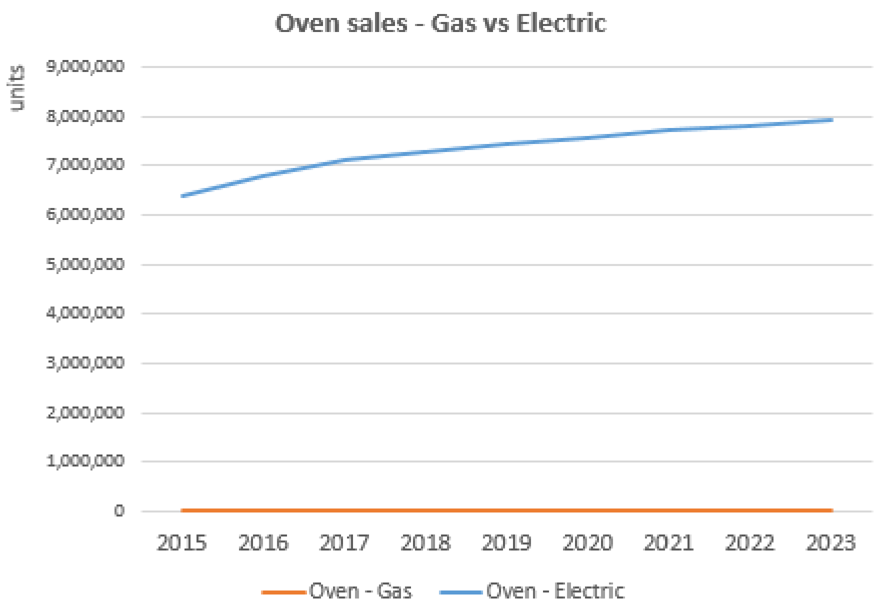


Figure 47. Oven heat source trends

In terms of cookers (Figure 48), energy sources are distributed differently, with approximately 25% of the sales being gas and 75% electric. In both cases, sales are expected to slowly decrease over the period 2018-2023.

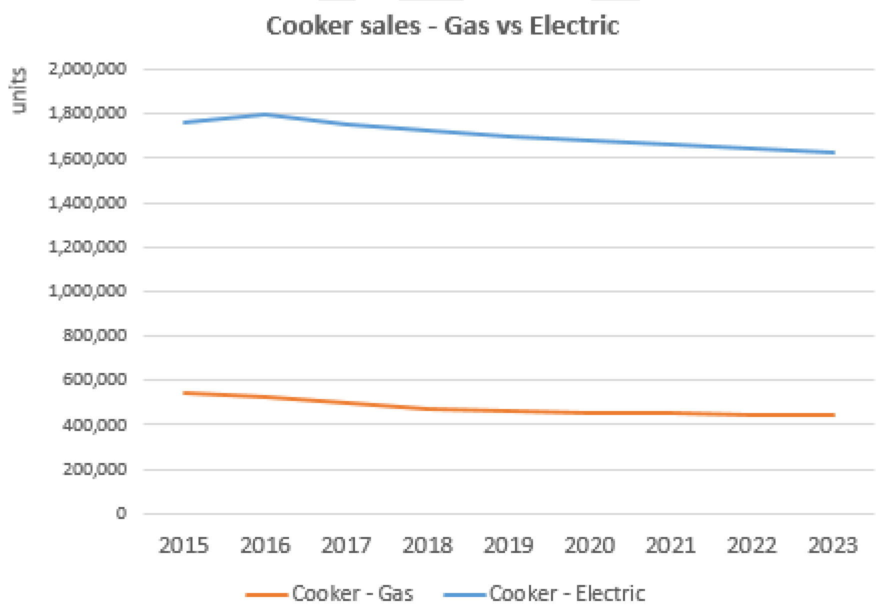


Figure 48. Cooker heat source trends

In terms of hobs (Figure 49), induction technologies are expected to see a significant growth over the next years. Gas hob sales are expected to grow at a very slow rate, with radiant and solid plates technologies decreasing gradually.

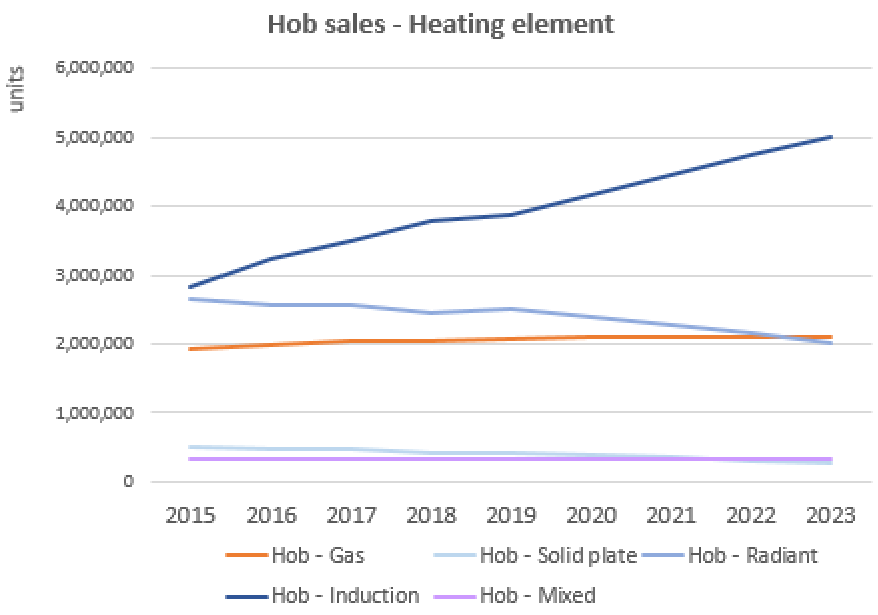


Figure 49. Hobs heat source trends

According to the market data of five EU countries, the sales of range hoods have slightly decreased between 2017 and 2018. As can be observed in Figure 50, under cabinet range hoods have declined at a constant pace seemingly in benefit of built-in hoods. Chimney hoods show upward trend, as well as ceiling and worktop hoods, though their market share are much lower.

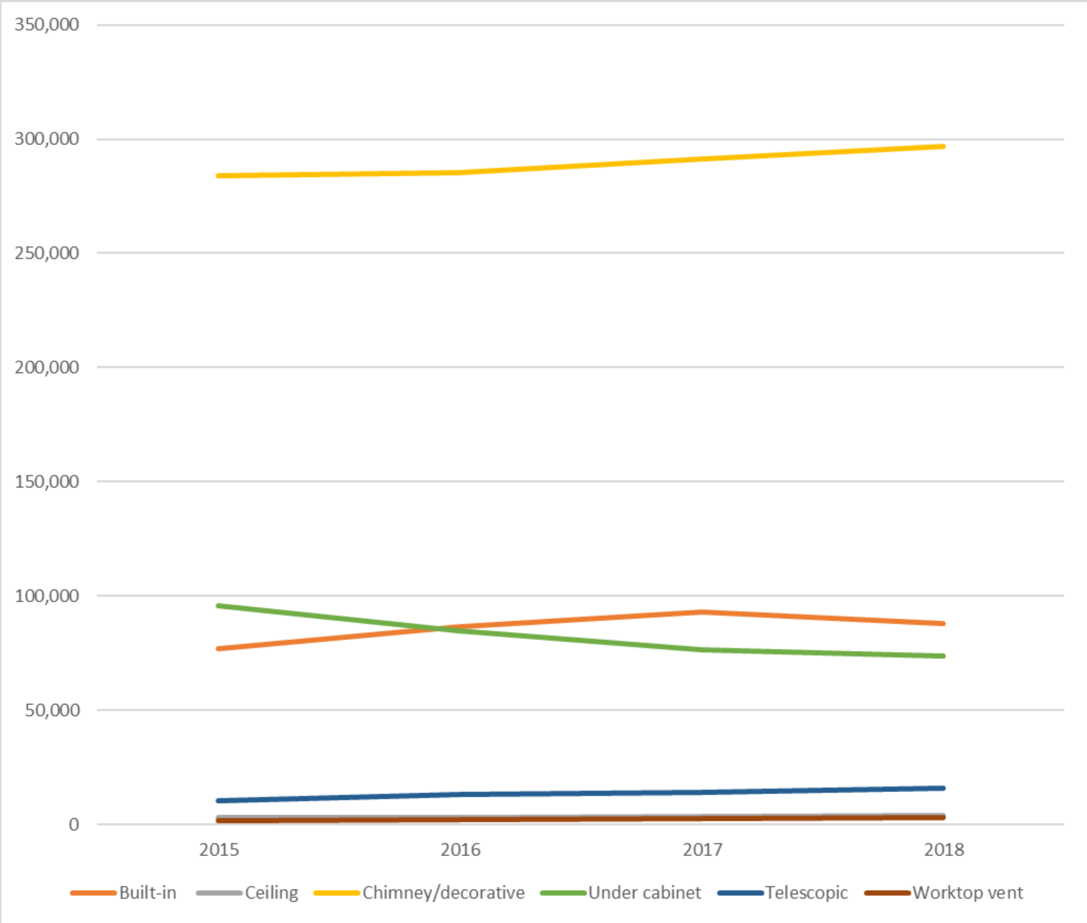


Figure 50. Evolution of sales of different types of range hood in five EU countries

In the case of the market distribution in terms of flow, no significant trend is apparent, as Figure 51 shows. The different flow ranges are quite evenly distributed, since it is related to the different types and sizes of the kitchen furniture and the space available.

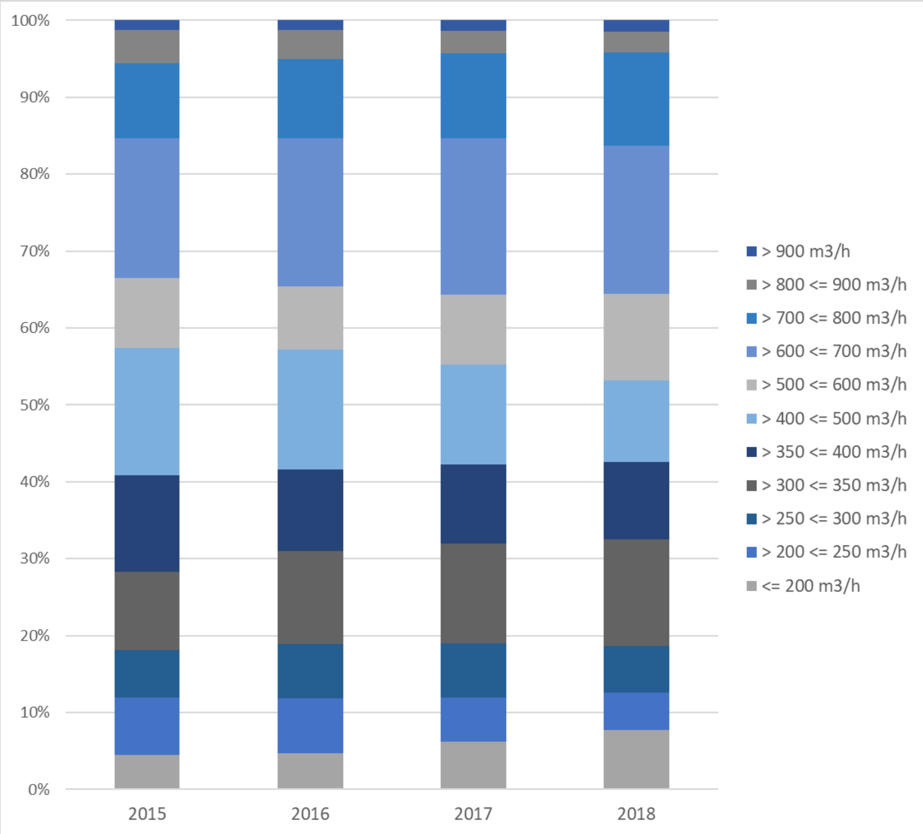


Figure 51. Evolution of sales of different range hoods in terms of flow in five EU countries

2.2.6 Stock of domestic cooking appliances

In this section, the stock of appliances will be estimated for:

a) Ovens
b) Cookers
c) Hobs
d) Range hoods

There are several ways to estimate stock of appliances. One simple way could be to use the penetrations rates published in Foteinaki et al (2019) and calculate stock of appliances based on amount of households per year. However, with that method, the trends in terms of sales of different type of appliances and technologies would not be taken into account.

In this report, the estimation of stocks has been made based on the annual sales of each type of appliance and the replacement rates of appliances per year. The method is analogous to the one followed in Yilmaz et al (2019).

The changes in the stock each year are determined by the sales of appliances (entry of appliances in the stock) and the probabilities of obsolescence, which represent the number of appliances that have reached their lifetime and are hence leaving the system as waste flow. This calculation is repeated for every year in the analysis.

Stock on year (X) = Stock on year (X-1) + Sales over year (X) – Obsolete products over year (X)

The number of products becoming obsolete each year is estimated using a Weibull distribution, as in Yilmaz et al (2019). The Weibull function provides a distribution of obsolete appliances for a given population through time. It represents the probability that an appliance will become obsolete in the year

Y_{obs} if it was sold in the year Y_{sold}. An example of a Weibull distribution for ovens purchased in 1990 is shown in Figure 52.

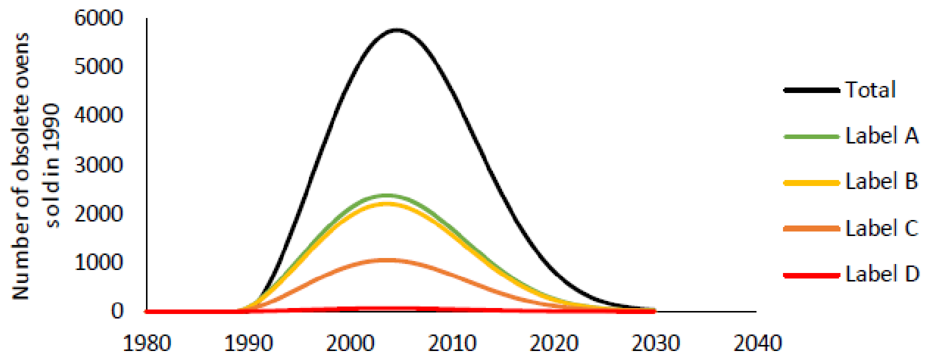


Figure 52. Number of obsolete ovens per year for devices sold in 1990 (Yilmaz et al, 2019)

In order to conduct stock estimations, data regarding annual sales of ovens, cookers, hobs and range hoods is needed for a considerable number of years. However, annual sales data for appliances is very valuable and therefore scarce. In this study, sales data is available for 2015-2018, with growth estimations for 2019-2023. Therefore, certain assumptions and estimations need to be made. Data sources and assumptions made are detailed below:

- Annual sales data for the period 2015 – 2018 comes from GfK and Euromonitor
- Annual sales data trends for the period 2019 – 2023 comes from Euromonitor
- For data not available from GfK or Euromonitor, annual growth trends from Mugdal et al (2011) have been used
- Annual sales data for the periods 2000-2014 and 2024-2040 have been estimated based on best-fit trends for each product group

It must be noted that stock estimation is a complex task involving data from different sources and a number of reasonable assumptions. This task does not aim in predicting exact sales or stocks, but to identify trends in terms of appliances or technologies present in EU households in the near future. Combining data from different sources may cause inconsistencies for certain product groups. This is an aspect that has been acknowledge during the development of this section and the intention is to refine stock of domestic cooking appliances if more reliable data becomes available. Stock estimates for the different product groups are detailed below.

As it can be seen in Figure 53, the total stock of ovens is estimated to grow between 2019-2040 up to 144 million units in 2040. This growth is consistent with the expected growth in sales for the period 2015-2018 seen in Section 2.2.3.

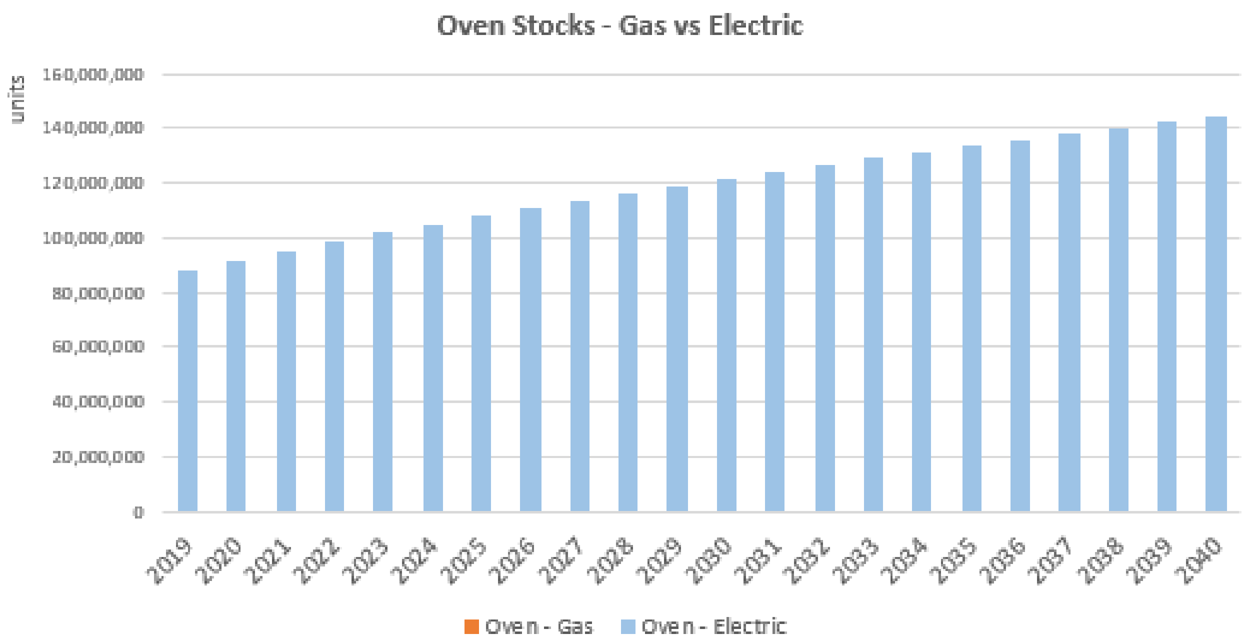


Figure 53. Estimated oven stocks 2014-2023

As it can be seen in Figure 54, the total stock of cookers present in EU28 households is estimated to decrease between 2019-2040 up to 29 million units in 2023. A decrease in stock is consistent with the expected decrease in sales for the period 2015-2018 seen in Section 2.2.3.

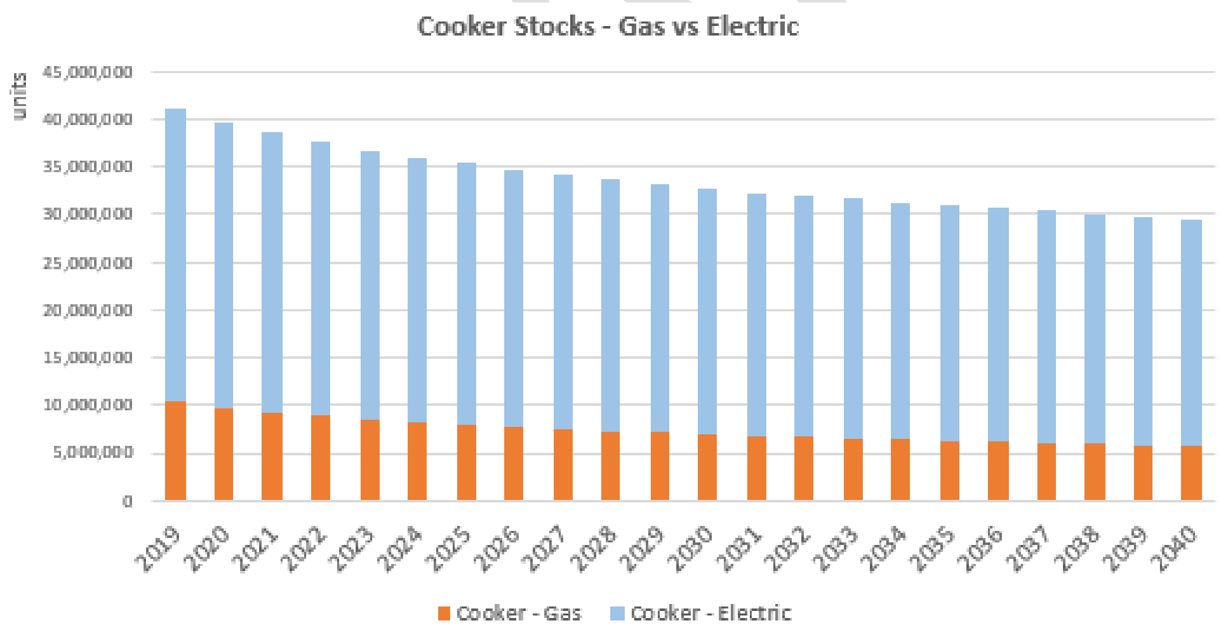


Figure 54. Estimated cooker stock 2014-2023

As it can be seen in Figure 55, the total stock of hobs is expected to stay relatively flat between 2019-2040, with a slow growth, reaching 190 million units installed in 2040.

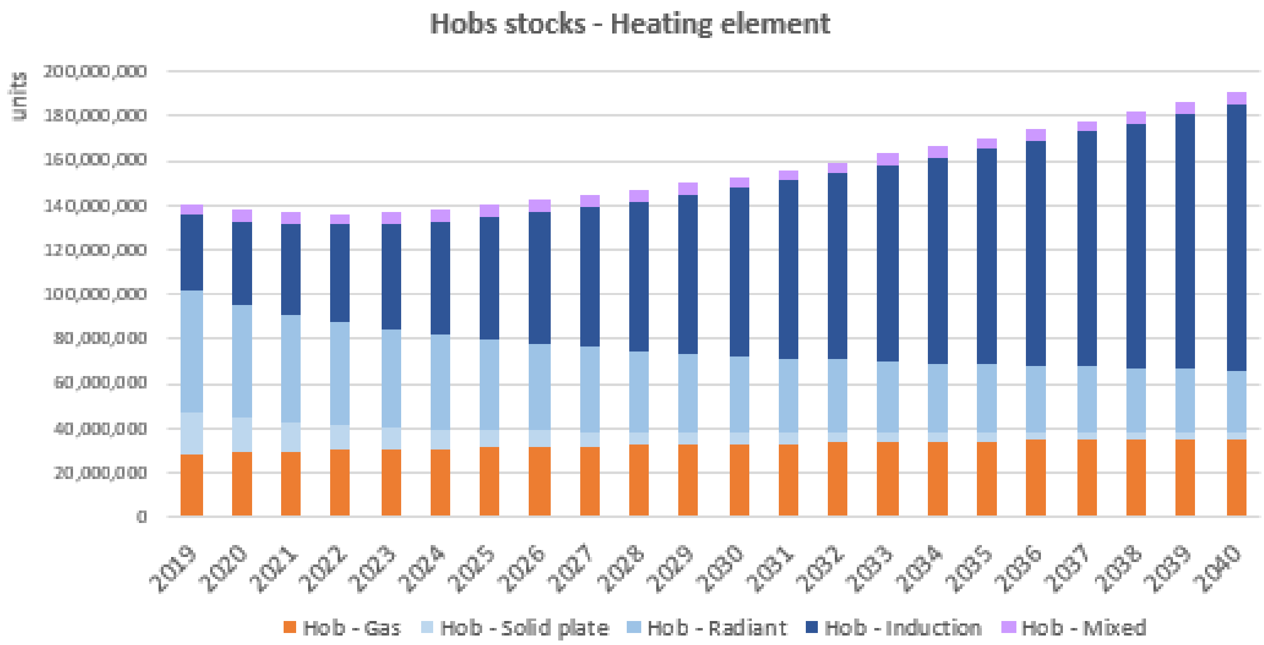


Figure 55. Estimated hob stock 2014-2023

In terms of hob technologies, a significant increase in the amount of induction hobs can be expected between 2019 and 2040. This technology is growing mostly at the expense of radiant hobs, which still may have a significant presence in households in 2040. Solid plates and mixed hobs are expected to have a marginal presence.

As it can be seen in Figure 56, the total stocks of range hoods is estimated to grow between 2019-2040 up to 129 million units in 2040. This growth is consistent with the expected growth in sales for the period 2015-2018 seen in Section 2.2.3.

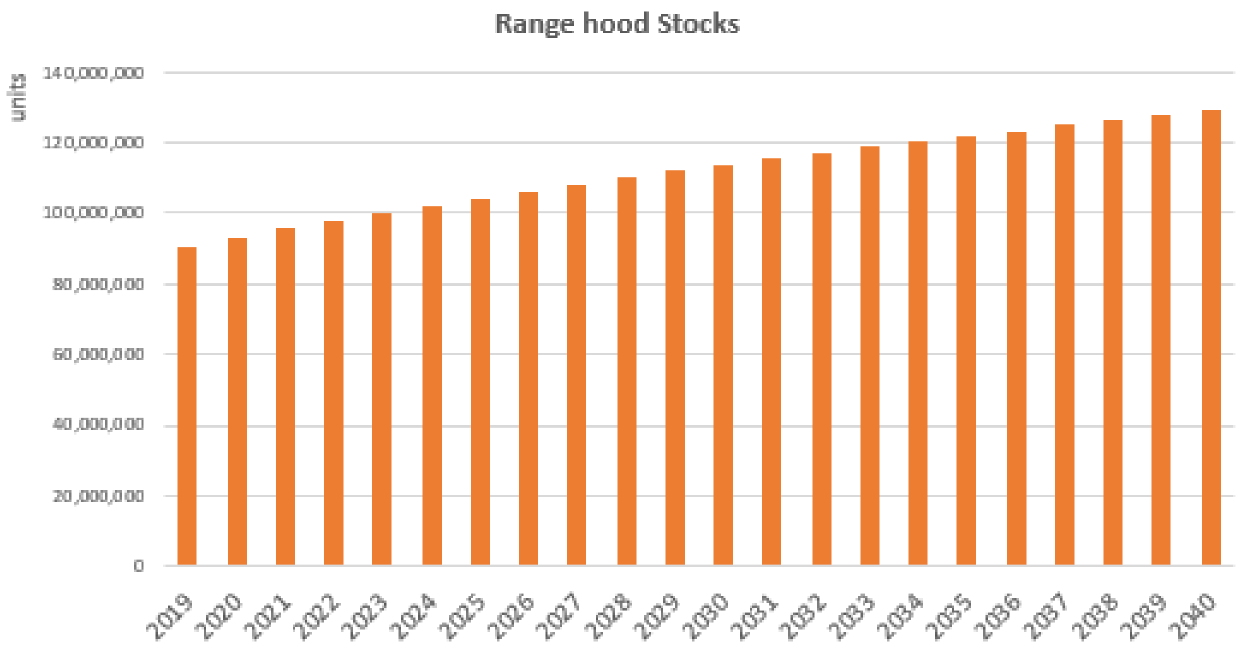


Figure 56. Estimated range hoods stock 2014-2023

2.2.7 Market structure of the European domestic cooking appliances industry

According to Mudgal et al (2011), the domestic oven market appears to be highly concentrated. In 1999, the three leading manufacturers were covering between 40 to 80% of the market (e.g. General domestic appliances and Electrolux in UK and BSH in Germany). The situation was considered to be similar in 2008, even though the number of brands increased due to more competition, especially from Asian manufacturers.

The relevance of original equipment manufacturers (OEM) in the domestic cooking appliance sector is quite significant. OEMs are producers of appliances for other brands, which generally operate as small and medium enterprises (SMEs). According to Mudgal et al (2011), they manufactured approximately 25% of the appliances in 1999. In that year, most of the factories were located in Italy, Germany and UK. Some manufacturers also own factories outside the EU (in Eastern Europe or Turkey). The size of the factories is variable, from 50 to more than 3000 employees. The production of these factories is also very variable, potentially ranging from 30.000 to 300.000 units. APPLIA provides an indication on the location of large home appliances manufacturing sites in Europe in 2018 (Figure 57).

Figure 57. Large home appliances manufacturing sites in Europe in 2018 (APPLIA, 2018)

As it can be seen in Figure 57, the countries with the highest number of manufacturers are Germany and Italy, followed by France, Poland and Turkey. Spain, UK and Romania also have a significant number of manufacturing sites.

Since the publication of Mudgal et al (2011), not much data has been made publicly available regarding cooking appliances specifically. Most of the data in this section will therefore refer to household appliances in general: it will include cooking cooking appliances in particular but also fridges, washing machines, dishwashers, etc.

Euromonitor International (2010) published data regarding home appliance manufacturers in general. The top five companies on that year were Whirlpool, Electrolux, Haier, BSH and LG (Figure 58).

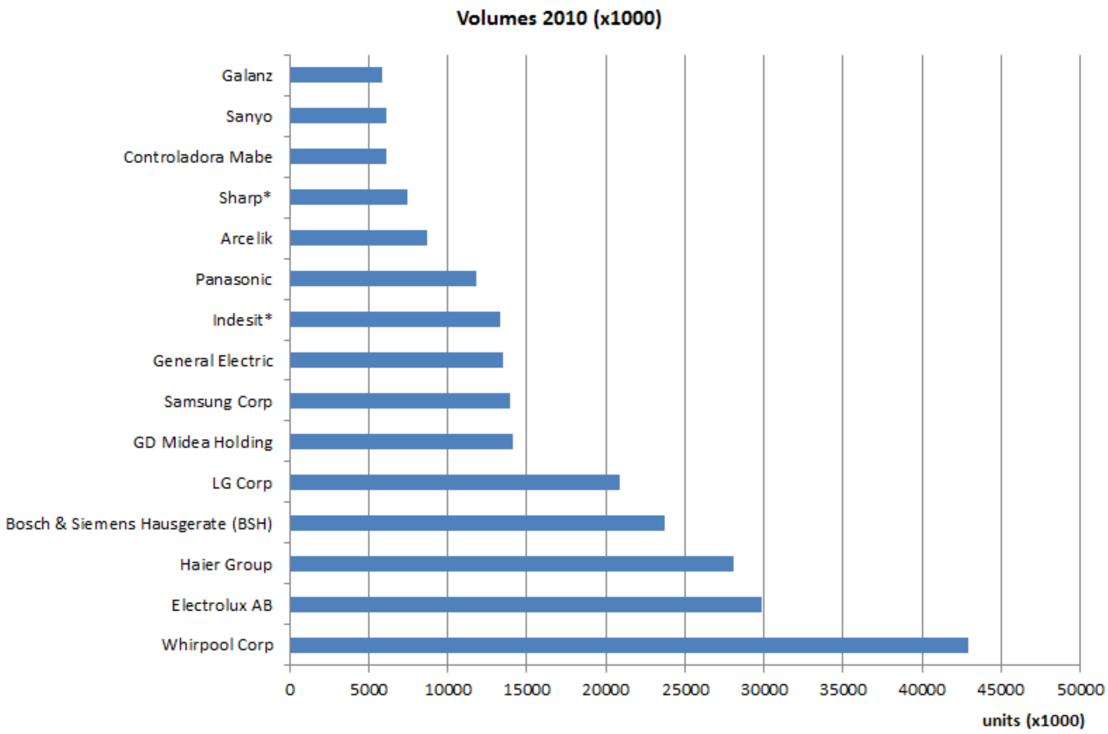


Figure 58. Top 15 home appliances manufacturers in 2010 (Euromonitor International)

It is worth noting that some of the information seen in Figure 58 may be out of date by 2019, since some of the smaller brands may have been acquired by bigger corporations. This is the case of Sharp (which currently operates under the multinational electronics group Foxconn) or Indesit (which was acquired by Whirlpool in 2014). These acquisitions may have modified the current picture of global home appliances market share.

In terms of specialization, some of the companies in Figure 58 are focused in home appliances (such as Whirlpool), whereas other have much bigger markets in completely different sectors (such as LG or Panasonic). Another relevant point is that many of the corporations in Figure 58 are companies which own and distribute a wide variety of home appliances brands (this is the case of Whirlpool, Electrolux, Haier, BSH and others), whereas others such as LG, Samsung or Panasonic operate under a single brand. In Table 20, it is presented a summary of different brands under bigger corporations.

Table 20 Corporations and brands (Euromonitor International, 2010)

Corporation	**Brands**
Whirlpool	Whirlpool, Hotpoint, Amana, Drop, Maytag, Brastemp, Acros, Yummly, KitchenAid, Consul, Bauknecht, Gladiator, Indesit, Jennair, Diqua,
Electrolux	Electrolux, Electrolux Grand Cuisine, AEG, Molteni, Frigidaire, Eureka, Zanussi, Westinghouse
Haier	Haier, Casarte, Leader, RRS, Aqua, Fisher & Paykel, Candy
BSH	Bosch, Siemens, Gaggenau, Neff, Thermador, Balay, Coldex, Constructa, Pitsos, Profilo, Zelmer, Junker, Viva
Midea	Colmo, Toshiba, Midea, Comfee, Little Swan, Eureka
General Electric	GE Appliances, Monogram, Café, Profile, Hotpoint
Arçelik	Arçelik, Beko, Grunding, Defy, Altus, Blomberg, Arctic, Elektra Bregenz, Leisure, Flavel, Arstil,

	Dawlance

In terms of value, the global household appliances market was valued at $501,532 million in 2017 and is projected to reach $763,451 million by 2025, growing at a CAGR of 5.4% from 2018 to 2025 (AMR, 2019). Some of the key factors affecting this growth are:

- Technological advancements
- Shift towards more energy efficient appliances
- Rapid urbanization
- Growth in housing sector
- Rise in per capita income
- Improved living standards
- Surge in need for comfort in household chores
- Change in consumer lifestyle
- Escalating number of smaller households

Considering distribution channels, AMR indicates that most of household appliances are purchased through specialty stores, followed by supermarkets/hypermarkets, online commerce and others. This trend is expected to continue towards 2025. The biggest growth is expected to happen in the e-commerce segment, due to high penetration of internet connection and smartphones.

A brief analysis by region shows that the European market experiences growth owing to low interest rates and a good economic situation. The market is witnessing an increase in demand for premium built-in or integrated appliances such as ovens, with integrated steam function, flexible induction hobs, integrated hob extractors, and built-in dishwasher among others. Destination of EU exports can be seen in Figure 59.

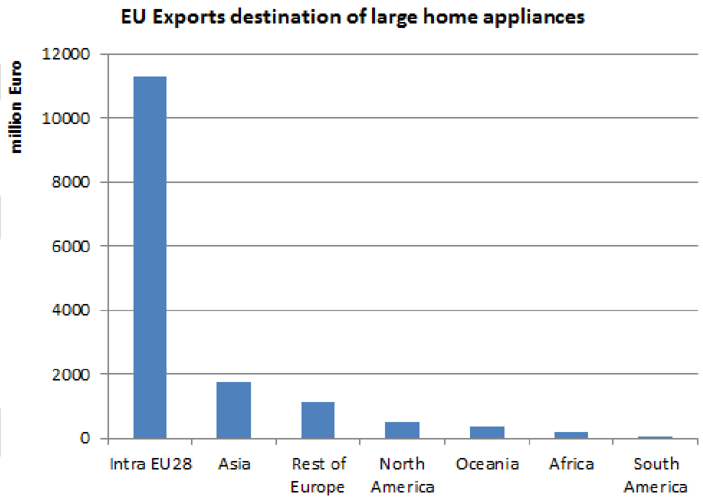


Figure 59. EU export destinations of large home appliances 2017 (APPLIA, 2018)

Still focusing on the EU market, the top five exports destinations outside of EU were Russia, USA, Norway, Switzerland and Australia. In contrast, the top five countries of origin of large home appliances from outside of EU were China, Turkey, South Korea, Malaysia and Russia.

North America is a matured and homogenous market for household appliances with high product penetration. The demand for household appliances is dominated by product replacement. The Asia-Pacific household appliances market is anticipated to witness strong growth owing to increase in household income, rapid urbanization, rise in the middle-class population, easy access to goods through development of retail channels, easy access to consumer finance, and change in lifestyles of the population.

2.3 Consumer expenditure base data

This section presents purchase prices, installation, repair and maintenance costs as well as applicable rates for running costs (e.g. electricity, natural gas) and other financial parameters (e.g. taxes, rates of interest, inflation rates). This data will be input for later tasks where Life Cycle Costing (LCC) for new products will be calculated.

The average consumer prices and costs experienced by the end user throughout the product lifetime are determined by unit prices in the following categories:

- average price per HPC unit for each category;
- consumer prices of electricity and fuel;
- inflation and discount rate;
- installation costs;
- repair and maintenance costs;
- disposal tariffs and end-of-life cost.

2.3.1 Average unit values of domestic cooking appliances

2.3.1.1 Average unit value of ovens

In Figure 60, a comparison is conducted between the two most common energy classes for ovens (A+ and A) for five different countries in terms of price. As it can be seen, there is a significant difference between the price of A+ and A ovens. Both energy classes have seen a decrease in price between 2015-2018.

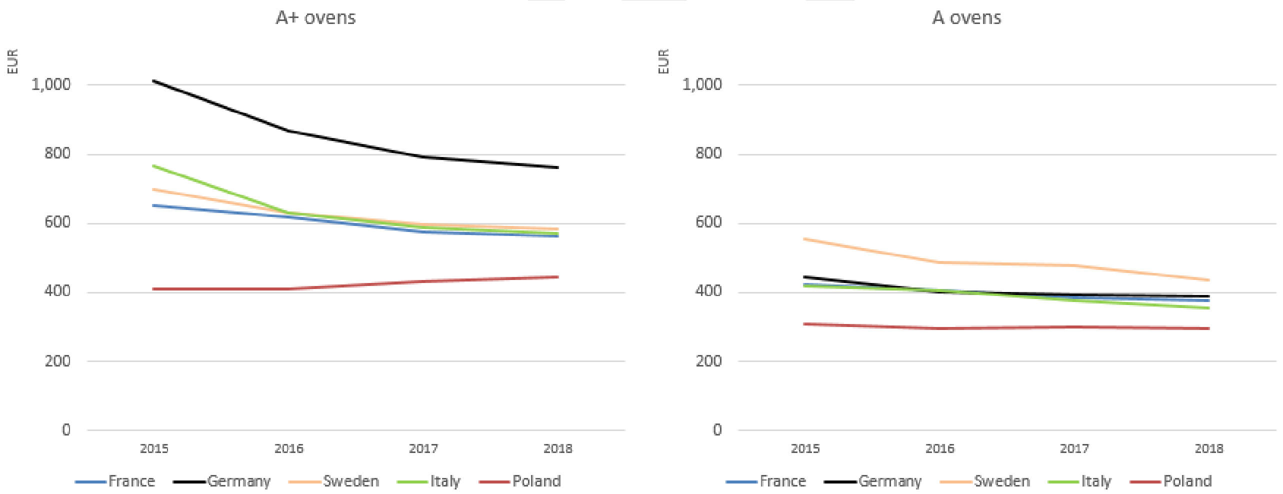


Figure 60. Price of ovens by energy class

In Figure 61, a comparison is conducted between two different functions offered by ovens (steam and microwave functions) for five different countries in terms of price. As it can be inferred from the graph, both functions tend to be found in high-end products. A wider range of prices can be seen in steam-assisted ovens, whereas prices of microwave-assisted ovens tend to be consistently higher. Prices of both types of functions are stable over the period 2015-2018.

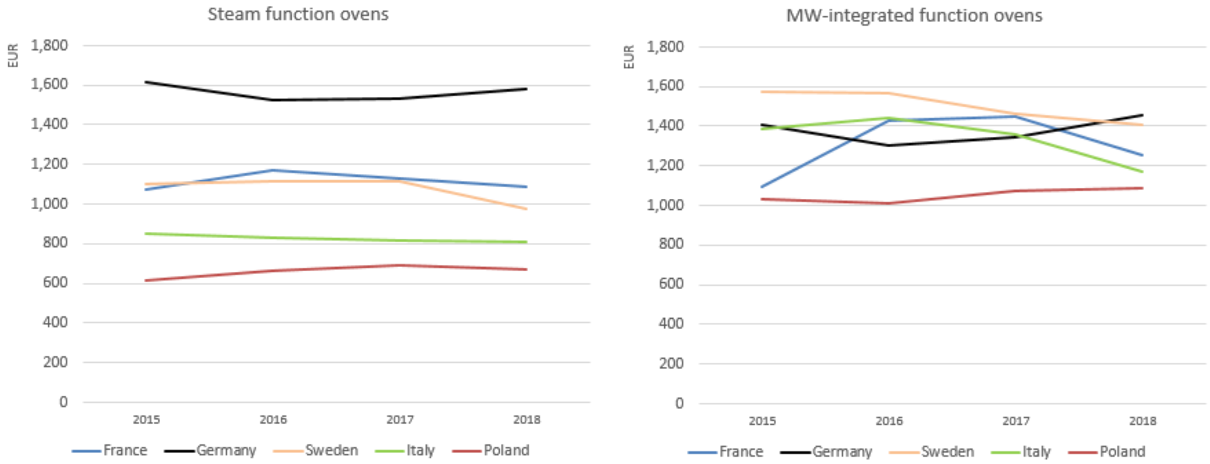


Figure 61. Price of ovens by function

2.3.1.2 Average unit value of hobs

In Figure 62, a comparison is conducted between three different heating elements for hobs (gas, induction and radiant) for five different countries in terms of price. As it can be seen, the most expensive technology is currently induction. Gas and radiant hobs tend to have similar prices, with a wider range for gas appliances. Prices of the three types of technologies are stable over the period 2015-2018.

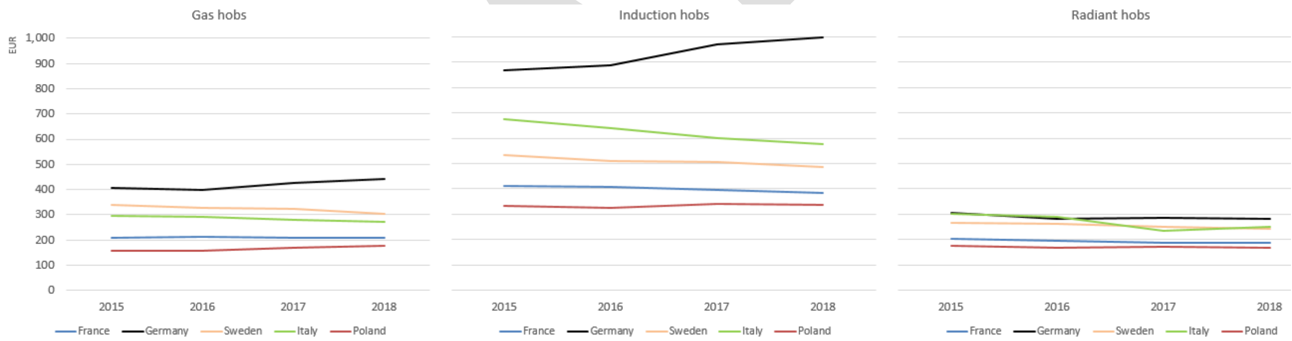


Figure 62. Price of hobs by heating element

2.3.1.3 Average unit value of range hoods

In Figure 63, a comparison is conducted between three different energy classes in range hoods (A+, C and F) for five different countries in terms of price. As it can be seen, there is a clear relationship between energy class and price in the case of range hoods. Top categories (A+) have significantly higher prices that middle and low categories (C and F).

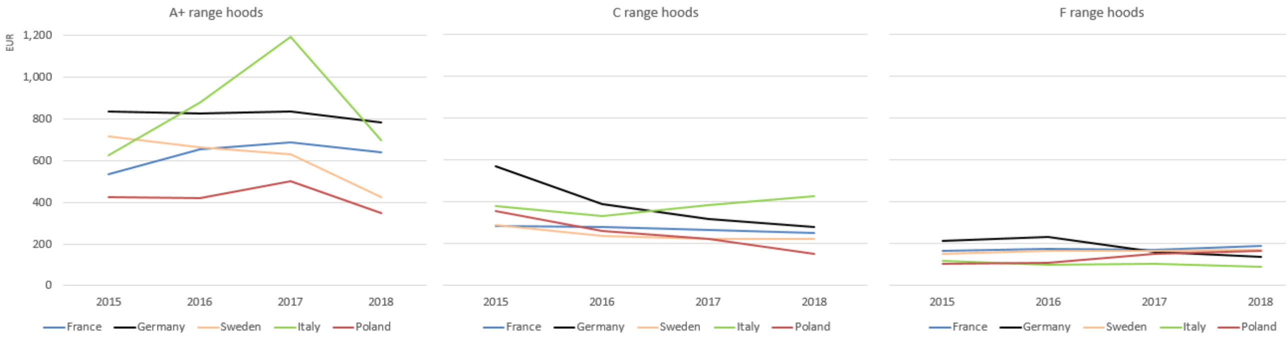


Figure 63. Price of range hoods by energy class

In Figure 64, a comparison is conducted between two different mounting configurations in range hoods (standard and ceiling) for five different countries in terms of price. Standard range hoods tend to have the lowest energy classes and ceiling range hoods tend to be in the top energy classes, as seen in Figure 36. Price is consistent with what was already observed previously: standard range hoods are in the lower spectrum of prices (the most expensive is less than 250 Euro), whereas ceiling range hoods are in the highest spectrum (with range hoods up to 2500 Euro).

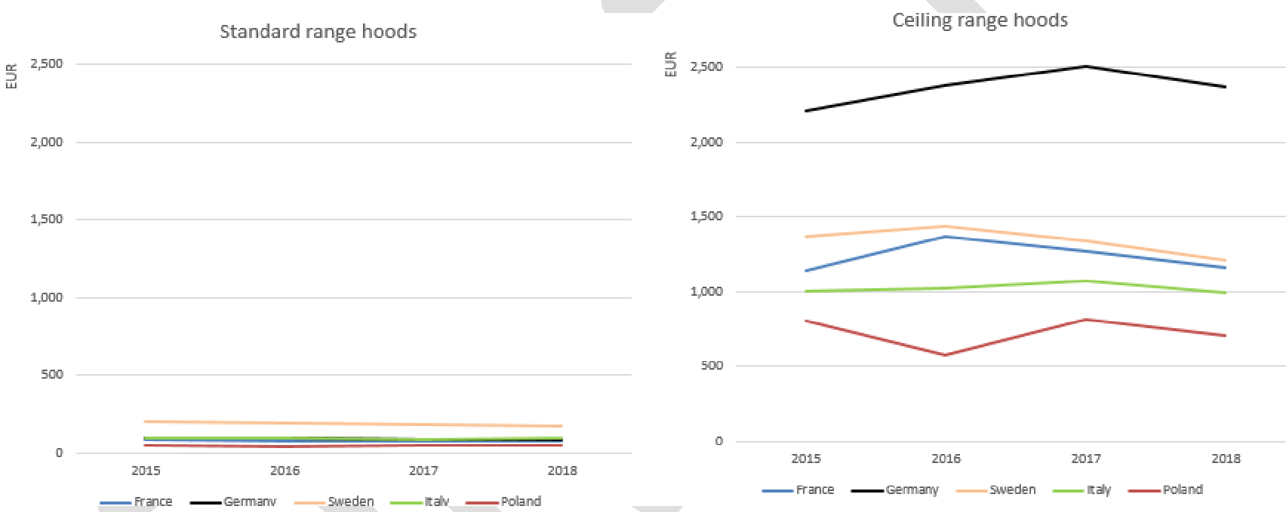


Figure 64. Price of range hoods by configuration

2.3.2 Consumer prices of electricity/fuel

The annual energy prices are taken from the PRIMES Model[9], which provides the prices referred to the year 2013 (Table 21). The reference year prices will be calculated using the inflation rates from Eurostat.

Table 21. Annual prices of energy products

	2013 END USER PRICE (in € cents/kWh)					
Electricity	2005	2010	2015	2020	2025	2030
Average price	**11.7**	**13.6**	**14.4**	**15.3**	**15.7**	**16.1**
Industry	8.4	9.7	9.7	9.8	9.9	10.0
Households	15.6	17.2	19.0	20.3	20.9	21.2
Services	12.7	14.8	15.7	17.1	17.6	17.9

[9] https://ec.europa.eu/clima/policies/strategies/analysis/models_en

Natural gas						
Industry	3.0	3.8	3.8	4.3	4.5	4.8
Households	4.6	6.1	7.1	7.5	7.9	8.4
Services	3.9	5.0	5.7	6.1	6.5	6.9
LPG						
Industry	7.4	7.8	5.6	8.3	9.0	9.5
Households	7.7	8.6	6.7	9.5	10.2	10.8
Services	6.6	7.1	5.5	7.6	8.1	8.7

2.3.3 Installation, repair and maintenance costs

If the installation, repair or maintenance requires a professional service, the average EU labour cost in the category “Industry, construction and services (except public administration, defence, compulsory social security)” is to be used, as shown in Table 22[10].

Table 22. Average total labour costs for repair services

Year	2000	2004	2008	2012	2013	2014	2015	2016	2017	2018
EU-28 countries, (EUR/h)	16.7	19.8	21.5	23.9	24.2	24.5	25.0	26.0	26.7	27.4

2.3.4 Disposal tariffs/ taxes

Since domestic cooking appliacnes are covered by the WEEE Directive and producers are responsible for paying a WEEE tax or in some other way financing the EOL treatment, it is assumed that end users will not experience any further EOL costs. The WEEE tax paid by manufacturers is assumed to be reflected in the sales prices of HPCs to end users. In the end user life cycle cost calculations, the EOL cost is therefore set to zero.

2.4 Recommendations

Ovens and cookers conclusions

In terms of sales and technology trends:

- Total oven sales are growing steadily. Vast majority of consumers prefer electric ovens.
- Steam assisted oven sales are growing rapidly, although still a very small part of the market. These products are currently within scope of ecodesign and energy labelling regulation.
- MW assisted oven sales are stable and are a very small part of the market. These products are currently out of the scope of ecodesign and energy labelling regulation. Market data does not suggest there is an urgent need to include those within scope.
- Larger cavity volume oven sales are growing and currently are the main preference for consumers
- Connected oven sales are growing rapidly, although still a very small part of the market
- Total cooker sales are decreasing. Majority of consumers prefer electric cookers.

In terms of energy classes (ovens):

- There are no A+++ ovens and only 0.06% are A++ (top energy classes)

[10] http://ec.europa.eu/eurostat/cache/metadata/en/lc_lci_lev_esms.htm#unit_measure1475137997963

- A+ category has been growing up to a 29% in 2018
- The vast majority of ovens are either A or A+ (mid energy classes)
- Nearly 70% of ovens in 2018 are A (minimum possible class after 2020)
- 0.24% of ovens in 2018 are either B or C (banned after 2020)
- There are no ovens in the lowest energy class (D)
- It appears that there is a bigger proportion of larger cavity volumes in the top energy classes (A++ and A+) than in the low energy classes (A and B)
- It seems easier to reach top energy classes when the oven has a steam heating function supporting the convective function

In terms of energy classes (cookers):

- There are no A+++ or A++ cookers (top energy classes)
- A+ category has been growing very slowly up to a 2% in 2018
- The vast majority (79%) of cookers are A (minimum energy class after 2020)
- 4.5% of cookers in 2018 are either B or C (banned after 2020)
- There are no cookers in the lowest energy class (D)

Hobs conclusions

- Induction technologies are expected to see a significant growth over the next years. Gas hob sales are expected to grow at a very slow rate, with radiant and solid plates technologies decreasing gradually.

Range hoods conclusions

- The energy classes of the sales have improved along the last years, and worktop vent hoods have reached A++. However, the market share of this type of hood is very low (<1%). Under cabinet hoods perform the worst energy classes (C to E), though their sales show a downward trend.
- There seem to be a relation between energy class and flow, since the data available show a concentration of the best energy classes in the larger flow ranges and of the worst energy classes in the smaller flow ranges. However, there is not a significant trend towards a specific range of flow, probably because the flow and the size of the hood are dependent to the kitchen furniture and space available, which significantly vary across EU households.

3 Task 3: Preliminary work. Analysis of user behaviour and system aspects

User behaviour has a significant effect on the environmental impacts of domestic cooking appliances during all phases of their life-cycle: firstly through the selection of the appliance type, secondly through the actual use of the appliance over the life time and finally on the end-of-life. 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.

It has been reported that the most valuable source of energy conservation during cooking is consumer education, making sure that cooking activities happen under proper conditions (Hager, 2013). In fact, behaviours of consumer can double energy demands if they are unaware of energy saving techniques. Therefore, the aim of this section is to investigate the influence of consumer behaviour on the energy and environmental performance of cooking appliances, as well as best-practices in sustainable product use.

- In Section 3.1, the relevance of energy consumption of domestic cooking activities will be put in perspective within the European context.
- In Section 3.2, system aspects affecting energy consumption such as frequency of use and duration of cycles will be presented. This section will include currently available published data and will be used for reference only (this data will not be used for environmental or economic impact assessment).
- In Section 3.3, other aspects affecting total energy consumption such as purchase decision and cooking habits will be presented.
- In Section 2.4, aspects related to user behaviour and end of life –such as reusability, repairability and disposal channels- will be presented.
- In Section 3.5, aspects related to local infrastructure will be addressed. For domestic cooking appliances, these will be mainly related to the effects of product installation and maintenance on performance and durability
- Section 3.6 is **work in progress**, and will include the results of a complete user behaviour study. This study will provide up to date information on frequency of use, duration of cycles and preferred programmes and modes. It will provide information on how representative current test standards are in comparison to typical real uses of appliances. This is the data that will be used in subsequent sections of this report (environmental and economic impact assessment).

3.1 The relevance of domestic cooking activities in the European energy context

In 2017, households energy consumption represented 27% of total final energy in the European Union (Eurostat, 2017), being the second consuming sector after transport (33%). The peak of energy used in residential sector was observed in 2010 with 3,721 MWh, with a slight decrease of 9% since then (European Commission, 2018). Total energy consumption in EU households may be reduced with the help of energy efficiency initiatives. It has been estimated that European households could save roughly 27-30% of their energy usage by correcting inefficiencies (PENNY, 2019).

Energy is used for various purposes within households: space and water heating, space cooling, cooking, lighting and other electrical appliances and other end-uses. Most of that energy is spent in space heating (64%). Cooking activities represent 5.6% of household electricity consumption (**Figure 65**).

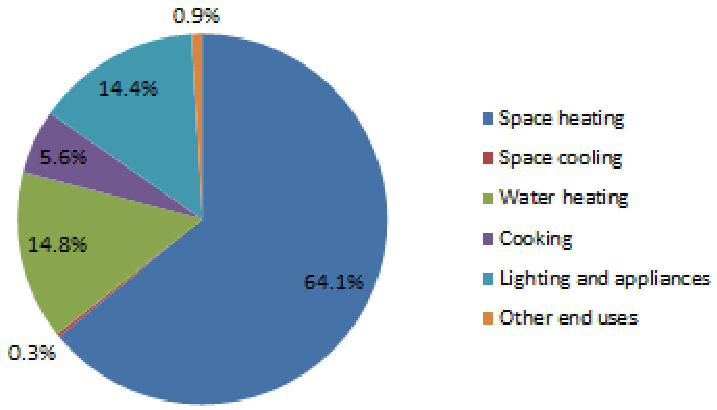


Figure 65. Final energy consumption in the residential sector of the EU28 (Eurostat, 2017)

Average annual energy consumption for cooking has been estimated in 460 kWh per year (Zimmermann et al, 2012). Energy spent also differs significantly depending on the type of household and on level of occupancy. The highest energy consumption has been reported in household with single inhabitants non-pensioners, with 505 kWh/year and person; whereas the lowest average is in households with multiple people with children: 422 kWh/year and person (Zimmermann et al, 2012).

The share of final energy consumption dedicated to cooking activities within the household varies considerably when analysing member states individually, ranging from 1% up to 39%. Several factors can affect that wide variability. First, in certain countries, most of energy may be spent in other areas, such as space heating (as it happens in Finland with 66%), reducing proportionally the share dedicated to cooking. In fact, it is observed that most of the countries with the highest proportion of energy dedicated to cooking are in the South/Mediterranean area (Portugal, 39%; Malta, 12%; Spain, 8%), whereas those with lowest proportion tend to be in the north (Finland, 1%; Sweden, 2%; Denmark, 2%; UK, 3%). Differences in terms of food culture and diet may have an influence on the energy spent on cooking.

3.2 System aspects use phase for products with direct energy consumption

As seen in Task 1 of this report, energy consumption of domestic cooking appliances is measured as in **Table 23**:

Table 23. Ways of measuring energy consumption for domestic cooking appliances

Appliance	Energy efficiency in product declaration fiche	Unit
Ovens	Energy per cycle	Electric (kWh/cycle) Gas (MJ/cycle)
Hobs	Energy per amount of standard load	Electric (kWh/kg water) EE [1] (%)
Range hoods	Energy per year	kWh/year

1-EE is expressed as % in gas hobs but is also related to energy required to heat a standard amount of water (see Task 1 for details)

As it can be seen in **Table 23**, a key parameter is the frequency of use (generally expressed as cycles/year). A secondary but also relevant parameter will be the duration of each cycle (generally expressed as minutes/cycle). Data published so far on those two parameters will be presented in Section 3.2.1. Based on frequency of use, typical energy consumption values will be presented in Section 3.2.2.

3.2.1 Frequency of use of domestic cooking appliances

European citizens invest a considerable amount of time in cooking at home, both in weekdays and in weekends. As it was analysed in Foteinaki et al. (2019) for the case of Denmark, at certain times of the day, nearly 30% of the population may be doing cooking/eating related activities (Figure 66).

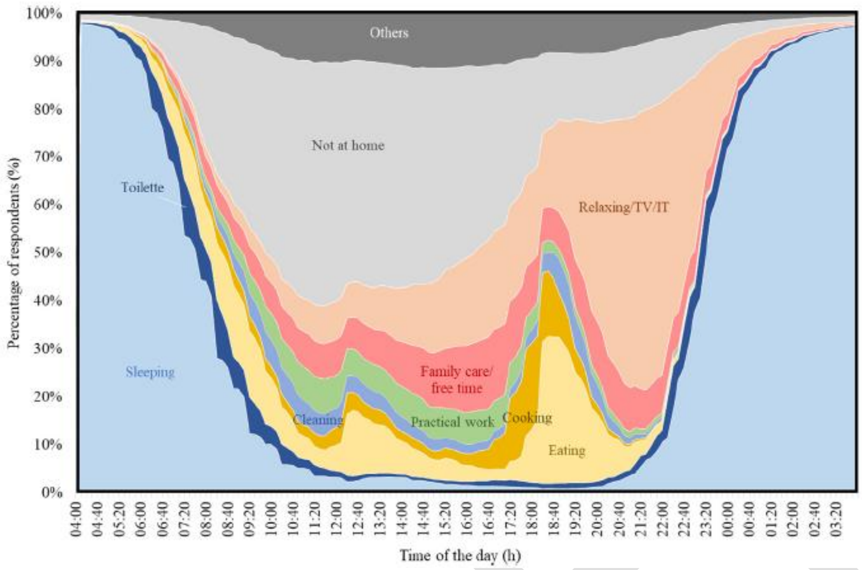


Figure 66. Daily activity profiles in Denmark

Similar patterns, with slight differences are observed in other European countries such as Spain (**Figure 67**). As indicated in Santiago et al (2014), food preparation shows a small peak in the morning, another much larger peak at noon (with 20% of households involved in this activity on weekdays and more than 30% on weekends), and another peak corresponding to the evening.

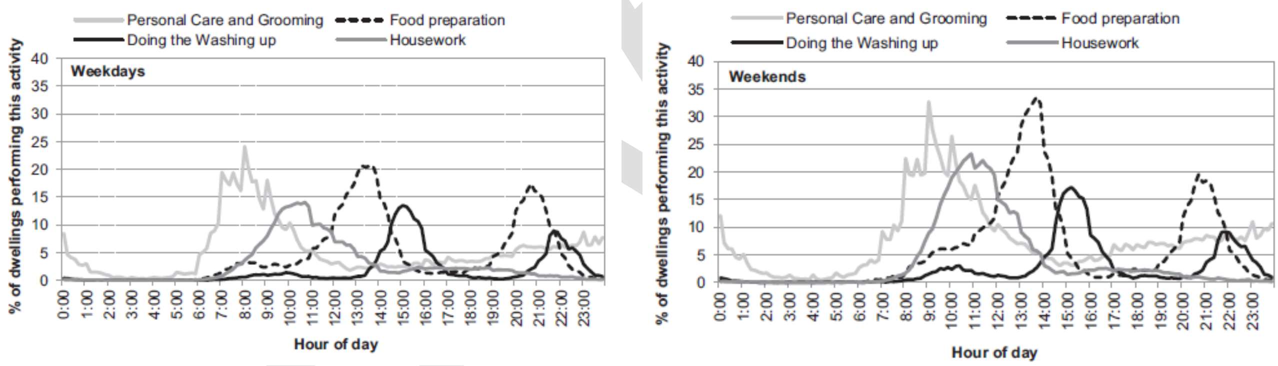


Figure 67. Daily activity profiles in Spain

Figure 66 and Figure 67 show that there are differences in the schedules and habits among the different European countries, reflecting different lifestyles and routines, closely linked to the customs, practices and climate of each zone. Another relevant comment pointed out by the authors is that energy consumption related to cooking activities coincides with household active occupancy peaks and with the greatest electricity demand in the residential sector. This is a time interval which is difficult to modify, as it is closely linked to habits and working schedules and therefore occupants must necessarily be in the home.

In general, cooking activities last between 36-43 min/day, with slightly longer duration for weekends and colder seasons (Barthelmes et al, 2018). Lower energy consumption for cooking activities in summer is also observed, mainly because of the type of meals prepared and the time spent on cooking (Zimmermann et al, 2012). In Wood et al (2013) it is also observed that energy consumption in cooking of the average Sunday is twice as big as the energy consumption on the average weekday. Santiago et al (2014) also indicate that size of municipality has certain influence on amount of energy spent on cooking activities. In small municipalities, there are more homes dedicated to cooking than in the cities during the day. At the noon peak, for instance, there are 8% more households engaged in this activity than in the big cities.

Ovens

In previous Preparatory Study for Domestic Cooking Appliances -Mugdal et al (2011)-, on average a household uses the oven 110 times per year (**Table 24**). The average duration of cycles was estimated at 55 minutes both for electric and gas ovens.

Table 24. Frequency of use and cycle duration for ovens (Mugdal et al, 2011)

	Electric oven	Gas oven
Frequency of use (cycles / year)	110	110
Average duration of cycle (min)	55	55
Standby mode (hours/year)	8595	8595

Regarding frequency of operation, feedback from a stakeholder highlighted that for cooking appliances this is highly influenced by household size, region, season, eating habits, family situation, and even the kitchen equipment. The stakeholder provided information as well on frequency of use of different oven applications (**Figure 68**).

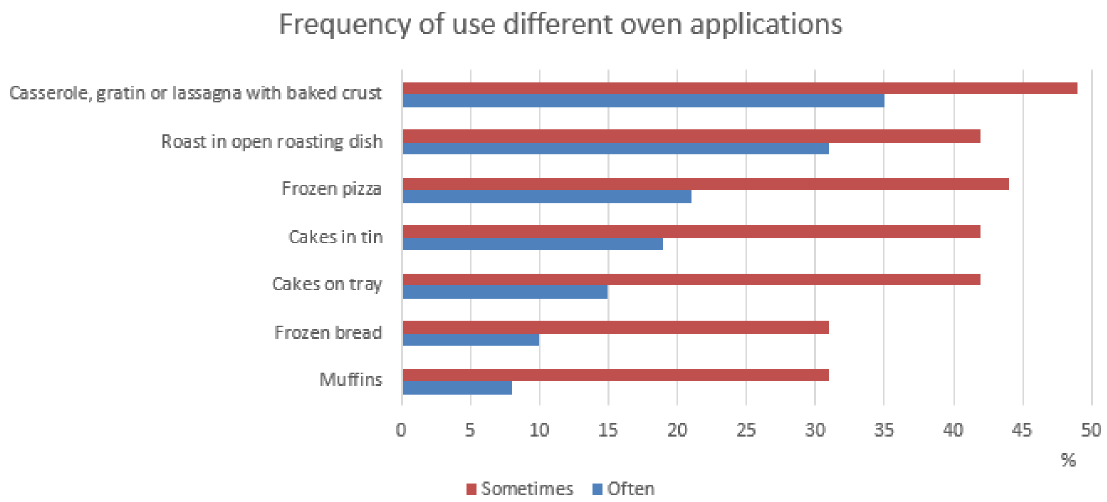


Figure 68. Frequency of use of oven applications

In terms of duration of cycles, the same stakeholder indicated that almost half of oven users turn on the oven for about 0.5 to 1 hour, as seen in **Figure 69**.

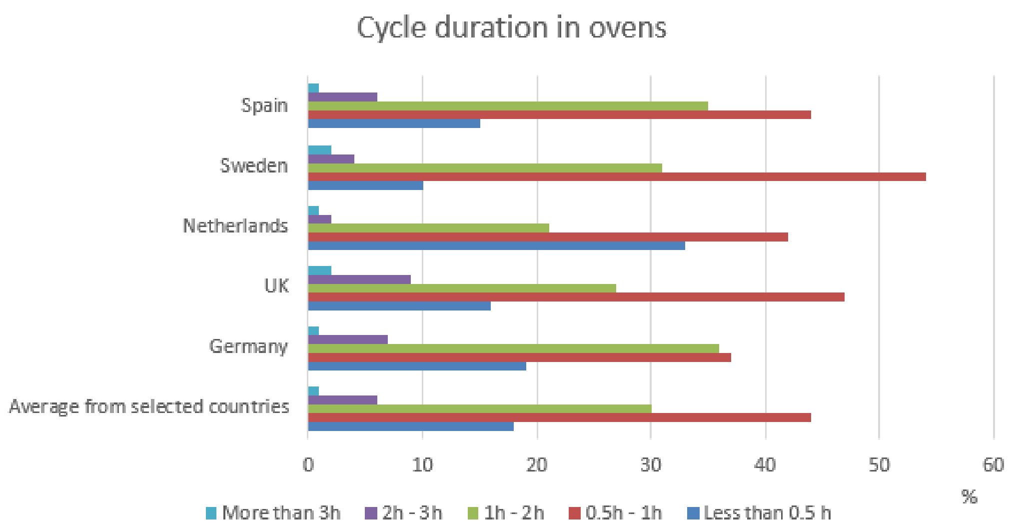


Figure 69. Duration of oven cycles in different EU countries

Finally, the same stakeholder also provided information on the frequency of use of oven modes (**Figure 70**). The mode which is used more often is "hot air" (59% of times the oven is operated), followed by "top and bottom heating" (22% of the times). The rest of the oven modes only account for 19% combined.

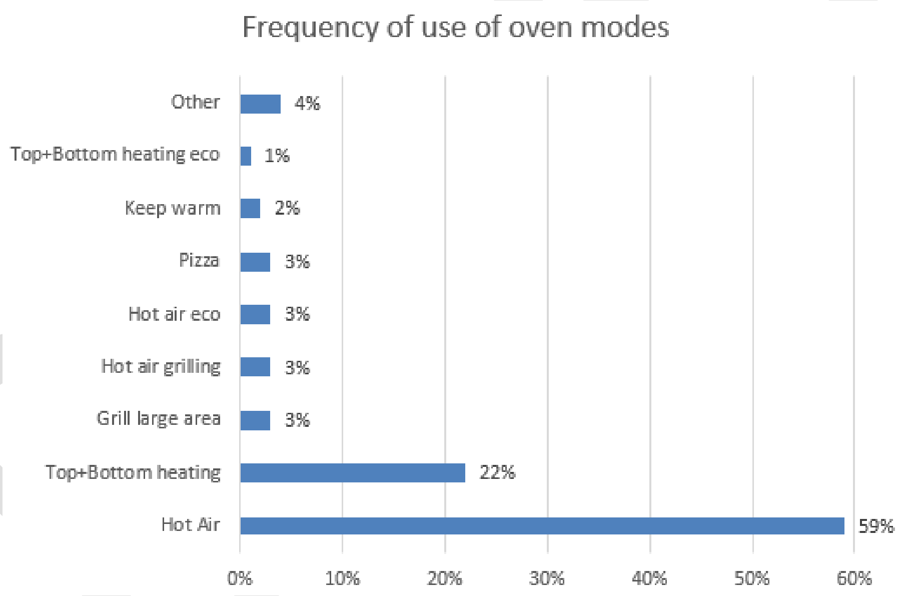


Figure 70. Frequency of use of oven modes

Another stakeholder highlighted the Project "PANEL ELECDOM" in France, in which the electricity consumption of 100 households is monitored in detail (10 minutes time step). The monitoring campaign is currently ongoing and the results will be available in June 2020. The project includes hobs, ovens, microwaves, etc.

<u>Hobs</u>

In previous Preparatory Study for Domestic Cooking Appliances -Mugdal et al (2011)- the frequency of use for domestic hobs is 424 cycles per year (**Table 25**).

Table 25. Frequency of use and cycle duration for hobs (Mugdal et al, 2011)

	Gas	Solid plate	Glass ceramic	Induction
Frequency of use (cycles / year)	424	424	424	424
Average duration of cycle (min)	n/a	26	45	58

According to Mudgal et al (2011a), induction hobs are used an average time of 58 minutes per cycle, whereas for the ceramic and solid plates it is 45 and 26 minutes respectively (**Table 25**). The differences in times are not explained in the report, even though induction hobs heat food more quickly with lower heat losses and therefore shorten the cooking time and consume less electricity annually than other types of hobs. An explanation could be related to different usage patterns.

In contrast to **Table 25**, data provided from relevant stakeholders indicate that for induction hobs:

- The average duration per usage is approximately 19 minutes.
- The number of usages of the cooktop per year is 679 times.

Range hoods

In previous Preparatory Study for Domestic Cooking Appliances -Mugdal et al (2011)-, no data is provided on range hoods in terms of frequency of use or duration of cycles. According to a stakeholder, a range hood operates for approximately **300 hours/year**.

Other stakeholders indicate that, according to internal company studies, all speeds of range hoods (min, medium, max) are used equally, whereas boost mode is rarely activated and it is used only during specific cooking types. The frequency of use is from **1h-3h/day**.

3.2.2 Typical energy consumption of domestic cooking appliances

Ovens

In terms of ovens, Mudgal et al (2011a) gathered data on user behaviour, specifically on typical dishes, number of times they were prepared and the temperature used was collected for several countries. The study concluded that it was not possible to identify major differences in oven use practices. Information was collected for six different types of uses of meal cooking: meat, home-made meals, cakes/bread, snacks, ready meals, and reheating.

It was also reported a decrease in the consumption per use by 25% from 1980 to 2008 possibly due to the fact the market share of most energy efficienct ovens and cookers has increased although the energy consumption in additional functions (such as standby power) also increased, shrinking households and the shift to other appliances (e.g. microwave ovens). Values of Energy consumption, frequency and duration used in the previous Preparatory Study for Ecodesign Requirements for Cooking Appliances are presented in **Table 26**.

Table 26. Electricity consumption electric and gas ovens (Mudgal et al, 2011a)

	Electric oven	Gas oven
Electricity consumption (kWh/cycle)	1.1	1.67
Standby electricity consumption (kWh)	0.005	0.005
Annual Electricity consumption (kWh/year)	164	184

Lot 22, Task 3, p16

According to a relevant stakeholder, energy consumption of current electric oven ranges from **0.87-0.93 kWh/cycle** in conventional cooking mode (top+bottom) and from **0.69-0.70 kWh/cycle** in convection mode (fan-forced). This indicates that the energy consumption values used in the previous preparatory study may be out of date by now.

Hobs

Energy consumption values used for scenario modelling and analysis in the previous Preparatory Study for Ecodesign Requirements for Cooking Appliances are reported in **Table 27**.

Table 27. Hobs annual energy consumption (Mudgal et al, 2011a)

	Gas	Solid plate	Glass ceramic	Induction
Energy consumption (kWh/cycle)	0.78	0.58	0.57	0.45
Annual energy consumption (kWh/year)	334	250	240	190

Lot 23, Task 3, p12 & p15

Regarding gas hobs, Mudgal et al (2011b) suggested that the evolution of the gas hobs energy consumption was approximately constant for 20 years (1980-2008), as the main parameters remained constant: the consumption per use and the number of uses per year. The reason for the slight increase in the evolution is the standby power demand that has increased in the last years.

According to a relevant stakeholder, energy consumption of current hobs is around **0.55 kWh/cycle for radiant vitroceramic** and around **0.75 kWh/cycle for gas**. These figures are in the same order of magnitude than in the previous preparatory study.

Range hoods

In previous Preparatory Study for Domestic Cooking Appliances -Mugdal et al (2011)-, no data is provided on range hoods in terms of energy consumption.

According to a relevant stakeholder, energy consumption of domestic range hoods is **between 36.5 and 72.1 kWh/year**, depending on different performance factors such as airflow, lighting power or grease filtering efficiency.

3.3 Other aspects affecting the performance of domestic cooking appliances

Beyond energy consumption per cycle and number of cycles per year, total energy consumption is also affected by other aspects. For instance, if European consumers are driven to purchase very energy efficient appliances, total energy consumption will decrease over the years. However, if users do not follow best potential cooking practices, the benefits of these energy efficient appliances may be lost. Both purchase behaviour and cooking habits are analysed in this section.

3.3.1 Purchase of domestic cooking appliances

3.3.1.1 General drivers on purchase decision

Most of the households in the EU28 have some type of oven, hob and hood. In a study focused on Denmark (Foteinaki et al, 2019), it is stated that these appliances can be found in 90% of households. Similar picture is observed in the United States, where the most popular choice by consumers is oven with hob together –also known as cooking range-, present in 91% of households. Separate hobs or ovens are present in 14% and 12% of households respectively (EIA, 2019).

. Similar to the topic, some authors (Baldini et al, 2018) have focused their analysis in analysing which are the socioeconomic characteristics which can predict better the choice of purchasing energy efficient appliances in general (not focused on cooking appliances). Variables used in this study were the number of inhabitants in the household, the type, age and size of house, the age of respondents, their job, their income and their environmental awareness. Some of the findings from this study are summarized below:

- The higher the income, the higher the probability to choose more energy efficient appliances
- It is more probable to choose more energy efficient appliances in farmhouses and single houses than in townhouses and apartments
- The higher the number of people living in the dwelling, the greater the propensity to choose an energy efficient appliance
- The higher the environmental previous awareness and behaviour, the higher the chance of selecting a more energy efficient appliance
- Older respondents have a higher propensity to choose energy efficient appliances

Since there is no specific research on purchase behaviour for cooking appliances, it is only possible to extrapolate conclusions from previous studies applied in different products. Some of the potential aspects influencing purchase behaviour for ovens, hobs and hoods are commented in this section.

Price and **cost of use** are obvious factors that may affect purchase decisions of cooking appliances. At equal level of performance in terms of functionalities or energy consumptions, consumers will likely prefer appliances that allow them to save money across their lifetime. Aspects which may have influence consumers in acquiring a more expensive product –of similar performance- are brand reputation or aesthetics. It has been demonstrated that consumer age is a factor that correlates with the amount of money spent on home appliances (Hennies et al, 2016). In general, younger people buy significantly more low-cost appliances such as washing machines and TVs. It has also been observed that the price paid for these appliances correlates significantly with the lifespan of the appliance.

Related to price and cost of use, **durability** is a relevant factor as well that may affect purchase decisions. In the case of cooking appliances, consumers tend to prefer ovens, hobs and hoods that guarantee longer periods without maintenance needs or critical failures. Durable products avoid –or delay significantly- the need of acquiring new appliances to substitute old ones. Consumers have shown a clear preference for durable products: in Perez-Belis et al (2017), it was concluded that 79% of consumers find very relevant to include durability requirements in product design.

Nevertheless, an although it may be correct to assume that consumers do prefer purchasing durable products, this statement can be debated with the current trend of rapid substitution of appliances, driven by the constant availability of new technologies and products, which make older products quickly obsolete. The topic of **obsolescence** is addressed by Hennies et al (2016). In their study, the authors differentiate between:

- Quality obsolescence, when the product does not work anymore.
- Functional obsolescence, when the product does not satisfy completely the expectations of consumer
- Psychological obsolescence, induced purely by the desire of acquiring new products.

The most problematic of the types of obsolescence defined would be the psychological, since the decision of discarding the product in those cases is neither related to failure or to lack of required functionalities. However, the authors point out that psychological obsolescence tends to be low in 'workhorse' appliances such as washing machines (1%) and slightly higher in 'up-to-date' appliances such as TVs (14%). In terms of socioeconomic characteristics related to obsolescence, Dindarian et al (2012) indicate that high income and low educational achievement are both correlated with early replacement of durable products. End of life aspects are discussed in more detail in Section 3.4 of this report.

In terms of **second hand market**, there is not much data publicly available for ovens, hobs and range hoods. With regards to other home appliances such as small ICT devices, it has been estimated that only

12% of population actually purchase second hand products (Bovea et al, 2018), and that when they do, it is mainly due to economic reasons (environmental aspects are generally ignored). This figure is even lower in Perez-Belis et al (2017), where only 0.75% of respondents to a survey admitted having bought second hand small home appliances. When they actually did, they did not invest more than 20 Euros in them.

In terms of the barriers for this low preference of second hand products from the consumers' side, the most common are the association with potential premature failure of second hand products, health, safety and hygiene concerns, perception of inferior quality, perception of little difference in price between new and second hand products, lack of repair guarantees and general desire to acquire new products. In addition to those, second hand product sellers also argue that barriers for this market to grow are the unpredictability of supply and demand, the lack of legal incentives to promote repair and the perception that, on occasions, consumers may feel ashamed of purchasing second hand products (Bovea et al, 2017).

Other authors suggest that the **reputation** of the seller of the second hand product is important. Reputation mechanisms such as the ones in online second hand selling sites can provide signals about product or service quality and help mitigate uncertainties faced by potential buyers of remanufactured products. It has also been observed that consumers pay relatively higher prices (8%) for products remanufactured by OEMs or their authorized factories than those remanufactured by third parties (Subramanian et al, 2012).

Another important purchase decision regarding cooking appliances may be **energy source**. Considering that, it is relevant to point out that most ovens and hobs in the EU28 are electrically heated. The market share of electrical appliances is growing even bigger, with gas appliances still in a significant 16% for ovens and 36% of for hobs (European Commission, 2012). This pattern is similar in markets such as in the United States, where 35% of total cooking appliances work with natural gas and 63% with electricity. Type and size of household tend to determine the choice of energy source for appliance. For instance, it has been observed that the use of gas appliances is greater as household size and income increase (Hager, 2013).

Another factor that can influence the selection of gas or electric appliances is the **local infrastructure**. For example, 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 cooking appliances instead of gas.

An important aspect influencing purchase decision is the amount and type of **information provided** to the consumer. According to the results presented in PENNY (2019), providing tailored information about the potential of monetary savings from adopting new energy efficient durables induces households to purchase home appliances that consume on average 18% less electricity compared to those purchased by households that did not receive such information. In the same study, it is also highlighted that what matters is not only the content of the information provided, but also the way in which this information is presented. For instance, if information of energy usage cost for a specific product is presented –instead of monetary savings-, consumers tend to shift towards less efficient products. The format of the information presented is therefore a strong moderator of the effectiveness of information policies on investments.

Another important factor is **literacy** regarding energy consumption and related environmental impact of appliances. It has been observed that households with a low degree of energy literacy tend to underestimate the benefits of purchasing efficient appliances. Therefore, educational campaigns could increase the level of energy literacy and promote investments into energy-efficient appliances. Still on the matter of information provided, in Baldini et al (2018), it is concluded that information campaigns such as labelling have not had significant effects in promoting energy efficiency improvements. The authors recommend that the focus for future policies is to consider not only what metric is shown in the label, but also what this metric actually means to the customer in the moment of purchase.

In terms of appliance choice, it is also worth mentioning that in certain contexts, consumers cannot affect energy efficiency of cooking activities through the purchase of appliances, such as tenants in already furnished houses or students in residences, where energy efficient devices are often not the option. In other occasions, people may be economically constrained when trying to incorporate energy efficient behaviours, not being able to replace old inefficient appliances even if they are willing to do so. In these situations, the only way consumers can affect energy consumption will be through the actual use they make of those appliances.

3.3.1.2 Product specific drivers on purchase decision

Oven capacity (cavity volume) is a factor for consumers when purchasing a new oven. Even when the dishes cooked more often might not be large in size, they might opt for ovens with more capacity to cover the rare occasions when they cook large meals.

On this topic, one stakeholder indicated that for built-in ovens the maximum capacity is limited due to the typical furniture in European kitchens. Also, the used capacity varies strongly during the year. For a given consumer, even if only once per year a large meal (such as a goose) is prepared, this consumer will never decide on a smaller capacity. Usually, the oven provides more levels for inserting the food to optimize the application for the different modes and dishes. In order to ensure the very high range of applications (grilling, pizza, roasting a turkey, baking cookies on several levels, baking bread) the concept of more levels in a certain volume is needed. Another stakeholder adds that optimal capacity of the oven depends also on the family composition and status.

In current oven models, there is a trend to include **self-cleaning programmes**. There is certain debate around potential hygienic issues related to the inclusion of these programmes. According to stakeholders, ovens operate with very high surface temperatures inside, so there are in general no hygienic problems. This is highly supported by self-cleaning programs working with temperatures up to 500 °C.

Other stakeholder adds that high temperature cleaning programs are hygienic safe. Low temperature cleaning (water/steam based) could be under concern. However, the relevant heating processes are based on the use of accessories (which are not part of the cleaning program) and/or high temperature modes. Therefore, no hygienic problem is expected.

The purchase decision of a range hood is usually made together with the **kitchen design and installation**, and it is usually limited by the space available. The size of the range hood has a significant impact on its components and its energy efficiency. This is further explained in Task 4 Analysis of technologies.

3.3.2 User cooking habits

It has been estimated that 26-36% of the total in-home energy use is directly related to residents' behaviour (Wood et al, 2003). Specifically related to cooking, energy use has decreased 50% since the 1970s, but these gains have not come from changes in cooking methods but from the use of more energy efficient cooking devices (such as microwaves), through the expansion of ready-made meals and takeaways and from eating out habits. In fact, the connections between cookery practices and environmental impacts is often ignored by consumers, industry and government policy, when these practise may be up to 50% of energy use when analysing a food product's life cycle (Reynolds, 2017).

There are numerous energy saving behaviours that can be performed during cooking. Even when cooking simple meals, energy efficient techniques can help to reduce energy consumed by a third (Oliveira et al, 2012). Changing energy-using behaviour during cooking has therefore a significant potential for energy conservation.

An appropriate **cooking temperature** is a very relevant factor concerning energy consumption of appliances, especially in the case of ovens. Using higher temperatures than needed will mean a significant waste of heat –and the possibility of spoiling the meal-. However, it is also worth taking into account that according to Reynolds (2017), cooking at lower temperatures in the oven than indicated in the recipe actually increases energy use since it also increases the amount of time the meal needs to be in the appliance. The right balance in terms of temperature settings is essential.

Switching to **smart** or more **energy efficient appliances** has the potential of reducing significantly energy use while cooking. In the case of range hoods, it has been demonstrated that the use of smart devices, which are able to automatically adapt its performance and optimize its operation, depending on the type of system used (Castorani et al, 2018). However, it is important to note that using energy efficient products does not necessarily mean that people automatically use less energy, as the overuse or incorrect use of the appliance can drastically increase final energy consumption.

Clear **indications** and **energy consumption feedback** in cooking appliances has significant improvement potential. Indications of cooking appliances being on/off are important for reduced energy consumption. In Oliveira et al. (2012), it is demonstrated how a confusing display on a hob can lead to significant energy wasted when cooking a simple meal. Generally, when having controls on the same disposition as the burners, subjects tend to incur in less errors in identifying which one is working. It is also worth mentioning the reduction potential of information feedback to consumer. It has been demonstrated that a significant proportion of households are able to reduce electricity expenditures while cooking if they are given feedback on their energy related behaviours, especially if it is immediate and in electronic format (Wood et al, 2013).

Accurate **cooking times** can be a relevant factor that influences energy consumption. Turning hobs off when water is already boiling or switching ovens off for the last minutes of cooking has been highlighted as technique that has a big energy saving potential (Oliveira et al, 2012).

Reading carefully **cooking instructions** can have a significant energy saving potential, as it can lead to reduce errors in temperature settings, cooking times, quantities, as well as to the use of other simple tips such as the use of lids or not opening the oven door to check is food is already cooked.

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

As already mentioned in section 3.3.1, product **durability** can affect purchase decisions. At the same time, consumer behaviour is also decisive on product durability. They way in which the product is used and maintained can compromise the limit of their lifetime.

In O'Leary et al (2019), it is estimated that the existing domestic kitchen ventilation strategies and airflow rates are inadequate in over 88% of houses when the range hood is used only during the cooking operation. However, if the **range hood is used for a period of time after cooking**, it can reduce the daily mean of PM2.5 concentration significantly. Daily average concentration can be reduced 58% if range hood operates for 10 extra minutes after cooking. Dobbin et al (2018) also found benefits in operating the hood for longer time after cooking, although in their experiment it had a relatively small effect compared to the effects of fan flow rate and the specific fan used during cooking. For PM2.5, the effect of running an exhaust fan for 15 minutes after cooking was similar in magnitude to the impact of a 168 m3/h increase in the flow rate used during cooking. This suggests that one can partially compensate for low flow rate exhaust fan by continuing to run the fan after cooking. It must also be taken into account that running the hood for some time after cooking would be detrimental for the total energy consumption of the appliance, so a clear trade-off arises here between capture and energy efficiency of range hoods.

3.3.3 Maintenance of domestic cooking appliances

Maintenance is also a very relevant factor concerning domestic cooking appliances. According to a stakeholder, for a proper performance and durability of appliances, they should be appropriately cleaned and maintained. For instance:

- The cavity of the oven and the door sealing need to be regularly cleaned, in order to avoid excessive grease and soil deposition, which can burn irreversibly into the enamel and which can disturb the good functioning of the heating elements.
- In gas hobs, burners should be periodially cleaned
- Grease filters of hoods have to be regularly replaced or cleaned. Active charcoal filters of recirculation hoods also have to be cleaned or replaced according the manufactures' instructions.

With a proper maintenance, the performance is ensured and the risk of repairs can be significantly reduced.

3.3.4 Information to consumers

Information provided to consumers (both in terms of energy efficiency and on end of life) is a very relevant topic in this section.

One stakeholder argues that consumer studies have shown (https://www.verbraucherzentrale-rlp.de/sites/default/files/migration_files/media231718A.pdf) that the energy efficiency classes are better understood than the information on the total consumption. Thus, there is certainly room to explain this aspect better to consumers.

Some stakeholders provided feedback on potential additional information requirements which could be included in future regulation for domestic cooking appliances:

- Overall, they recommend to follow the example set by the recently adopted ecodesign and energy labelling regulations in which improved information requirements (also on resource efficiency aspects) have been set.
- Include information on how to carry out maintenance and repair, as well as information on end-of-life treatment.
- Explore the icons on the Energy Label that could help consumers buy more durable, reparable products, such as the free warranty period offered by the manufacturer or spare parts availability. DG Justice's behavioural study on consumer engagement in the circular economy describes how effective this could be in shifting purchasing decisions towards products with greater durability and reparability.
- Ovens: indicate on the energy label both, the energy consumption in standard mode, and optionally in the ecomode.
- Range hoods: Table 6 Annex I "information on domestic range hoods" contains a list of information, symbols, values and units but not on the type of range hoods which is important.
- Provide consumers with information on the performance of the appliances by introducing an energy label for hobs, and for the commercial appliances.

Other stakeholder adds that information about the used energy after a heating process, not in terms of absolute values, but in terms of steps or ranges (low-mid-high energy consumption) could guide users to save energy. Absolute values should be avoided, because the product is not mentioned as a measurement system and the tolerances of the power installation would require an advanced measurement system, which would make costs higher without a significant user advantage. Now, the users have no possibility to evaluate and improve their usage behaviour.

3.4 End of life behaviour

Domestic ovens, hobs and range hoods are appliances that are present in the majority of households of the EU. Domestic cooking appliances are heavy, bulky items with abundant different materials, including ferrous and non-ferrous metals, plastics and several types of electronics. This abundancy of materials –very valuable, but also energy-intensive and rich in rare resources- makes their proper management at end of life a very relevant aspect of their life cycle. Ovens, hobs and range hoods –among other large household appliances- are under the scope of the Directive 2012/19/EU on waste electrical and electronic equipment (WEEE Directive).

The habits of consumers in relation to end of life strategies concerning electrical and electronic equipment have not been widely analysed so far. However, it is necessary to know whether consumer behaviour is aligned with the objectives promoted by policies such as the WEEE Directive and also with the principles of the Circular Economy. This is fundamental to determine whether more awareness-raising actions are required to guide consumers towards priority strategies in the waste hierarchy, such as reuse and repair.

To date there is not much literature available on reuse and repair practices for domestic cooking devices specifically. In this section, information is provided on consumer behaviour at end of life regarding small electrical and electronic equipment and large home appliances in general. Although crucial aspects such as lifetime expectancies, usability patterns and technology evolution may be significantly different between those and domestic cooking appliances, some interesting conclusions can still be made based on the data available.

3.4.1 Reusing and repairing domestic cooking appliances

In the past years, it has been observed that electrical and electronic appliances are replaced earlier than they actually need to. In Bovea et al (2018), the authors conducted an analysis on the habits of consumers regarding the substitution, repair or second hand purchase of most frequent information and communication technology (ICT) devices in Spain (mobile phones, e-book readers and tablets). Some of their findings were that only 13% of the population stopped using the devices because they were broken. In terms of functionality or safety, there was not a real need to dispose of or substitute the device, but the consumer still decided to change it. This is in line with the findings of Dindarian et al (2012) regarding microwave ovens: half of the units studied required only minor repairs; some of them only minor cosmetic or cleaning operations. This short substitution cycle leads to an accelerate growth of the amount of waste, and is mainly caused by rapid technology evolution, particularly in the ICT sector.

Domestic cooking appliances are significantly different to ICT devices. They have different usage patterns, they are not so related to trends, and they generally do not generate an emotional attachment to consumers. Their lifetime, which will be discussed in further detail in subsequent sections of this report, is generally expected to be longer than ICT devices. However, this trend of substituting appliances even if they are still functioning –or if they can be easily repaired- may also be happening at a slower pace in the large appliances sector. More research should be carried in this field to confirm this aspect.

In terms of potential **reusability** of appliances, in Bovea et al (2016) a methodology was defined to classify small WEEE according to its potential reuse. The methodology was then applied to a sample of small devices. From the analysis it was concluded that 30% of the sample had to be diverted to recycling due to functional or safety requirements not met; 2% of the sample could be directly reused after minor cleaning operations; and 68% of the sample required posterior evaluation of its potential repair. Adding up the last two, it may be concluded that the total potential for reuse of small electrical and electronic appliances is of 70%. As said earlier, this cannot be directly extrapolated to the domestic cooking appliances sector due to the obvious differences between product types. However, it does provide an indication of the potential reusability and reparability of appliances in general.

In terms of **reparability** of domestic cooking appliances, from consumers' perspective, the barriers to repairing used appliances are related to the fact that most of them (79%) do not consider it worthwhile given the price of purchasing new equipment… Moreover, Dindarian et al (2012) also point out that refurbishing and remanufacturing costs are for some products only a fraction of manufacturing costs of a new product. Other barriers are not knowing where to take the appliance in order to be repaired and the inconvenience of bringing the equipment to the repair centre. From the repairers' perspective, the unpredictability of supply and demand and the difficulty of obtaining cheap spare parts are highlighted as the main barriers for this end of life alternative.

3.4.2 Disposal channels for domestic cooking appliances

Although reuse and repair are the preferable end of life alternatives, the average consumer is generally not aware of options beyond recycling or landfilling. According to Dindarian et al (2012), 67% of consumers bringing microwave ovens to collection points are not aware of other end of life options for this appliance. Reuse and repair do not seem like options that consumers are considering widely. When home appliances are not reused or repaired, consumers still need to dispose of them in an appropriate manner. In Huisman et al (2012) the authors describe different disposal alternatives for consumers regarding waste of electric and electronic equipment (WEEE):

- **Municipal collection points**, also known as waste transfer stations. By law, municipalities are obliged to have at least one such location. From these collection points, most WEEE is handed over to the system of the compliance schemes.
- **Retailers**. When consumers buy new equipment, they can hand in the items being replaced. Retailers having a contract with the compliance schemes will hand over the received equipment to recyclers. It must be taken into account that some of the contracted retailers still deliver such equipment outside compliance schemes.
- **Door-to-door collection**. Consumers can also choose to give or sell WEEE to door-to-door collection which mainly happens in bigger cities. Driven by high metal prizes, informal collection pathways also exist. The collected WEEE with these systems is rarely handed over to the system of the compliance schemes.
- **Charity initiatives**. They often work in close cooperation with municipalities and businesses. Their main function is to sell 2nd hand equipment, if still functioning, to other consumers.

Related to the disposal channels above, in Magalani et al (2012) an analysis was conducted on the main disposal channels for large household appliances. The two main disposal paths in Italy are through municipal collection points and retailers. Regarding retailers, large household appliances are mostly picked up at consumers' homes 75-95% of the time, often in conjunction with the delivery of new equipment (Table 28).

Table 28. Disposal channels for large household appliances in Italy (Magalani et al 2012)

Disposal channel	**Average***
Municipal collection points	39.1%
Retailers	37.1%
Reuse (sold or given away)	8.0%
Bad habits (e.g. waste bin, plastic waste, other wrong streams)	5.8%
Life extension (old house….)	5.3%
Do not know, do not remember	4.1%
Warranty replacement	0.6%

*Values correspond to large home appliances: dishwashers, washing machines, wash dryers and centrifuges, furnaces and ovens and microwave ovens.

Most of the materials recovered from the collection of large home appliances are ferrous metals, followed by plastics and non-ferrous metals in smaller proportion. Nowadays, the majority of these products are recycled at the end-of-life (Magalini et al, 2017).

3.4.3 Feedback on end of life behaviour

Regarding **recycling**, one stakeholder highlights the potential issues with the use of refractory ceramic fibres in domestic cooking appliances. According to them, ideally the use of these fibres should be prohibited. If not completely prohibited, at least they should be marked clearly (marking minimum 5 cm big, in clear colour).

Other stakeholder considers that appliances that are placed on the market today, do not pose any recycling problems, as they have to respect applicable substance regulation. For older appliances, there is a potential risk. Information about that potential can be found on the Information for Recyclers online platform: https://i4r-platform.eu/.

In terms of **reusing and remanufacturing** products, relevant stakeholders state they cannot provide any information on the market for re-used products as no conclusive data about that market –which is mostly informal– is available. They add that the market for remanufactured cooking appliances is rather limited. Most likely due to accumulated dirt and grease residues in the products after several years of use. Preparation for re-use organisations mostly focus on washing machines, tumble dryers, dishwashers and cooling and freezing appliances. The same is true for components.

According to another stakeholder, the market of reused and remanufactured cooking products is very limited (for instance, charity organisations). The remanufacturing of an appliance could heavily affect safety, EMC, performance and energy consumption of the product itself. For this reason, this operation should be done just by the original manufacturer that is the only player with the proper knowledge and capability for retesting and reverification of repaired products. Remanufacturing by other operators that are not the original manufacturers, should be made clear to the users and it must not, for any reason, affect the original manufacturer and nor the status of the original placement of the product in the market.

Another stakeholder reminds that Circular Economy, resource savings and savings on embedded energy and CO_2 are clear priorities for the EU. They have been assessed necessary to reach our climate goals as set in the EU Long-term Decarbonisation Strategy for 2050. They believe that ambitious action should be taken in this regard through the ecodesign policy. Several studies show that the lifetime for large household appliances has declined and such a decline in a product's service time needs to be reversed. A way to improve the lifetime of household appliances is to design products that are easier and less costly to repair so that it is more affordable for consumers to repair appliances than to replace them. Furthermore, they recommend to explore guidance for easy maintenance and proper cleaning of the cooking appliances.

3.5 Local infrastructure

3.5.1 Installation of domestic cooking appliances

One of the aspects that should be taken into account when installing a domestic cooking appliance is its most appropriate location within the kitchen. For instance, studies suggest that the location of the cooking appliances can have a significant effect on total energy consumed in the household. For instance, it is recommended that an oven is not placed adjacent to a fridge (Wood et al, 2003).

Product installation may have a significant influence on product durability and maintenance. On this topic, a relevant stakeholder indicates that ovens and hobs are appliances which need ventilation for cooling of the electronics, furniture, etc. Proper circulation of air should be assured by following the installation instruction manuals. However, experience shows that this is often not the case. For instance:

- Wrong electrical connection on 400 V instead of 230 V can cause defects to the appliance.
- Constraints of power quality can cause defects and may influence lifetime of products.
- Wrong installation leads to complaints from users. The range hood is identified as the cause, where in fact it is the installation.

Another stakeholder agrees with the significant impact of appropriate product installation on performance and durability, in particular for range hoods. When they are installed far from refrigerators, one can expect a significant benefit in durability. They add that all products must be installed according to manufacturer's instructions. For instance, recommended ventilation gaps should be respected.

In the case of range hoods, the type of installation has a significant impact on the configuration and performance of the hood. Hood performance is related to its design, both in terms of inherent **aerodynamic properties** and in terms of **mounting configuration**, since they all have different capture areas and are mounted at different heights relative to the cooking equipment. Island mounted hoods, for instance, require greater exhaust airflow rate than wall mounted hoods. They are also more sensitive to makeup air supply and cross drafts than wall mounted (Fisher et al, 2015).

Exhaust **duct arrangement** of the hood also has an influence on the hood capture efficiency. For optimal performance, duct runs must be short with minimal amount of bends and corners.

The type of ventilation and the availability of exhaust duct also affects the installation and operation. Three different configurations can be distinguished:

1) **Recirculation Hoods:** a grease filter and a charcoal filter clean the air collected, than is recirculated into the ambient air.
2) **Extraction Hoods:** the air collected is filtered by grease filter, and then evacuated outside.
3) **Extraction Hoods connected to a Central Ventilation System:** the air collected is filtered by a grease filter and then is evacuated outside. There is no motor and the hood does not control the motor speed but it can open or close a damper.

According to the industry, range hoods working only in recirculation version represent a niche market, and almost 100% of the products can work in both conditions, recirculation and extraction mode.

In terms of **size and position**, minimizing the vertical distance from appliance to the lower edge of the hood can reduce the required exhaust airflow rate and therefore improve performance. The higher the distance between hood and cooktop, the higher the opportunities for leakage, as cooking oil mists thermal plume expands with vertical distance from generation source. It has been demonstrated that increasing the installation height of the hood by 30 cm requires 14% increase in airflow (Swierczyna et al, 2006). However, low installations may affect cooking operations and are more likely to cause fires. Also, concentration of particles in the breathing zone of the cook is higher when the distance of hood and cooktop is lower (Sjaastad et al, 2010). Other authors indicate that for optimal performance, it should be 50-60 cm above an electric cooktop and 60-70 cm above a gas cooktop (Lowes, 2019).

Relevant parameters in range hood performance are also the **front overhang** and the **rear gap** (**Figure 71**).

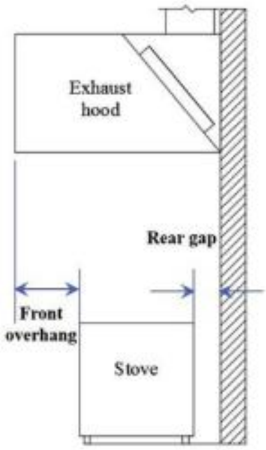


Figure 71. Front overhand and rear gap (Han, 2019)

For same sized-hoods, increasing the front overhang significantly improves the hood's ability to capture and contain cooking pollutants. A similar thing happens with the rear gap. In Swierczyna et al, 2006, it was demonstrated that for the same front overhang, a deeper hood required less airflow to operate, since rear gap becomes smaller. This is also the reason why inserting a rear seal behind the appliance to fill in the rear gap can improve hood performance, as some of the replacement air which would have otherwise been drawn up from behind the appliance, is instead drawn in along the perimeter of the hood, helping guide the plume into the hood. Other authors point out that for optimal performance, hood must be preferably around 8 cm longer than the cooktop on each side (Lowes, 2019). Related to overhand and rear gap is the **position of the burners**, which may also have an effect on hood capture efficiency. In Rim et al (2012), it is suggested that at the same hood flow rate, using the back burners is more effective in reducing particles than the front burner. This is confirmed in the experiment presented in Lunden et al (2015).

Disturbing airflows from cooking behaviour, movement of people, open windows or doors, etc., are unavoidable. These airflows have a detrimental effect on hood performance. The presence of a person in front of the cooktop, for instance, creates a wake which can potentially transport the pollutants out of the hood. In general, an island range hood is more affected by disturbing airflows than a wall mounted hood. A potential solution to mitigate the negative effects of these airflows is the use of side panels next to the cooktop, which permit the use of a reduced exhaust rate in the range hood (CEC, 2012). However, they are not very popular in domestic kitchens for aesthetic reasons.

Another relevant aspect in capture efficiency is the effect of **make-up air**. A range hood extracts air from the kitchen area. This air removed from the kitchen must be replaced with an equal volume of air through a different pathway. This equal volume of air is known as the make-up air. The strategy used to introduce make-up air can significantly impact hood performance. Make-up air introduced close to the hood's capture zone may create local air velocities and turbulence that result in failures in thermal plume capture and containment. A series of design recommendations regarding make-up air installation is provided in CEC, 2012

3.5.2 Energy: Reliability, availability and nature

Electricity

The power sector is in a state of transition, moving from fossil fuels to renewable energy. The origin of the electricity is a very important factor to consider regarding both the environmental impact of using electrical cooking appliances and how it may affect consumer behaviour. A binding renewable energy target of at least 32% of final energy consumption for the EU was agreed in 2018 for 2030. The final energy consumption is the total energy consumed directly by end users, such as households, industry and agriculture. It is the energy which reaches the final consumer's door and excludes that which is used by the energy sector itself.

The reliability of the electricity grid could, to some degree, be affected by the transition to a renewable energy system. With more renewable energy in the system new challenges occur, e.g. with excess production of wind energy and the two-directional transfer of energy (e.g. electric cars that can supply electricity to the grid when they are not in use). Renewable energy production can vary greatly from hour to hour and day to day.

Due to technological developments, the reliability of the electricity supply in many EU countries is ensured via the expansion of the electricity grid to distribute renewable energy. The quality of the electricity grid in Europe is considered to be high and among the best in the world.

Natural gas

According to EU Reference Scenario 2016 (European Commission, 2016), natural gas consumption in the residential sector is projected to keep constant. The main consumers of natural gas are water and space heating appliances, while the share of cooking appliance in natural gas consumption is much lower.

The composition of the natural gas affects the safety, performance and the environmental impact of gas cooking appliances. Therefore, each manufacturer must test the oven or hob using the natural gas that is typical of the country where the appliance is to be sold.

GHG emissions of the combustion of natural gas can be drastically reduced by the injection of biomethane (upgraded biogas) in the natural gas grids. The terms "upgraded biogas" or "biomethane" are used to refer to the biogas that has undergone the upgrading process to remove impurities and achieve the standard requirements for grid injection purposes. Biogas is mainly produced from agriculture: energy crops, agricultural residues and manure. Other sources are sewage sludge and landfill, though more than 70% come from agriculture (European Biogas Association, 2014). Biomethane production has increased from 752 GWh in 2011 to 17 264 GWh in 2016 (European Biogas Association, 2017). This represents less than 2% of the total natural gas consumption in the residential sector. The increment between 2015 and 2016 was 40%, being Germany, France and Sweden the top countries in production increase (European Biogas Association, 2017). However, the injection of biomethane in the grids is far from being a common practice in EU. According to Scarlat et al (2018), in 2015 most of the biomethane injected into the gas grid was in Netherlands and marginal volumes in other countries.

Natural gas can be also blended with hydrogen, which would also reduce the GHG emissions from its combustion. The permitted concentration of hydrogen in the gas grid varies across EU countries ranging from 0.1 Vol. % to 14 Vol.%, and it can also vary within each country (e.g. Germany) (**Figure 72**).

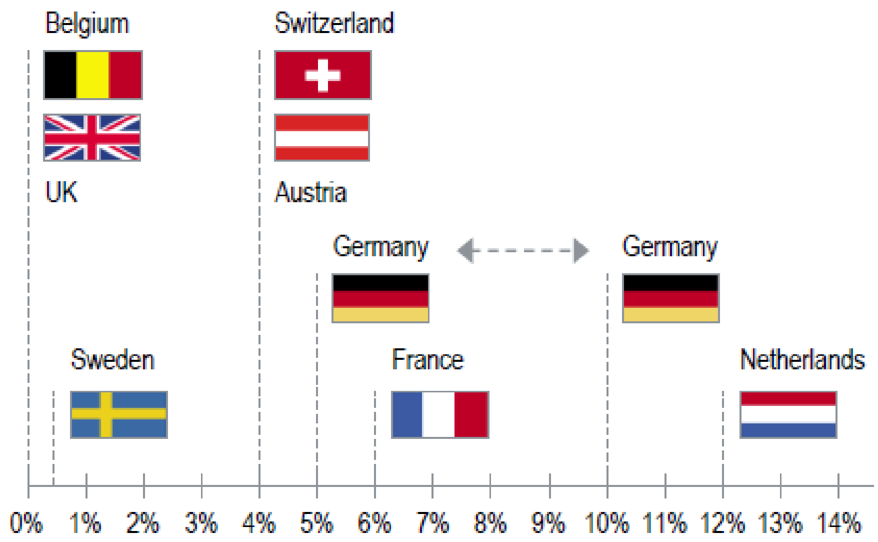


Figure 72. Injection percentage in EU countries in % vol. (FCH and Roland Berger, 2017)

Injections above 15% would require investments to adapt the infrastructure, including monitoring and maintenance measures, and upgrading due to the lower durability of the materials when exposed to hydrogen. Hydrogen injection is not allowed in a large number of EU countries (Hydrogen Europe 2019, FCH and Roland Berger, 2017).

There are no standards setting a common admissible concentration of hydrogen in the natural gas network. The European Committee for Standardisation (CEN) standard EN 16726: 2015 recommends a case by case analysis since the variety within the EU gas infrastructure prevents a general valid solution (Hydrogen Europe, 2019)

Concerning hydrogen production, the most common method in industry to produce hydrogen is Steam Methane Reforming (SMR), a chemical synthesis process which generates syngas (hydrogen and carbon monoxide) from hydrocarbons and natural gas. This process is conducted in a reformer which reacts steam at high temperature and pressure with methane in the presence of a nickel catalyst. SMR has been deemed by some authors (Schmidt-Rivera et al, 2018) as unsustainable for two reasons: as it requires natural gas it means a depletion of fossil fuel resources; moreover, the actual process of conversion generates significant greenhouse gas emissions. To avoid these emissions, CO2 could be captured and then sequestered underground, as suggested in Frazer-Nash (2018). The resulting hydrogen would then be transferred in the national grid pipeline to provide a zero-carbon heat at the point of end use.

Alternatively to SMR, excess energy from renewable sources such as photovoltaic (PV) panels could be used to produce hydrogen from the electrolysis of water. Hydrogen would then be blended with natural gas in the pipeline infrastructure, by compressed gas canisters or in low-pressure metal hydride tanks. This is a solution proposed by certain authors (Tropiska, 2016) for developing countries, where fuels such as charcoal, firewood or animal dung are primarily used for cooking. The use of these fuels causes significant air pollution and safety issues, so generating hydrogen from a renewable energy source may have the potential of solving several issues at a time.

An environmental analysis of that kind was completed in Schmidt-Rivera et al (2018). The authors evaluated different scenarios of substitution of solid fuels and liquefied petroleum gas (LPG) by hydrogen generated from renewable sources (solar PV). Results from the analysis indicated that, when compared to charcoal and firewood, hydrogen is the best option for fossil fuel depletion, climate change (2,5 to 14,1 times lower), ozone depletion and summer smog. However, hydrogen was worse when considering depletion of minerals, freshwater eutrophication and freshwater/marine ecotoxicity. They also pointed out that for most of impacts analysed, LPG is still a better option than hydrogen.

3.6 Study on consumer behaviour and domestic cooking appliances *(work in progress)*

Study available May 2020

3.7 Recommendations

Work in progress, to be completed once the Study on consumer behaviour is finalised.

4 Task 4: Analysis of technologies

Cooking is the transfer of heat into food items to make them more palatable and easier to digest. In order to cook food, heat must be transferred from a heat source to and through the food. When a substance gets hot, it means that the molecules have absorbed energy, which causes the molecules to vibrate rapidly. The molecules start to expand and bounce off one another. As the molecules move, they collide with nearby molecules, causing a transfer of heat energy. Heat can be transferred to food in three ways:

- **Conduction**. This is one of the most basic principles of cooking. It consists in the transfer of heat through direct contact. This is the type of heat transfer that happens when using a hob and a frying pan: the flame from the hob touches the bottom of the pan, heat is conducted to the pan and finally transferred to the food.
- **Convection**. This is the transfer of heat through a fluid, which may be in a liquid or gas state. There are two types of convection: natural and mechanical.
    - **Natural convection** causes a natural circulation of heat because warm fluids (liquid or gas) have a tendency to rise while cooler fluids fall. This is the type of heat transfer that happens in a conventional oven.
    - **Mechanical convection** makes heat circulate more evenly and quickly through mechanical elements such as fans. This is the type of heat transfer that happens in a convection oven.
- **Radiation**. This is the transfer of heat by waves of heat or light striking the food. There are two types of radiation in the cooking context:
    - **Infrared radiation**, where an electric or ceramic element is heated to such a high temperature that gives off waves of radiant heat. This is the type of heat transfer that happens in toasters and broilers.
    - **Microwave radiation**, where food is cooked by exposing it to electromagnetic radiation in the microwave frequency range. This induces polar molecules in the food to rotate and produce thermal energy in a process known as dielectric heating.

The act of cooking is conducted with the help of cooking appliances, mostly ovens and hobs for the actual heating of food, often using as well range hoods to collect and remove odours and volatile substances. Cooking appliances designs have evolved quickly over the past years. Starting from a traditional, purely-functional design and size, there is a current trend to offer ovens, hobs and range hoods that are a merge between a cooking appliance and a piece of furniture.

Appearance and design is starting to be a factor almost as important as functionality and performance, as confirmed by top-brand manufacturers, leading to the utilisation of innovative materials and finishes as well as a wide variety of sizes and configurations. Some experts highlight the importance of harmonious integration between cooking appliances and kitchen environment, a potentially lasting trend that will determine appliance design over the next years; whereas other point in the direction of focusing in functionality, since aesthetical and design trends are cyclical and risk limiting the actual performance of appliances (Corti, 2019).

Another remarkable trend is the emergence of the Internet of Things (IoT), an aspect which could change significantly the way cooking appliances are currently used and perceived. An abundance of connectivity features, cooking aids and even artificial intelligence aspects in the mid-term could mean a boost to energy efficiency as well as a significant time-saving element for users, if these features are applied intelligently.

In this section of the report, the main technologies related to domestic ovens, hobs and range hoods are described with more detail. The intention is not to cover every single technological aspect related to these appliances, but only that ones that have the potential of influencing in some way the environmental impact across their life cycles. Each of the three appliance group will be covered in an individual sub-section. Within each of them, technical descriptions and basic product types will be provided. Moreover, a brief description of relevant technological aspects and potential best available technologies will be discussed.

4.1 Domestic ovens

4.1.1 Technical product description: domestic ovens

An oven is an appliance which incorporates one or more cavities using electricity and/or gas in which food is prepared (Regulation 65/2014). In a general way, the main components of domestic ovens are described below. An exploded view of a typical electric oven can be seen in Figure 73.

- Cavity, where the food is located for cooking.
- Chassis, the structure that supports the cavity and the rest of the oven assemblies
- Door, which enables access to the cavity
- Heating elements, which will differ depending on heat source
- Fans, used to distribute heat evenly in convection oven
- Cables/pipes, which transfer energy from heat source to electrical resistance or burner

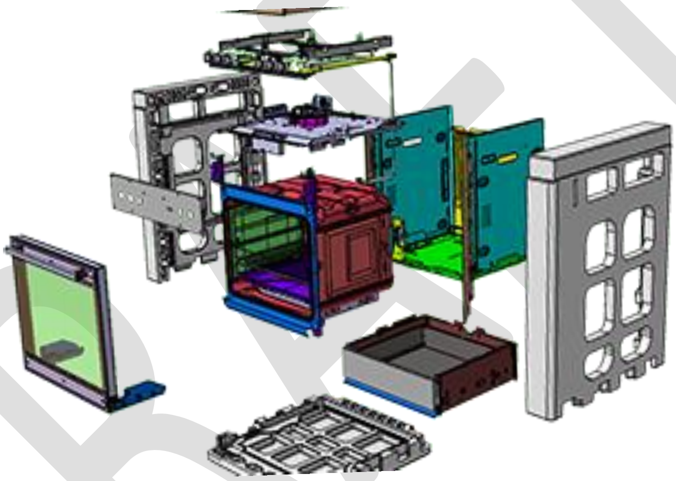


Figure 73. Exploded view of a domestic oven

4.1.2 Basic product types

Depending on the characteristics of the main components, domestic ovens can be classified in multiple ways. In Table 29, a classification is provided considering four different criteria: heat source, cooking mode, number of cavities and mounting.

Table 29. Types of ovens

Heat Source	Cooking mode	Number of cavities	Mounting
Gas	Conventional	Single	Free-standing
Electricity	Convection	Multiple	Built-in
	Steam		Portable
	Microwave		

Considering **heat source,** domestic ovens can be powered either by gas or electricity. In principle, the main components of a gas or an electric oven (cavity, chassis, door, fans) are the same. The differences between them are in the way the heat is generated and the fuel transported through the appliance. Gas ovens generate heat via gas-fuelled burners, and therefore will need special pipes to transport it, chimneys for expulsion of fumes and gas-related control/safety systems. Electric ovens generate heat by using an electric resistance, so they will need cables to transport electricity. Generally, gas ovens tend to require a higher amount of assemblies and materials, and their energy consumption is higher under equivalent use conditions (Landi, 2019). Due to the nature of the sources of energy, gas ovens tend to offer only conventional heating modes, whereas electric ovens have a wider variety of cooking modes and features.

Considering **cooking modes**, domestic ovens can be classified as conventional, convection, steam, or microwave. Other cooking modes offered in domestic ovens are grill and roasting. Some ovens can also offer a combination of these cooking modes. In conventional cooking mode, a stationary heat source radiates heat in the oven and therefore uses only natural convection for the circulation of heated air inside the cavity. The heat source is generally at the bottom of the oven, although in some models additional burners can be found at the top and at the back of the cavity. In convection cooking mode, a built-in fan circulates heated air inside the cabin, distributing it evenly throughout the cavity. Convection ovens can run at lower temperatures than conventional because heat movement increases inside the oven cavity. Convection ovens will need a motor to operate the fan, increasing slightly the complexity of the appliance. A steam oven operates by injecting water in the oven into a boiler. This boiler will create steam to heat up the cavity of the oven, creating a very moist cooking environment within the device.

A **microwave oven** is an electric oven that heats and cooks food by exposing it to electromagnetic radiation in the microwave frequency range, inducing polar molecules in the food to rotate and produce thermal energy in a process known as dielectric heating.

The cavity of the ovens is the enclosed compartment in which the temperature can be controlled for preparation of food. In terms of **number of cavities**, the most common configuration is single-cavity oven (Figure 74), although multiple-cavity ovens (those with two or more cavities) can also be found easily (Figure 75).

Figure 74. Single cavity oven (APPLIA)

Figure 75. Double cavity oven (APPLIA)

Considering **mounting** configuration, ovens can be classified as built-in or free-standing (

Figure **76**). **Free-standing** ovens can be either installed separated from cabinets or by sliding them into an open space into the kitchen cabinetry. In the first type, their sides, as they are visible when installed, are generally finished and they do not required cabinet work. They tend to have controls in the back, storage or warming drawers in the bottom and larger capacity than other ovens. In the second case, they generally have a slightly protruding cooktop, allowing the appliance to sit flush with the kitchen counters. The side panels are not finished as they will not be visible after installation. These appliances can also be known as **cookers**, since they include both an oven and a hob.

Built-in ovens, also known as wall ovens, are installed at a comfortable height in the wall, embedded between other kitchen cabinets or appliances.

Finally, in Regulation 65/2014 ovens are also classified in terms of their portability: a portable oven is one with a product mass of less than 18 kilograms (although these are out of the scope in the mentioned regulation).

Free-standing (electric)	**Free-standing (gas)**	**Built-in**	**Portable**

Figure 76. Types of ovens based on mounting (APPLIA)

According to stakeholders feedback, the most common ovens that could be considered base cases have the features shown in Table 30:

Table 30. Typical features of most common ovens

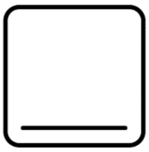
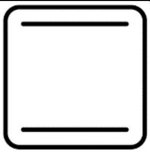
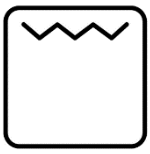
	Electric oven	**Gas oven**
Self-cleaning cycle (none, catalytic, pyrolytic, hydrolytic)	none / pyrolytic	none
Capacity (litres)	50 - 70	70
Number of cavities	1	1
Mounting configuration (Free-standing/slide-in/drop-in/wall)	built-in / slide-in	freestanding
Opening system (drop-down/side opening/extractable)	drop-down	drop-down
Smart features (remote control & diagnosis/voice activation)	None	None
Packaging materials (list of main materials)	cardboard, wood, EPS, foil	cardboard, wood, EPS, foil
Mass (kg)	30 - 40	25
Energy consumption in conventional mode (kWh/cycle)	≈ 0.9	

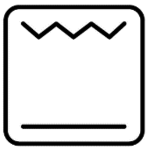
Energy consumption in convection/Fan-forced mode (kWh/cycle)	≈ 0.7	

4.1.3 Heating types

Ovens usually offer a wide variety of **heating types** or **settings** in which they can be operated. Some of these settings are common to the majority of ovens in the market today, whereas others are more specialized and can only be found on a few models. The names of these settings are usually marketing driven and may not necessarily be common around the industry –potentially causing confusion to consumers-. Although not universal, symbols used to represent each of those settings tend to be similar and recognisable. The most common oven settings, their symbols and a brief description can be seen in Table 31.

Table 31. Oven heating types

Symbol	**Mode**	**Description**
	Conventional – lower heating only	Heat will come solely from the heating element at the bottom of the oven. The fan won’t be used to circulate the heat.
	Conventional – upper and lower heating	Heat will be generated by elements in the top and bottom of the oven. The fan doesn't come on for this setting – instead heat spreads through the oven by natural convection.
	Fan-forced heating	Heat comes from a circular element surrounding the fan at the back of the oven and the fan then circulates this heat around.
	Fan-forced with lower heating	Heat will be produced at the base but will be wafted around by the fan.
	Full grill	Heat is being produced by the whole grill element. Some grills are designed to be used with the door closed, while some need the door to be open
	Part grill	Only one section of the grill element gets hot
	Grill and fan	Grill and fan are on at the same time. The fan spreads the grill’s heat, making it less fierce

	Grill and lower heat	The grill is used in combination with the lower heating element.
	Defrost	Fan is on but no heat is produced, so no cooking takes place. The moving air defrosts food much more quickly than simply leaving it on the kitchen table
	Plate warming	Plate-warming function. This gently warms plates or other dishes to prevent food from cooling too quickly when served.
	Pyrolytic cleaning	This program heats up the oven to around 500°C, which has the effect of incinerating burnt-on cooking grime.
	Eco	This is generally understood as the most energy-efficient mode of the oven, although it might be different for each manufacturer. In some occasions, it is a function for cooking small quantities of food, activating only a limited amount of the heating elements.

4.1.4 Electricity versus gas as heat sources for oven

Domestic ovens can be powered either by electricity or by gas. The main elements of electric and gas ovens will be similar or equal, the only differences being in the heating system. Different energy consumptions and environmental impacts are observed as well when comparing equivalent performance electric and gas ovens. A brief summary of these aspects is presented in this section.

In an electric oven, electric current is passed through a wire within the heating element and encounters electrical resistance that heats the wire and surround bulk of the element (Figure 77).

Figure 77. Heating elements in electric oven (APPLIA)

Heating elements for electric domestic ovens typically use Nichrome wire (80% nickel, 20% chromium), ribbon or strip, a material with relatively high resistance which forms an adherent layer of chromium oxide when it is heated for the first time. The wire is generally wound into a coil that is surrounded by densely packed magnesium oxide powder and then encased in a protective sheath. This material provides excellent thermal conductivity and dielectric strength. Ceramic or mica insulators ensure the electrical insulation of the terminal stud from the sheath. Due to the nature of the energy source and the possibilities it allows in terms of modulating temperature, a wide variety of heating types are usually available in an electric oven (see Table 31).

In contrast, the heating element in a gas oven is a gas burner located at the rear of the oven base, which burns a stream of gas in air, generating stable and controllable arrays of small flames, modulating the desired cavity temperatures (Figure 78). Additionally in some cases, a grill burner is located at the top of the cavity (Figure 79)

Figure 78. Gas burner (APPLIA)

Figure 79. Grill burner (APPLIA)

Gas ovens can work with different kind of gases:

- Manufactured gases (also known as town gas) of variable composition (hydrogen, nitrogen, methane), with nominal pressure of 8 mbars.
- Natural gas (mainly methane) with nominal pressures of 20-25 mbars.
- Liquefied petroleum gas (mainly propane or butane), with nominal pressures of 28-30, 37-50 mbars.

In gas ovens, the gas burner is located outside the food compartment and hot air is allowed to enter via ports to produce a more even spread of heat temperature throughout the oven, often with additional fans for improved efficiency. Due to the relatively slow circulatory motion, temperature zones develop within gas oven cavities, the hottest regions being at the top. The volume of gas entering the burner is managed through a thermostatic gas valve (Figure 80). Hot gases are eventually discharged from the rear of the oven by means of a flue. Ventilation of gas ovens is more important than electric ones, since toxic gases such as carbon monoxide (CO) may be produced.

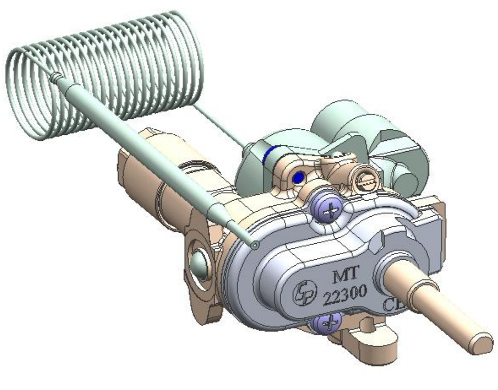


Figure 80. Thermostatic gas valve (APPLIA)

In a gas oven, a few cooking modes are normally available, since typically they have a burner at the bottom and a grill burner at the top. The burner at the bottom is mostly used for baking or preparing pizza, while the grill can be used for roasting or grilling meat and fish. Their settings are therefore much simpler than those of an electric oven, consisting mainly in a temperature setting and a grill settings (if available). Gas ovens do not offer automatic cleaning functions such as pyrolytic systems either.

Although in current regulation energy consumption of electric and gas ovens is measured differently (in kWh and MJ, respectively), recent research has been conducted to make a direct comparison of electric and gas ovens in kWh over lifetime of the appliance. This research indicates that final energy consumption tends to be higher in gas ovens, both in intensive and non-intensive uses (Figure 81).

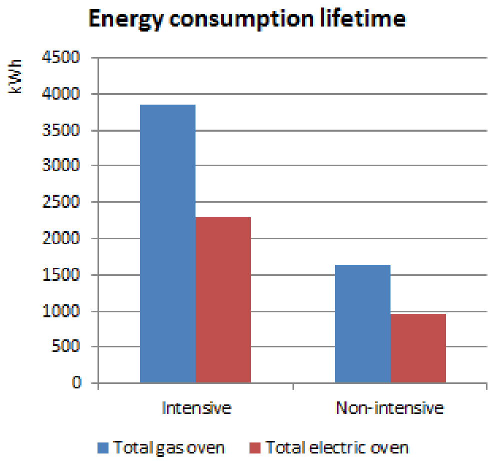


Figure 81. Energy consumption in gas and electric ovens over lifetime (Landi, 2019)

However, this does not mean that the operating cost of gas ovens are higher, as this will depend on the specific location analysed. If the price of gas is significantly lower than the price of electricity, gas ovens may be more economical for consumers than electric ones.

4.1.5 Technology areas of domestic ovens

4.1.5.1 Technology area 1: Cavity materials

In domestic ovens, the cavity and casing are generally made of pressed mild steel, a material that fulfils the requirements of functional strength and ease of manufacture, being suitable for bending and piercing, offering a durable surface with scratch and corrosion resistance. The selection and use of these materials have a high influence on the energy consumption of the oven. In fact, the energy fraction actually absorbed by the food during cooking is low because a large portion of energy goes into the structure (walls, door, insulation), and is lost in the surrounding environment. High emissivity linings absorb the thermal radiation energy from the cavity which then is lost through conductive bridges and convective leaks. In addition to that, a lot of energy is lost through the venting of the evaporated moisture form the cavity (Burlon, 2015).

The mass of materials inside the oven cavity –casing, racks, internal parts- is proportional to the energy consumed when bringing the oven up to its operating temperature. Therefore, in order to reduce energy consumption, manufacturers are continuously working in reducing the mass of metal used in the cavity and casing. In Burlon (2015), it is reported that reducing the mass of the oven structure has energy savings potential between 10-18%. Modern ovens use steel sheet of about 1 mm thickness.

Enamel-coated steels are commonly utilised in the oven cavity. Conventional porcelain enamels for low carbon steel substrates are generally based on alkali borosilicate glasses which are fired at 750-850C on a continuous fast belt furnace. Most abundant materials in a standard enamel are Al_2O_3 (37%), S (16%), Fe_2O_3 (13%). A complete breakdown of enamel materials is presented in Palmisano et al (2011). Regarding oven interior walls, there has been debate over the years around emissivity and energy consumption. Certain studies point out that low emissivity ovens use around 35% less energy than standard ovens (Shaughnessy, 2000), whereas others indicate that wall emissivity should be high, as dark surfaces adsorb energy but are also efficient energy radiators. The project named Highly Efficient Oven (Santacatterina et al, 2016) is a demonstrative project involving four European partners, co-financed by LIFE Environmental Programe. Its main objective is to showcase a mix of environmentally friendly technologies for manufacturing domestic electric ovens when compared with current state of the art ovens, in order to:

- Use less energy in the production process
- Avoid the use of toxic substances
- Improve efficiency during use

To achieve that, specific aspects of the electric oven that were investigated are:

- Substitution of the steel enamel cavity with a stainless steel cavity with increased reflectivity
- Use of a new sol-gel coating applied to avoid deterioration of oven's metal cavities
- Upgrade of the oven heating system to increase the amount of energy transferred directly to food

The rationale of this project is based on the fact that traditional ovens use convection as the main vector of heat transfer to food. Radiation does not provide a significant contribution to this transfer, since the cavity is usually made of a dark enamelled material. In this project, it was identified that using a reflecting cavity wall (Figure 82) was a good solution to increase radiation heat transfer mechanism, allowing to reduce energy consumption during use.

Figure 82. Dark enamelled cavity vs Reflective stainless steel cavity

As part of the experiment, different ferritic stainless steels were compared to identify the best substrate for the oven cavity based on the worst case working conditions (highest temperature). Several transparent coatings (instead of dark enamel) were evaluated: a sol-gel coating was selected, since it was the only transparent coating which was able to withstand temperatures without degrading and due to its extremely high chemical resistance. The selection of this material for the cavity allowed reducing energy use during cavity manufacture by 50% (when compared to typical dark enamel oven). Moreover, a set of tests on prototypes were carried out to evaluate performance. When following the 'brick test method', there was an energy efficiency improvement of 30% in comparison to a conventional oven (black enamelled cavity).

However, it must be noted that the use of stainless steel in oven cavities comes with certain disadvantages, mainly related to the cleaning process. Feedback from industry points out that they generally do not admit pyrolytic process, since high temperatures degrade stainless steel surfaces. Also, the emissivity of heat from the bottom part of the cavity is worse when using stainless steel. For these reasons, most modern ovens use dark high emissivity surfaces. Highly reflective surfaces are normally used for solo and combi microwave ovens and for steam ovens, to avoid corrosion issues.

4.1.5.2 Technology area 2: Cavity volume

In terms of cavity volume (generally measured in litres), a wide variety is available in the market today (Figure 83).

Figure 83. Different cavity volumes in the market

Cavity volume has a relevant role in energy consumption declaration of ovens. In principle, the bigger the cavity volume, the larger will be the mass of the oven and therefore the higher will be the energy consumption of the oven. However, in regulation this is taken into account in the Energy Efficiency Index (EEI) formulas:

$$EEI_{cavity} = \frac{EC_{electric\ cavity}}{SEC_{electric\ cavity}} \times 100$$

$$SEC_{electric\ cavity} = 0{,}0042 \times V + 0{,}55 \text{ (in kWh)}$$

As it can be inferred from the formulas, manufacturers have an incentive to declare the biggest possible volume cavity when testing an oven, which will bring the highest EEI. This is the reason why during testing, all the potentially removable parts of the cavity (racks and rails) are actually removed. Using as an example two typical cavity volumes (45 and 71 litres), Table 32 shows the energy consumption limits to heat the standard load (the brick described in Task 1) in order to be compliant with ecodesign and energy labelling regulation.

Table 32. Ecodesign and energy label limits for two typical oven cavity volumes

	45 litre cavity	**71 litre cavity**
Ecodesign limit 2015 (kWh)	1.07	1.23
Ecodesign limit 2017 (kWh)	0.89	1.02
Ecodesign limit 2019 (kWh)	0.70	0.81
Energy label B (kWh)	0.79 – 0.96	0.90 – 1.10
Energy label A (kWh)	0.60 – 0.78	0.69 – 0.89
Energy label A+ (kWh)	0.45 – 0.59	0.52 – 0.68
Energy label A++ (kWh)	0.33 – 0.44	0.38 – 0.51

As it can be seen, for larger cavity volumes, higher energy consumption values are allowed to heat the standard load. The example in Table 32 is provided for electric ovens but it works in an equivalent way for gas ovens.

4.1.5.3 Technology area 3: Thermal insulation and door glazing

Domestic ovens have a layer of insulation to restrict loss of heat. The performance of the thermal insulation depends on the thickness, density and thermal conductivity. Generally, mass of insulation material is proportional to the heat energy used by the oven.

Air trapped between fibres or particles act as a good insulator, although this air must not be allowed to move, since flow of hot air from interior to exterior surfaces may cause heat losses. Ideal insulating materials have microporous characteristics, with trapped porosity which prevents air flow and low density. However, these materials tend to be less flexible, a preferable condition in ovens because of large expansion and contraction that occurs during heat-up and cool-down (as much as 1 cm in pyrolytic ovens during cleaning cycles). If insulation is damaged, heat losses will occur through gaps in the material.

In domestic ovens, insulation is based on flexible rolls or rigid slabs made of glass-fibre. For non-pyrolytic ovens, typically 25 mm thickness is used. Pyrolytic ovens require superior insulation systems to maintain external surface temperatures below safe limits and to comply with applicable standards, therefore slightly thicker and denser layers are used, with additional layers of aluminium foil acting as reflector of heat radiation. According to feedback from industry, increasing insulation level from 25mm to 40mm can reduce energy consumption by 12% when following the brick method test.

In terms of glazing, historically ovens did not have glazed doors. This element of the door is actually a significant source of heat loss. Certain studies indicate that an oven with an unglazed door has a very significant potential to reduce energy consumption (Burlon, 2015). However, if an oven door does not allow seeing the interior of the cavity, it will be opened more frequently by the user, causing even more significant heat losses. Since the widespread introduction of this feature, unglazed doors have become an unacceptable product feature in domestic ovens. The combination of a glass door and oven cavity light reduces the number of times that the oven door must be opened to check the progress of the cooking, limiting the amount of heat lost each time the door is opened.

Oven doors are opened during cooking processes mainly to examine and to turn and manipulate food. When they are opened, most of the hot air from inside the cavity escapes. The relationship between opening frequency, window size and heat loss is complex and no data is available. However, it is assumed that window size potentially has an influence opening frequency: a bigger window may reduce number of opening times as it allows a proper examination of food. Nevertheless, certain conflicting effects need to be considered:

- More heat is lost by conduction through windows than through insulated metal panels, so ovens with no window –or small window- lose less heat. This is counterbalanced by the heat lost every time the door is opened.
- The outer layer of the glass needs to be air cooled to limit the outer surface temperature to safe limits (this is not necessary for insulated metal panels).
- Heat consumption is proportional to the mass of materials: the higher the mass, the larger the energy consumed by the oven. More layers of glass provide a higher level of insulation but also induce higher energy consumption. Depending on cooking times, more layers of glass will be beneficial or detrimental. As a general rule, for shorter cooking times, less layers of glass are better, whereas for larger cooking times, the insulating effect of additional layers compensates the increase of energy consumption.

Two types of glass window configurations are used. In one, the glass window is inserted into an opening in the metal door using heat resistant adhesives. In the other, the door itself is made of a sandwich of two or more sheets of glass so that there is no need to seal the glass to a metal door. The outer sheet is usually made of clear float glass, tinted glass, coated –mirror effect- or white glass. For the middle and inner glass, heat transfer is limited by the use of low emissivity glasses. The inner panel of most new domestic oven includes as well an infrared reflective coating.

4.1.5.4 Technology area 4: Conventional and convection cooking modes

As stated earlier, in a domestic oven, the food is cooked by transferring heat by means of radiation, convection or conduction. A typical measure of performance for a domestic oven is the heat transfer coefficient, which gives an indication of the heat flux between the appliance and the product being cooked. An oven has heat transfer coefficients referred to radiation (Hr) and to convection (Hc). Some authors also use the combined heat transfer coefficient, which takes into account both radiation and convection (Sakin, 2009).

In conventional cooking mode, food is only cooked by radiation and natural convection, meaning that the convection is not forced by any external element. In these ovens, heat transfer between the appliance and the food happens typically 70% by radiation and 30% by convection.

In convection cooking mode, heat transfer is artificially forced by the use of a fan. The use of this fan helps to distribute the hot air evenly throughout the oven, reaching food which is located anywhere inside de cavity, achieving even temperatures and evaporation rates. Operating under a forced-air convection mode, values of convection heat transfer coefficient (Hc) roughly double. This allows to reduce cooking times and to operate at slightly lower temperatures since the heating element does not need to be as hot to heat up the cavity. In contrast to conventional ovens, in convection ovens, the ratio of heat transfer due to convection can be of up to 60% (Cernela, 2014). However, it must be kept in mind that increasing the level of convective heat transfer leads to an increase of product drying rate (evaporation rate is higher in the convective process), resulting in product surface desiccation and overheating. The appropriate balance between convection and radiation heat transfer needs to be achieved, depending on the dish being cooked.

In Ramirez-Laboreo et al (2016), an analysis is conducted on how much energy is transferred to a standard load and lost in different cooking modes on a domestic oven, comparing heat transfer in convective and radiative processes (Figure 84). As it can be seen, more energy has been transferred to the load (the food) in a convective process than in a purely radiative process (13% to 11%).

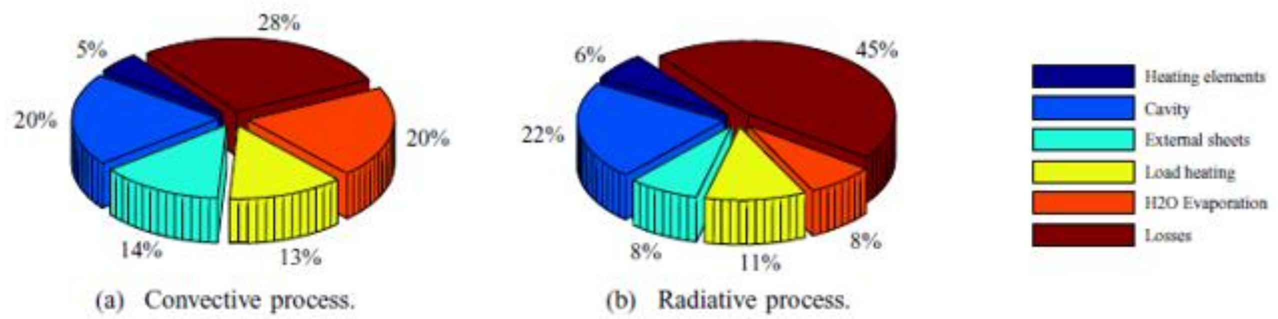


Figure 84. Distribution of energy supplied by the oven in convective and radiative cooking (Ramirez-Laboreo et al, 2016)

Energy losses in the radiative process tend to be higher, mainly because fan operation during convective cooking causes the heat generated in the ring heating element to flow into the cavity, losing less energy through the rear side. However, although energy losses are higher in a purely radiative process, this does not mean convection should be the only cooking function to use, as this will depend on the type of food to be cooked. In bread baking, for instance, an even heat distribution and considerable water evaporation is needed, therefore a convective process is more appropriate. However, for meat or fish roasting, water evaporation has to be minimal to keep food juicy and succulent, therefore a radiative process is the most appropriate option (Ramirez-Laboreo et al, 2016).

In a typical oven with convection cooking mode, a centrifugal fan is mounted on the back wall. The fan shrouding tends to be minimal and it can expel air on all points around its circumference. An appropriate design of the fan and its surrounding elements has a significant effect on temperature distribution and energy consumption of the oven. The fan is generally separated from the oven cavity by a baffling plate, which allows circulation of air circulates through holes, which may have a variety of geometries. In Diaz-Ovalle et al (2017), different baffle plate geometries are assessed in order to identify the hole shape that optimizes the performance of the oven. Results proved that the baffle plate geometry exerted an important hydrodynamic influence in the reduction of pre-heating time. On a similar subject, Park et al (2018) discuss the effect of fan case design on the performance of a gas oven. In this oven, the burner is mounted around the fan, entering and leaving the case through holes in both sides of it. Using different hole locations, a total of 15 cases were examined. This research showed that the flow pattern and temperature distribution inside the oven cavity changed dramatically, depending on the position of these holes, highlighting the importance of careful design in every element of the oven.

4.1.5.5 Technology area 5: Microwave ovens

Microwave ovens are enclosures inside which food is exposed to microwave radiation at a frequency of 2.45 GHz, with a power usually ranging from 500 to 1100 W. Microwaves are produced by an electronic tube called a magnetron. Once the oven is switched on, the microwaves are dispersed in the oven cavity and reflected by a stirrer fan so the microwaves are propagated in all directions. They are reflected by the metal sides of the oven cavity and absorbed by the food. Uniformity of heating in the food is usually assisted by having the food on a rotating turntable in the oven. Water molecules vibrate when they absorb microwave energy, and the friction between the molecules results in heating which cooks the food (WHO, 2005). Unlike conventional ovens, microwaves are absorbed only in the food and not in the surrounding oven cavity. In comparison to heating in conventional ovens, the main differences of microwave heating are as follows (Datta et al, 2013):

- It is a quicker process. The rates of heating are much higher than in conventional heating
- It is a more non-uniform process.
- It is a selective process. Moist areas heat more than dry areas of food.
- It has significant internal evaporation, enhancing moisture loss during heating.
- It can be turned on or off instantly

The main components of a microwave oven are:

- Enclosure, usually made of steel
- Door, usually made of glass with a metallic mesh which provides a barrier to radiation with enough visibility of the interior
- Magnetron, which generates the microwave radiation. This is a device made mainly from copper with an electrode inside a specially shaped cavity.
- Circuitry, in charge of converting mains input into microwave frequency for operating the magnetron.
- Fans, which cool the magnetron and circuitry
- Turntables, which allow food to rotate while cooking, ensuring an even distribution of microwave radiation

To prevent microwave radiation from escaping, the interior of the oven comprises a metallic mesh structure that prevents microwave radiation from passing through. This is used on the glass door and has gaps that are large enough for visible light to pass.

In terms of energy consumption, microwave cooking can offer substantial energy savings over traditional ovens, when considering processes that both types of oven can be used. Industry estimates that typically up to 40% of the input energy is transferred to the food, although this figure depends on many variables, particularly the size of the load and whether it is being heated to raise its temperature or extended cooking is being carried out. Estimates of energy savings obtained with microwave ovens in comparison to alternative methods were published in Market Transformation Programme (2007).

Table 33. Energy savings when cooking with microwave oven. Adapted from MTP (2007)

Food	Energy saving (%)	Alternative method
Potatoes	70-75	Pan on hob
Fresh salmon fillet	63-78	Pan on hob
Frozen ready meal	55-73	Electric oven
Lasagne	40-81	Electric oven
Milk	25-50	Saucepan on hob
Frozen vegetables	65	Pan on hob

Energy efficiency values regarding microwaves are very dependent on type of meal prepared and also in which conditions the food is actually cooked. Since there is no method to measure energy consumption in microwave ovens comparable to the method used in conventional ovens –the brick method-, direct energy efficiency comparisons between conventional and microwave ovens are currently not possible. Related to this topic, Lakshmi et al (2007) conducted energy assessments of rice cooking, comparing microwaves with other methods of cooking rice. It was concluded that microwaves are on par with rice pressure cooking in Liquefied Petroleum Gas (LPG) stoves, and not as efficient as electric rice cookers.

As already indicated in Task 1, microwaves ovens are out of the scope of current ecodesign and energy labelling regulation. Some of the reasons argued for not being included in current regulation are listed below:

- There is a wide variety of different products with microwave function, which makes comparisons challenging. Consumers can find ovens with microwave function only, but also appliances that combine conventional heating and microwave (see Section 4.1.5.6).
- Microwave ovens tend to be used for short cooking periods (1-2 minutes) with maximum powers of 1000W, making their total energy consumption significantly lower than other cooking appliances.
- The use of turntables makes the testing method used for conventional ovens (the brick method test) not feasible for microwave ovens.
- The use of thermocouples to check temperature of the standard load inside the oven is also not possible in microwave ovens.
- Potential of improvement in terms of energy efficiency has been considered as low.

In terms of energy efficiency potential improvement of microwave ovens, it appears to be a topic under debate. On one hand, in a report published in 2005 by the Energy Conservation Center of Japan (ECCJ, 2005), it was stated that in the previous years, engineering developments had been carried out mainly with the objective of improving taste of food cooked with microwave technology. In addition, although engineering developments had also been taking place for improving energy consumption efficiency –such as reduction of standby power consumption- it was concluded that there was still some room for improvement in efficiency of microwave ovens, possibly by improving the radiation method and thermal insulation performance. Efficiency of the magnetron, which comprises a large percentage of power consumption, appeared to be saturated.

On the other hand, in the previous Preparatory study for Ecodesign requirements for domestic and commercial ovens (Mudgal, 2011), it was published that in the view of manufacturers members of the European Committee of Domestic Equipment Manufacturers (CECED), modern microwave oven designs are close to the maximum energy efficiency. Cavity size has no effect on it whereas internal coatings could only improve it by 1-2%.

Cooking food with a microwave is quite different to traditional cooking and is not usually understood by the average cook. Many recipes were developed for traditional ovens and cannot be adapted to microwave ovens. Moreover, it can cause uneven heating, soggy food texture and does not produce browning. To overcome these issues, manufacturers have added turntables and mode stirrers, developed the use of actives packages (shields and receptors) and have combined microwaves with other modes of heating (convection, grill, etc.). In global terms, an increased use of microwave ovens in substitution of other ovens or hobs -when the recipe allows it- would reduce total energy consumption. However, consumers are resistant to change, especially if they perceive that food cooked in the microwave has lower quality results. Energy savings are also not immediately obvious or significant. As a result, consumers tend to use microwaves for defrosting and reheating only and not to cook whole meals.

4.1.5.6 Technology area 6: Microwave combination heating

Some manufacturers offer ovens with combined function of forced-air convection and microwave simultaneously. These appliances integrate the advantages of microwave energy to overcome the shortcomings of other food processing technologies, with benefits including energy conservation, improved product quality, reduced time and operational cost (Chizoba et al, 2017). Adding microwaves to convective heating, for instance, generates heat inside food in a short time due to heightened penetration depth and rapid heating.

Using more than one mode of heating at the same time gives a higher degree of control over the characteristics of the food, although it is important to take into account that each heating mode affects quality parameters in a very different way. In general, the main reasons to introduce microwave energy within conventional domestic ovens is to reduce cooking times, improve quality in certain recipes and to obtain a higher degree of automation (Datta et al, 2013). A clear advantage of these appliances is that they allow the faster heating of the microwave ovens with the surface browning ability of hot air or grills.

Microwave energy can be introduced in many different ways when cooking a specific dish in an oven, in terms of power level, duration, sequence, etc. Therefore, there is enormous variation between manufacturers of similar ovens in terms of how to combine these modes. Due to this high variation in terms of options, microwave combined heating is generally used in an automated mode, for specific processes or recipes. In a typical microwave combined oven, the user can select the power levels used for each individual heating mode (hot air and microwave) as well as the sequence of the combination (for instance, microwave first followed by forced-air convection). According to Datta et al (2013), microwave combination heating appliances can be grouped into:

- **Microwave with infra-red**. A source of infrared heat is provided inside the oven, using halogen lamps or heated rods (grill).
- **Microwave with hot air**. Typically forced hot air is provided to emulate simultaneous hot air heating. This is the most common microwave combination mode in the domestic market.
- **Microwave with steam**. This is a relatively recent feature. Steam is generated and fed to the oven cavity. Generally steam appears to be used not simultaneously with microwaves, although it should be possible to design combinations that sequence microwave and steam.
- **Microwave with induction**. A shielding plate is mounted on the bottom surface and an induction coil is provided below it to selectively choose between microwave and/or induction cooking. Currently there is no known commercially available unit with this technology.

Benefits and drawbacks of the above microwave-assisted food processing technologies and others (such as ultrasound, ohmic heating, vacuum, etc.) are listed in Chizoba et al (2017).

The main differences between a conventional oven and a microwave combined oven are the presence of all the required components for the generation of the actual microwaves (essentially the magnetron and rest of componentry listed in Section 4.1.5.5). With microwave combined ovens there are a number of compromises that need to be made in design. For example, enameled surfaces are better for conventional oven modes but stainless is better for microwave modes. Enamelled surfaces are required if pyrolytic cleaning is an option. A microwave combined oven also require a different level of insulation to avoid potential leakage of microwaves.

As indicated in previous section, any appliance that offers a microwave heating function is currently out of the scope of ecodesign and energy labelling regulation. One of the main reasons for this exclusion is that any oven with microwave functionality and a turntable cannot be tested by the brick method, according to feedback from industry. Ovens with microwave function but no turntable can be tested by the conventional brick method, but the microwave function would need to be decoupled first because some manufacturers may “hide” microwave operation within conventional operating modes. Besides, door seals for ovens with microwave function are tighter and make it more complicated to run a thermocouple wire through the door. Any hidden microwave activity would be potentially dangerous for the convention test set-up. Additionally to those reasons, there are so many different combinations of convection heat and microwave possible that it would make comparisons between products unfeasible (unless a standard combined cycle was defined).

Feedback from industry highlights the the energy saving potential (and time saving potential) of combi-modes was clearly seen in tests with real food. Depending on the type of dish being prepared, time savings observed when compared to convective heating only were between 40% and 55%, whereas energy savings were between 5% and 20%. Despite this clear energy saving potential of microwave combined ovens, there is no current method to assess these savings in a consistent manner, so this potential is currently not perceived by consumers.

4.1.5.7 Technology area 7: Steam ovens

A steam oven is an oven that uses steam to cook food. Depending on the way in which the steam is utilised, different options are available in the market (Table 34).

Table 34. Types of steam ovens

Type of steam oven	Ecodesign / Energy label regulation	Heating functions
Steam oven (solo-steam oven)	Out of scope	- Steam cooking
Convection steam oven (combi-steam oven)	Within scope	- Steam cooking - Steam cooking with fan-forced convection - Fan-forced convection
Steam-assisted oven	Within scope	- Steam cooking with fan-forced convection - Fan-forced convection

A **steam oven** uses hot steam rather than hot air to cook food. They work by siphoning water from a small tank into a built-in boiler, heating it to 100C, and releasing the steam into the cavity. Steam ovens (also known as solo-steam ovens) are generally considered to be healthier than standard ovens, since steam helps lock moisture into the food being cooked, eliminating the need for extra oils and fats to keep food moist. They also help food retain its natural vitamins and minerals (Elias, 2019). The main downside of traditional steam-solo ovens is that they do not allow cooking foods that require temperatures above 100C, since this is the boiling temperature for water. They are only able to conduct “wet” cooking. Also, they are not able to roast or brown food, limiting their cooking possibilities. Unlike in conventional ovens, steam prohibits the formation of a crust on the surface of the food.

Solo-steam ovens are out of the scope of current ecodesign and energy labelling regulation. The reasons argued for this exclusion are related to the fact that these ovens are a small part of the European market and therefore less relevant than other cooking appliances in terms of energy efficiency. Moreover, in current testing method, the amount of steam that is siphoned into the cavity cannot be measured, which could lead to unfair comparisons between apparently equivalent solo-steam ovens.

Convection steam ovens -or combi-steam ovens- can cook using three different modes, depending on the dish's needs: with steam only, with steam and fan-forced convection, and with fan-forced convection only. These appliances are within the scope of current ecodesign and energy labelling regulation.

Convection steam ovens combine both wet and dry cooking, with the advantages of evenly distributed heat. In a convection-steam oven, while the movement of hot air ensures consistent heating and browning, steam adds moisture at the right times in the right amounts (Papageorge, 2013). In Burlon (2015), an analysis is conducted on how much energy is transferred to a standard load and lost in different mechanisms within a convection steam oven. Around 79% of the energy goes to the load in the centre of the oven, whereas the rest is lost in walls (6%), vapours (11%), door (3%) and liquids (1%). This analysis is completed on a commercial steam oven, but it may give an indication on how much energy is actually transferred to the element being cooked.

A **steam-assisted oven** is a similar appliance to a convection steam oven. In this case, however, the oven can work in two modes only: either fan-forced convection or fan-forced convection with addition of steam. This appliances does not offer the option of working with solo-steam function. Steam function in these types of ovens is essentially used to add moisture to the food. These appliances are within the scope of current ecodesign and energy labelling regulation.

The matter of health regarding steam cooking has been subject to research over the last years. For instance, in Sakin-Yilmazer et al (2013), the concentration of acrylamide (a carcinogen/mutagen) was analysed when baking the same product with a conventional oven and with a steam-assisted oven. This research showed that steam-assisted baking resulted in lower acrylamide concentrations at all baking temperatures, while providing the average moisture content, not significantly different to conventional ovens.

In Bowers et al (2012), other aspects of cooking such as time, yield, colour, tenderness and sensory traits were analysed, comparing a steam oven with a convection oven. In this case, the appliances were destined for commercial use, but relevant conclusions can still be extracted. It was observed that cooking of a beef roast showed a steeper increase in temperature in the steam oven, leading to slightly faster cooking cycles. However, endpoint temperatures of beef were slightly higher, obtaining reduced yields. In terms of colour, roasts cooked in a steam oven tended to show a lighter tone with more moisture on the external surface and a whiter colour in fat, whereas with the convection oven results where darker, with a more caramelized, drier surface and more yellow fat appearance. There were not significant differences in the internal colour. Finally, in terms of sensory evaluation, slightly better results were obtained by the steam oven in terms of tenderness.

4.1.5.8 Technology area 8: Self-cleaning systems

Ovens are appliances which need periodical cleaning. Most of the modern appliances already incorporate some sort of self-cleaning system, but before that, the only way to clean a domestic oven was manually, often using toxic products. Three different cleaning methods are available in the market (Schmidt, 2019).

It is worth noting that some manufacturers offer more than one cleaning system, so that consumers can choose between different levels of cleaning.

- **Pyrolytic cleaning**. This is currently the main commercial solution in the market, a self-cleaning process where the oven is heated in a special heating cycle up to 500C for long periods of time (1-3 hours). This causes fat deposits to pyrolyse, mainly to gaseous by-products. Organic residues are incinerated, then easily removed as dust. With this system, even the most inaccessible dirt is eliminated. In comparison to a standard oven, the composition of the enamel is significantly different, in order to withstand the higher temperatures. The most abundant materials in the enamel in this case are SiO_2 (29%), ZrO_2 (19%) and CeO_2 (11%). A complete breakdown of materials for a pyrolytic enamel is presented in Palmisano et al (2011). The pyrolytic cleaning cycle has high energy consumption, which could be larger than the energy saved by the improved insulation needed for these types of oven. Total annual energy consumption will depend on how frequent this system is used.

- **Catalytic cleaning**. This is a modern version of the self-cleaning oven, where the cleaning cycle is conducted at a lower temperature than the pyrolytic (around 350C). These are ovens which can be recognised by their porous interior walls which are rough to touch. This type of wall absorbs the cooking grease. The catalysis destroys splashes of fat by oxidation when cooking dishes at more than 200C. It has been reported that catalytic cleaning is less effective than pyrolytic cleaning, since the catalytic liners cannot be cleaned, and there are certain gaps within the cavity which may need to be cleaned manually using chemicals. Catalytic liners require additional parts to be installed, adding about 1 kg of mass. This additional mass will absorb heat, increasing oven energy consumption. However, published research points out that there is still room for improvement, mainly around the properties of the oven wall coating.

- **Hydrolytic cleaning**. This is a cleaning process which involves the use of steam, combining evaporation and condensation. The dirt in the oven turns soft and detaches easily, making it easier to clean the oven. The system is simple and economical, as it just needs a small amount of water and washing up liquid. This is also the least energy consuming self-cleaning process.

In terms of innovative solutions for self-cleaning ovens, in Palmisano et al (2011), a series of tests were conducted to analyse the ability of cerium oxide (CeO_2) as a main component in the enamel of catalytic self-cleaning ovens. Four different synthesis techniques were studied for CeO_2 deposition over an enamelled oven tray. In terms of temperatures required, it was observed that for 4 different solid residues, when using the CeO_2-based enamel, the temperatures needed to remove 90% of that residue were between 8%-49% lower than with a standard enamel. Moreover, when comparing the CeO_2 catalytic enamel with an equivalent pyrolytic enamel, it was observed that similar results in terms of residue elimination can be obtained at temperatures around 150C lower. These results indicate that room for improvement may be available in energy consumption of self-cleaning systems.

4.1.5.9 Technology area 9: Smart and connected ovens

With the onset of home automation and the Internet of Things, modern cooking appliances are increasingly equipped with connectivity features. A smart cooking appliance is essentially a Wi-Fi enabled appliance which allows its connection to the Internet. In the specific case of ovens, being connected to the Internet provides a series of benefits to its users.

- A connected oven may become the hub or the centre of **connection and dialogue** for the management of all kitchen appliances: induction hob, range hood, refrigerator, dishwasher and washer dryer. From a touchscreen available in the oven door, the user may manipulate the rest of related appliances as required, before and after the cooking activities.

- A connected oven may have access to an extensive **database of recipes** which is continuously updated. The user may select a recipe from the database and load it onto the device, which automatically sets the right temperature and timing for the selected dish. The oven may also suggest seasonal recipes based on the time of the year or provide additional information regarding the nutritional value of the food being prepared.

- A connected oven can also be **manipulated remotely** by the user via smartphone or tablet. This can be used to pre-heat the oven before the user arrives home, to reduce time spent in the kitchen. This can also be used to check status of food remotely –via cameras or sensors-, and to change temperature, timing settings, if required. A connected oven can also provide information regarding the remaining cooking time or send a notification to the user when a program has ended.

- A connected oven may be also **operated via voice control** devices. While the user is preparing food in the kitchen, the oven may be pre-heated and set ready for cooking via voice command, without the need of approaching the oven or touching the screen and controls. This may help reduce cooking time and also avoid leaving fingerprints on display.

- A connected oven with a failure may send a notification to the user when it detects something is not working properly, and can also be **diagnosed remotely**. With remote diagnosis, customer service can obtain online access to the device, identifying the cause of any problems and giving advice on what needs to be done.

- Having an oven connected to the Internet can also be considered a **safety feature**: the user can check remotely if the oven has been left on accidentally, turning it off remotely, if needed. The oven can also be locked remotely if there may be children in the surroundings.

Considering the features above, one stakeholder pointed out that energy consumption due to software updates should be taken into account in the analysis. These updates might cause higher annual energy consumption of the device, particularly if high oven temperatures, high power demand of microwaves or long cooking processes in steam ovens are implemented.

4.1.5.10 Technology area 10: Comfort and convenience features in ovens

Modern ovens offer a wide variety of comfort and convenience features aimed at improving consumer's cooking experience. These features are making cooking process easier, on occasions faster, more enjoyable; although it is worth noting that they are also heightening complexity of appliances and increasing the amount of electronics and other materials. Although modern ovens are each time more energy efficient, adding excessive comfort and convenience features could risk increasing total life cycle energy consumption, if materials used for manufacturing are too energy intensive or if these features prevent repair or recovery of materials at end of life. More research is still needed in this area. In this section, a brief review of comfort and convenience features of main oven manufacturers is presented.

- Current ovens offer a variety of **opening systems** for user comfort. The most common opening system is drop-down doors, although other systems are also available in the market to provide different levels of comfort and design: side opening and extractable doors

- A typical offering these days are **cooking aid features**, such as pre-set programmes, food probes or automatic turning-on and off, which try to ensure that dishes are cooked with accuracy in terms of timing, temperature and settings. Some of these food probes, for instance, even incorporate wireless connection, allowing the consumer to check the status of their dishes remotely via smartphone or tablet. Certain ovens are capable of understanding how much energy is stored in food and optimally regulate temperature and cooking time, through antennas and wave modulators which penetrate deep into food, in combination with upper and lower or ventilated heat. This feature may reduce cooking time up to 70% when compared to traditional cooking methods (Preda, 2018).

- Another typical comfort feature offering are technologies with the aim of **reducing odours** from cooking vapours. These technologies, based on a catalyser that filters the circulated air during cooking, prevent grease deposits on furniture, walls and curtains, reducing significantly odours from cooking. Depending on models, the absorber can be activated or deactivated as desired. Some of these filters can also be operated during pyrolytic cleaning cycles, eliminating the smell of burned grease and CO gasses.

- Although door glazing is in place to avoid opening the oven during cooking, on occasions users need to access the food in order to move it, add ingredients, check status, etc. This operation needs to be quick, to minimise heat losses, and safe, to avoid burns from accidental touches. For this reason, several oven manufacturers offer pull-out shelf systems with **telescopic runners**, which enable easy and safe access to the cooking tray, reducing also the time the oven door is actually open.

- To increase flexibility in cooking activities, certain manufacturers are offering **flexible number of cavities**, allowing to cook two preparations with different times and temperatures. Specially designed doors allow being opened completely or only in one of the cavities. A removable separator avoids the exchange of odours between the two sections.

- In order to improve cooking experience even further, some manufacturers are offering opening and closing systems with damping systems which enable **smooth opening and closing** of oven door. This feature reduces noises and shocks, making cooking experience more pleasant for consumer.

- Modern ovens offer a wide variety of **lighting and displays**, which facilitate the use of the appliance, improving at the same time their appearance and style. In the exterior, both Thin Film Transistor (TFT) touchscreens and Liquid Crystal Displays (LCD) and controls are available on offer. In the interior of the oven, Light Emitting Diode (LED) light tubes are also available to ensure complete illumination of the cavity while the food is being cooked.

- With the aim of reducing burns and inconvenience of accidental touches to the oven exterior, manufacturers are offering **cool door** technologies. In these appliances, multi-layer glass panels insulate the oven door effectively, ensuring that controls, handles and adjacent cabinets stay cool to the touch, even during pyrolytic cycles.

- Manufacturers are increasingly offering as well a variety of **sensors and cameras** in the oven, with the goal of helping the user keep control of the status of the food being cooked, without the need of opening the oven door or even being present in the kitchen. Sensors and thermometers placed in the cavity ensure that temperature is always at the right level, augmenting or reducing when required, turning oven off and keeping food warm after the programme has finished. Certain manufacturers offer motion-sensors which detect when the user approaches to the oven door, illuminating the cavity only in that instance. Some ovens also include a camera in the interior which allow the user check the status of the food remotely via smartphone or tablet.

4.1.6 Best Available Technologies in ovens (BAT)

In this section, the Best Available Technologies (BAT) in terms of energy efficiency for domestic ovens are investigated. Data for this investigation will be taken from TopTen database. This database provides data on a different range of products, according to a criteria set that is regularly updated.

In this database, ovens are classified in three categories: ovens, steamers and stoves. There is no explicit definition of these categories in their website, although from the analysis of the models, it appears that they can be understood as:

- **Ovens**: built-in ovens, without additional steam function and without a hob.
- **Steamers**: built-in ovens, with additional steam function and without a hob
- **Stoves**: without additional steam function, with a hob (cookers)

All ovens currently listed within this database are either in energy classes A+ or A++. The energy efficiency classes and EEI of the 46 models listed in TopTen are displayed in Figure 85. Indicative benchmark as in Ecodesign regulation 66/2014 is also shown in the graph in orange dotted line.

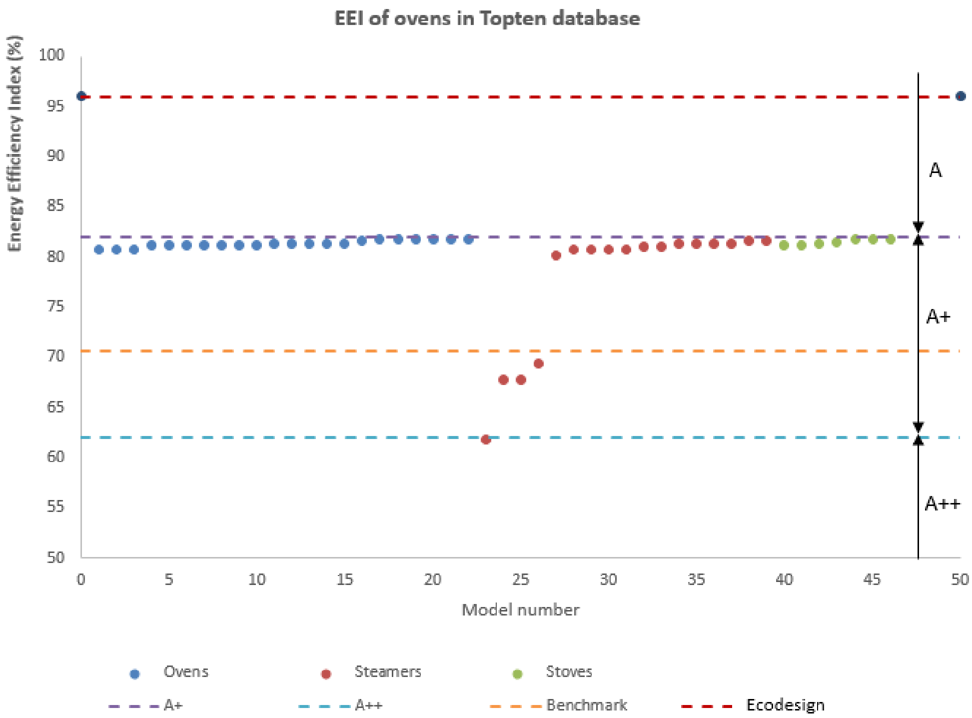


Figure 85. EEI and Energy classes of ovens in Topten database

As it can be observed, most of the products in the database have very similar EEI, with very small variation between them (80.2%-81.7%), with no significant difference between ovens, steamers or stoves.

- All the products in the database are comfortably below the EEI ecodesign limit for 2019 (96%)
- There are 4 products with significantly better EEI than the rest and all of them are steamers (ovens with additional steam function).
  - The four of those steamers are below the indicative benchmark for electric ovens (70.7%).
  - Only one of those steamers is within A++ energy class.
- Ovens and stoves show similar EEI values.
  - All of the ovens and stoves are right below the value to be within A+ energy class (82%)

An additional analysis is conducted to investigate whether there is a relationship between EEI and cavity volume (Figure 86).

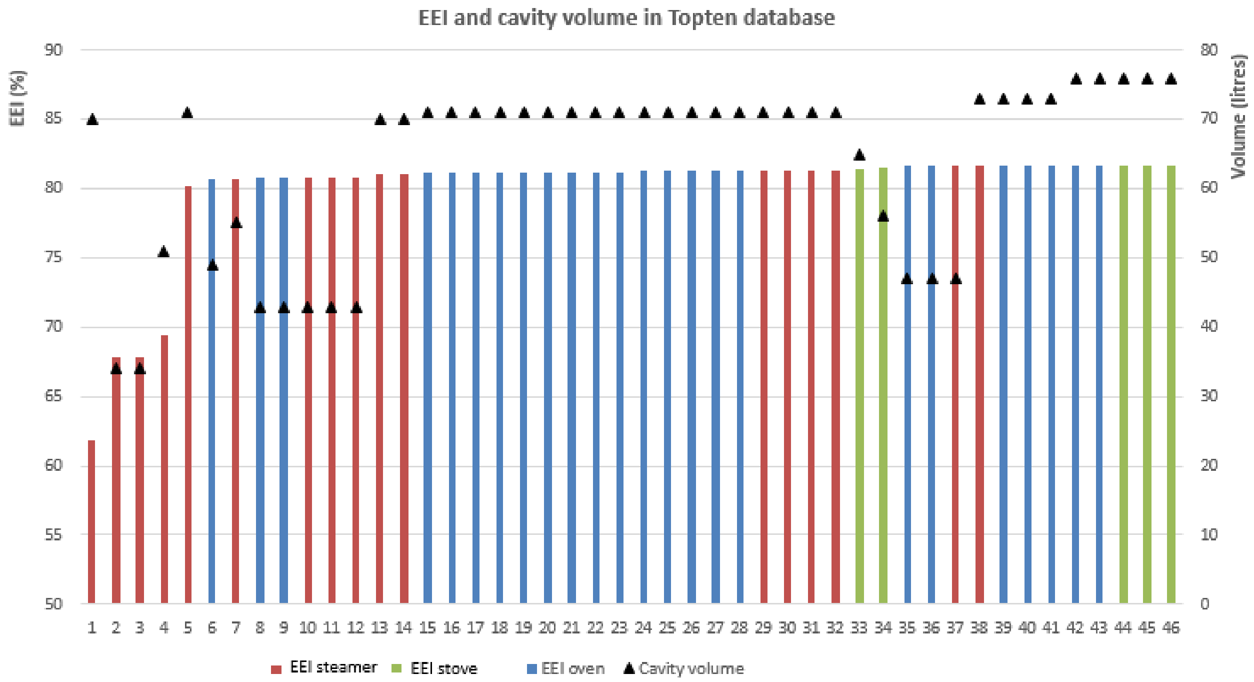


Figure 86. EEI and cavity volume of ovens and stoves in Topten database

As can be seen in Figure 86, not very obvious trends can be observed regarding EEI and cavity volume:

- The best performing product is model number 1 in this figure (EEI=61.9%) and has a big cavity (70 litres).
- On the contrary, the next two models in terms of EEI (67.8%) have smaller cavities (34 litres).
- The nine products (models 36-45) with the highest EEI values (81.7%) also have the highest cavity volumes (73-76 litres).

Therefore, a very general trend can be observed regarding EEI and cavity volume: bigger cavities lead to slightly higher EEI values. However, this needs to be taken with caution, since the sample is small (46 models) and the differences in EEI among most of the models are marginal (most of them between 80.2%-81.7%).

From the analysis of Figure 85 and Figure 86, it can be concluded that **Best Available Technology (BAT) regarding energy efficiency is an oven with an additional steam function**, since the 5 best performing products in the database are within this category. Cavity volume appears not to have a significant influence on EEI, as the best performing product has a cavity of 70 litres.

4.1.7 Best Not Available Technologies in ovens (BNAT)

In this section, the Best Not Available Technologies (BNAT) in terms of energy efficiency for domestic ovens are investigated. Data for this investigation will be obtained from scientific literature and feedback from industry and stakeholders.

From the analysis of scientific literature, there is no obvious technology for domestic ovens, currently not available in the market, which could improve drastically energy efficiency in the near future. Feedback from manufacturers also points at the fact that there are no significant technology developments expected in terms of energy efficiency for the upcoming years. In their view, the biggest potential for energy efficiency improvement is more related to user behaviour than to the actual appliances. Best practices for energy savings when cooking with an oven have been mentioned in Task 3 of this report.

Certain projects have been developed in the latest years in order to reduce energy consumption of ovens with the substitution of the steel enamel cavity with a stainless steel cavity with increased reflectivity

(Santacatterina et al, 2016). However, it still needs to be demonstrated that these materials could withstand the high energy temperatures of pyrolytic cleaning, for instance.

Other technology mentioned in specialized magazines is solid-state semiconductor materials, described in detail in next sub-section.

4.1.7.1 Solid-state semiconductor materials for microwave ovens

As explained in Section 4.1.5.5, microwave ovens are based on the use of magnetrons, devices capable of creating microwaves, a form of electromagnetic radiation with waves shorter than radio waves but longer than anything human eye can see. When electricity runs through a metal filament, negatively charged electrons rush to the positive end. Magnetrons keep these electrons going in a loop created by a magnet, creating electromagnetic waves that radiate outward. These waves affect the water molecules in the food, which start wiggling around rapidly. Metal mesh lining in microwave ovens reflect these waves, bouncing them around the cavity about 2.5 billion times per second. The friction created by this movement of water molecules heats food from within (Foley, 2017). One of the main disadvantages of microwave ovens is related to the uncontrolled bouncing of the electromagnetic waves within the cavity, affecting the food from different angles. The turntable is in charge of balancing this but the cooking results are often not repeatable even using the same power amount.

In Werner (2015), a potential solution is presented to overcome this issue, based on the use of a **solid-state semiconductor**, paired with signal amplifiers and receivers. Semiconductors are made out of ceramics like silicon, which typically block the flow of electrons, but have chemical impurities that help electrons move only in one direction. Semiconductors slow down electricity coursing through a system. The amplifier and receiver create a power feedback loop that allows the semiconductor to adjust and produce the right amount of microwaves, at the right power level, and for the correct length of time, to heat food evenly. Unlike conventional microwave technology, this one may allow for much higher precision cooking because the signals generated provide a feedback loop to help the oven understand and target specific zones within the cooking cavity. A few examples of companies working on ovens with this technology is compiled in Wolf (2017). Another potential advantage of semiconductor-based microwave ovens is their portability. Substituting magnetrons (which are bulky, heavy components) by lighter and compact semiconductor materials could open the possibility to the manufacturing of portable microwave cookers (Hambling, 2016).

Currently, there is no scientific evidence published regarding any potential improvements in terms of energy efficiency regarding this technology. Feedback from industry indicates that whereas the efficiency of generating microwaves with a magnetron is around 70%, that of generating them by semiconductors is only of 35%. Semiconductors offer the theoretical advantage of variable wavelength. However, this brings also disadvantages as the ovens need to be dimensioned for a specific frequency to assure an efficient use and especially to avoid microwave leakage. On top of that, the costs of this technology are still far away from being applicable for the domestic sector.

4.2 Domestic hobs

4.2.1 Technical product description: hobs

A hob is a domestic appliance used for heating food. It generally works as a primary heat source which is used to warm a cooking vessel (a pan, pot, etc.), which then becomes the secondary heating source, transferring heat to the food within it. In the definitions section of Regulation 65/2014, European Commission differentiates between electric hobs, gas hobs and mixed hobs.

- **Electric hob**. Appliance which incorporates one or more cooking zones/areas, including a control unit, and which is heated by electricity
- **Gas hob**. Appliance which incorporates one or more cooking zones/areas, including a control unit, which is heated by gas burners of a minimum power of 1.16 kW.
- **Mixed hob**. Appliance with one or more electrically heated cooking zones/areas and one or more cooking zones heated by gas burners.

4.2.2 Basic product types

Depending on the characteristics of the main components, domestic hobs can be classified in different ways. In Table 35, a classification is provided considering three criteria: heat source, heating element, and mounting.

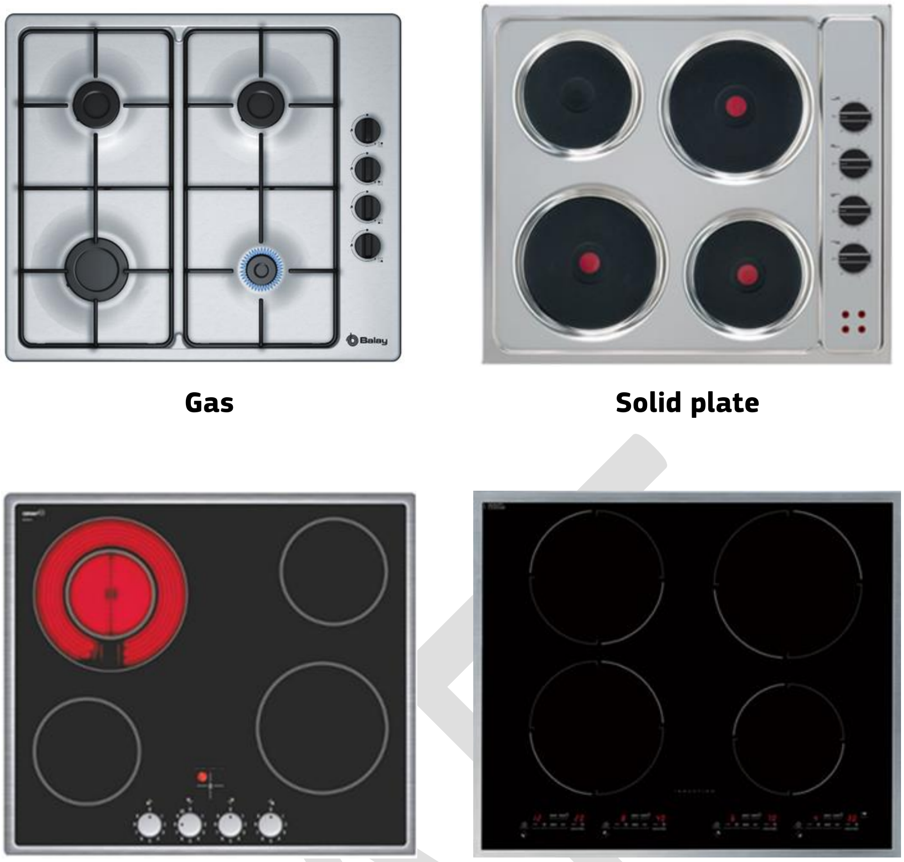
Table 35. Types of hobs

Heat Source	Heating element	Mounting
Gas	Burners (gas)	Built-in
Electricity	Solid plate (electric)	Integrated in a cooker
	Radiant (electric)	Portable or table top (out of the scope oft he current Ecodesign Regulation)
	Induction (electric)	

Considering **heat source**, domestic hobs can be powered either by gas or electricity. Gas hobs imply the use of burners that, after being ignited, maintain a flame that transfer heat to a cooking vessel. Although they can differ in size, configuration and ignition type, gas burners are relatively similar between them. On the other hand, there are more differences between electric powered hobs, depending on the heating element they use.

In terms of **heating element**, electric hobs can be classified in different types (Figure 87):

- **Solid plate** hobs contain a sealed electric resistance, through which circulates electrical current, transferring heat to the cooking vessel on top of it.
- **Radiant hobs** are a type of radiant cooking appliance. They use an electrical resistance wire or ribbon with a current that makes it glow red hot, so that most heat is transferred to the cooking vessel by conduction via a glass-ceramic surface
- **Induction hobs** are an electric cooking appliance where the hob itself is not specifically heated. Instead, below the surface of the hob there is a planar copper coil that is fed electrical power via a medium frequency inverter. This alternating current induces eddy currents in nearby metallic objects (cooking vessel). These eddy currents heat up the cooking vessel, transferring the heat to the food.



Gas **Solid plate**

Radiant **Induction**

Figure 87. Different types of hobs according their heating element (APPLIA)

An important usability factor when comparing domestic hobs is the ability to **control temperature**, as this is a key aspect of the cooking process. In general, it is considered that gas hobs offer a basic level of control, whereas radiant ones allow the user to be slightly more accurate thanks to different levels offered in this kind of cooktops. Induction hobs are considered the most precise and reactive to temperature changes (Electrolux, 2019).

Time response is another factor valued by consumers. Induction hobs have the quickest response to temperature changes. As an average, the time needed to boil 2 litres of water with an induction hob is 5 minutes. This is mainly due to the fact that the electromagnetic fields created in these hobs do not heat the cooking surface, but rather directly the cooking vessel. Moreover, the flat surface prevents heat to be lost (highest energy efficiency among hobs).

In terms of **cleaning process**, it is worth noting that a flat surface is always more convenient to clean, reducing significantly the amount of time needed and potentially the amount of cleaning product. Therefore, electric radiant and induction hobs have an important advantage over gas hobs. Moreover, in induction hobs, heat is only transferred through the area where the pot is located, so if food is dropped or spilled over the cooktop it will not get burnt or attached, facilitating even more the subsequent cleaning process.

In terms of **durability**, gas hobs have been widely used over time and their durability has been long proven. 19 years is a widespread figure used for gas hobs lifetime (ETSAP, 2012). On contrast, glass-ceramic is more prone to scratching and breaking. If a pot is accidentally dropped over the cooktop it may damage the surface, affecting its performance. Induction and radiant hobs may have a slightly lower average lifetime because of that (a range between 15 and 19 years is provided in ETSAP, 2012). Moreover, the significant amount of electronic components present in induction hobs may reduce lifetime of these appliances. As reported in Favi et al, (2018), lifetime bottleneck is usually represented by electronic components, which tend to have the shortest lifetime among all components of a product. It is suggested that lifetime may be lower than gas or radiant cooktops, more similar to other consumer electrical products (10-15 years).

4.2.3 Safety in domestic hobs

In terms of safety, it is worth noting that generally every product placed on the market has put in place every measured required to make them safe enough for the consumer. However, this does not mean that the user will never make any mistake when using the appliance, such as forgetting to turn it off after cooking or touching the cooking surface accidentally.

On the topic of safety related with gas cooking appliances, a manufacturer indicates that the design of a gas burner with very good efficiency may sometimes challenge safety requirements: the closer to the flame a pot is, the more efficiency you have, but the worse combustion you get (leading to increased emissions of pollutants like CO). Finding the right balance between a good efficiency and a good combustion is the key.

Considering accidental touches, there is an obvious risk in touching a gas hob when it is working, as the flame can cause instant burns to the user. Nevertheless, it seems unlikely that this sort of accident may happen. On the contrary, this is a situation that seems slightly more likely in the case of electric radiant hobs. The flat surface is often used to cook and chop food, particularly in small kitchens where cooking space is limited. Radiant hobs have a glowing red colour when turned on, but go almost instantly black after use. Although there is generally a small pilot light indicating the surface is still hot, the user may rush to use it for preparing food, increasing the risk of accidental burns. Some manufacturers offer electric hobs with LED lights which simulate the appearance of the flame and light up or down according to the temperature. Finally, induction hobs are the safest from this point of view. While cooking, the surface will only get slightly warm, due to the heat transmitted from the pan to the actual surface.

Forgetting to turn off the hob after cooking is a common mistake made by users. Generally, gas hobs do not come with any automatic turn off device, so if the user forgets to turn it off after cooking, it will keep on burning gas indefinitely, posing an obvious fire risk. According to certain studies, 62% of home fires start because of the hob (Rance, 2019). Just a limited number of gas hobs are equipped with independent timers for programming the cooking times and switching off each burner after certain time. Others also include a sound alarm that alerts if the hob remains active beyond certain threshold (Preda, 2018). There is certain risk as well in forgetting to turn off an electric radiant hob, although with these ones the fire risk is considerably reduced. In this case, the highest risk is again related to burns by accidental touch. Induction hobs will be again the safest ones: if the user forgets to turn off the device after cooking, the pan will get hot, but it is unlikely that a fire will start because of a hot pan, or that any other user would touch the interior of the pan. If the user forgets to turn off an induction hob, but removes the pan from the surface, nothing will happen, as induction needs a ferromagnetic material to be located on top of the surface to start working.

4.2.4 Technology areas: hobs

4.2.4.1 Technology area 1: Gas hobs

Gas hobs are usually made of a metal plate that functions as a frame; upon which several cooking spots or burners are mounted (a typical configuration is 4 burners). Generally, hobs are made with burners of two or more different sizes and maximum energy output, in order to accommodate different size cooking vessels. A steel grid is placed over each of the cooking spots to allow cooking pots be positioned (Favi et al, 2018). The main components of gas hobs are:

- Burners
- Igniters
- Gas flow controllers

Most **burners** are round with an array of small gas flames around the periphery. Typical domestic hob burners have a maximum power output of approximately 3.7 kW, although some burners with up to 6 kW can also be found. In the traditional gas hob, each burner is centrally located below a pan support and surrounded by a dish shaped depression to avoid spillages from the cooking vessels extinguishing the flame. Control of the power to the burner is typically only by the control of the gas supply, although some manufactures market dual burners consisting in inner and outer circular burners, intended to provide more even heat distribution.

In gas hobs, gas is premixed with some air before it reaches the burner, so that a smoke-free blue flame is produced. Combustion also requires secondary air from around the flame to burn all the hydrocarbon gases. To avoid CO formation, it is essential that some excess air is mixed in the flame. The amount needs to be limited, as too much cold air cools the flame and reduces heat transfer efficiency.

High voltage spark **igniters** are the most common type in the case of domestic hobs, since they provide near-instantaneous ignition of the gas. The spark electrode surfaces are affected by contamination and moisture, causing gradual loss of energy efficiency. However, their useful life is long and they usually do not need to be replaced across the hob lifetime.

Hot surface igniters use electrically heated ceramic surfaces that are sufficiently hot to ignite the gas. Originally, these took as long as 30 seconds before ignition, but some recent designs operate much quicker. One potential problem is that, being made of ceramic, the igniters could be physically damaged from thermal shock. This technology is rare in the EU and more common in the US.

Hot wire igniters use a proprietary alloy resistance wire that heats up to over 1000C in order to ignite the gas. Ignition takes less than 3 seconds. The wire is not affected by contamination and there are no electromagnetic compatibility issues. This type of igniter is also rare in the EU.

Gas flow control elements (valves) are made from either brass or aluminium. Valves restrict the flow of gas in order to control the heat output. Electronic gas control valves have recently been introduced, providing a variety of functions, including:

- Automatic burner ignition (reignites gas if the flame goes out)
- Electronic gas flow control (more accurate control of gas flow)
- Safety switch that turns gas off after certain time
- Timers to turn gas off after pre-set time
- Touch control systems

The main materials used to manufacture gas hobs are aluminium alloy, carbon steel, copper, brass and synthetic rubber. A detailed Bill of Materials of a gas hob system is presented in Favi et al (2018).

In terms of energy efficiency, it is generally considered that gas technology is largely accepted and well known in the global market. Therefore, less research and development actions are currently being undertaken to improve its efficiency (in comparison to other hob technology such as induction). Current innovation in gas hobs are related to aspects listed below:

- A more precise flame control that makes the gas hob more efficient and performant. Manufacturers are offering gas hobs where the flame increases or decreases according to several power levels, with a similar precision to that of induction (Preda, 2018).
- Technologies with pressurized pre-mix burners, which allow achieving high power with a single fire, managing to have in only one stove the equivalent of four burners (Corti, 2019b).
- The design of gas hobs which reduce the distance between the pot and the flame, which may greater speed in cooking and lower energy consumption (Corti, 2019b). However, this may

jeopardise the safety of the hob, thus any improvement in this area is limited by safety requirements that must be fulfilled above any other requirement.

4.2.4.2 Technology area 2: solid plates

Solid plates consist of a resistance wire of Nichrome, either as a spiral ring or within a solid plate. Heat transfer is primarily by conduction, so it only occurs efficiently where the cooking vessel and the ring are actually in contact. Hobs are usually sold with a range of ring sizes to accommodate cookware of different dimensions. The main elements of solid plates are shown in Figure 88:

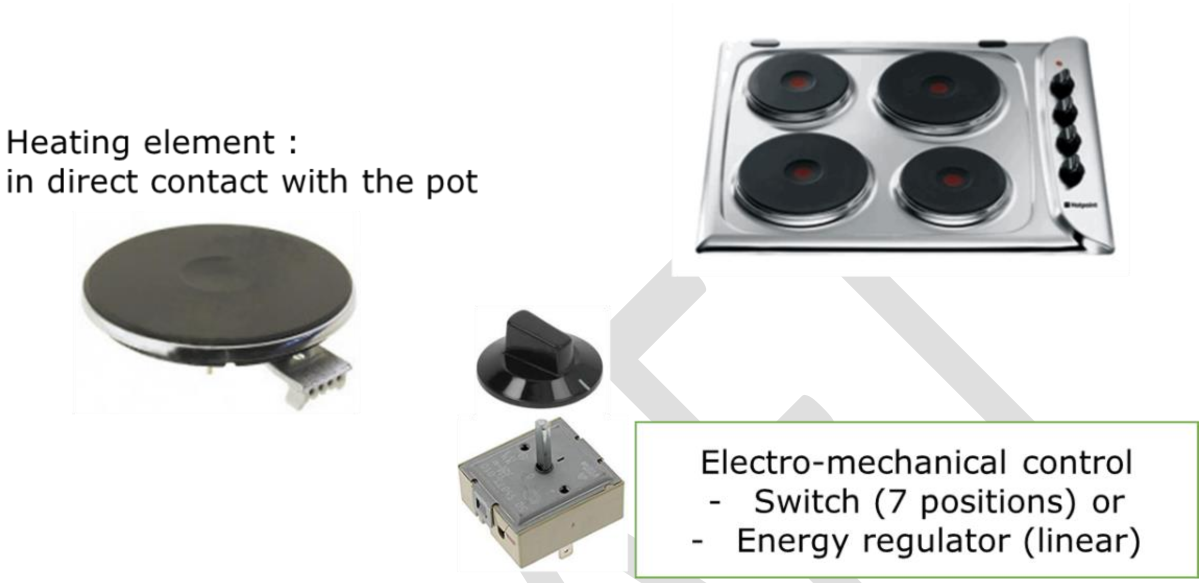


Figure 88. Components of solid plates (APPLIA)

The main advantages of these hobs are the low price and robustness. However, cooking temperature control is difficult as they are relatively slow to respond to changes in the controls due to their high thermal mass (inertia of the plate).

There is a potential reduction of energy consumption for solid plate hobs by replacing the switch control to energy regulator control.

4.2.4.3 Technology area 3: Radiant hobs

Electric radiant hobs consist of a glass-ceramic surface, beneath which electrical current flows through a unique metal coil. Electrical resistance heats to generate a hot glowing metal coil that transfers its heat through the glass-ceramic via radiant energy and to the glass-ceramic via convective heat. (Joachim, 2019).

The main components of radiant hobs are shown in Figure 89:

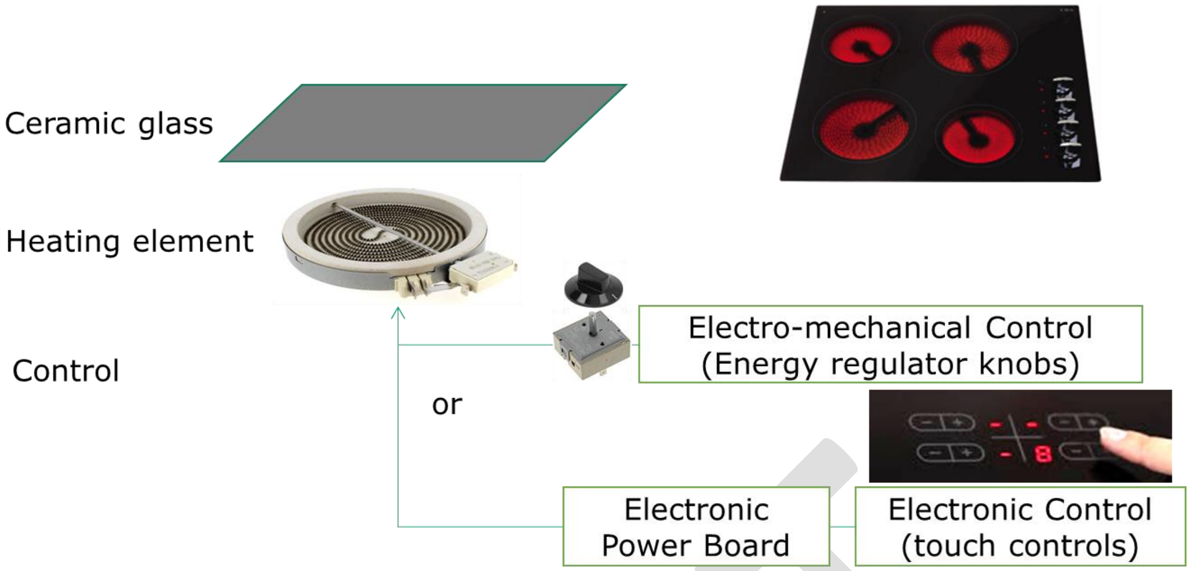


Figure 89. Components of a radiant hob (APPLIA)

Food is cooked by the transfer of heat from the electric coil to the ceramic-glass surface and finally to the cookware. At the same time, the surrounding surface of the glass-ceramic remains relatively cool. The glass-ceramic continues to emit heat after electricity stops flowing, so this residual heat can be used to continue cooking or to keep food warm (Wegert, 2015). As the thermal mass of the heating elements is relatively low, they cool rapidly when the current is reduced, giving much better temperature control than solid plate hobs. The response time is not as fast as in induction hobs, as some heat is retained by the glass ceramic.

Because of the glass-ceramic's low thermal expansion and infrared transmission and emission characteristics, the pot or pan on the cooking zone is warmed evenly by the energy transmitted through the glass-ceramic to the cookware. They also have less thermal inertia and a faster response than solid plates.

4.2.4.4 Technology area 4: Electric induction hobs

In induction hobs, below a glass-ceramic cooktop, there is an electronically controlled coil of copper. When power is on, constantly changing electric current flows through that coil, generating a magnetic field that terminates at the bottom of the ferromagnetic pot placed above the hob. This fluctuant magnetic field indirectly produces heat by inducing an electrical current flow in the pot: an eddy current (Favi et al, 2018). A diagram explaining the basic functioning of an induction hob can be seen in Figure 90 (Hager et al, 2013).

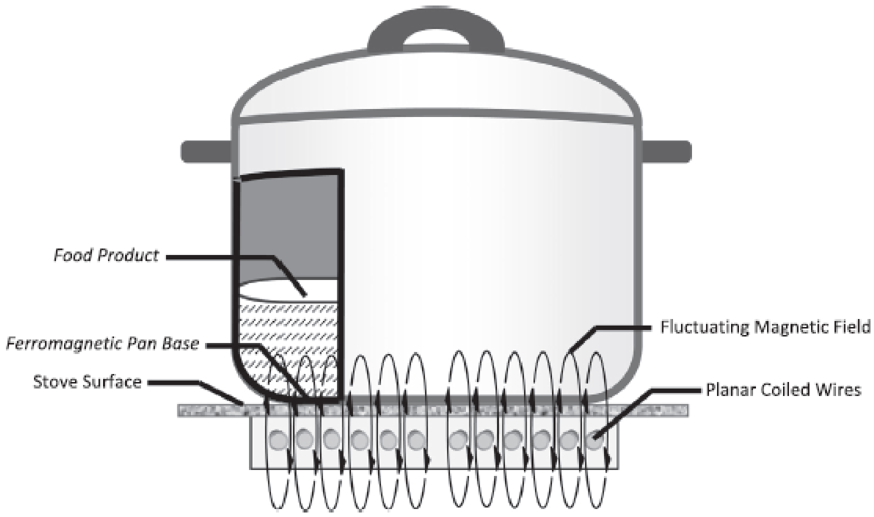


Figure 90. Diagram demonstrating basic functioning of induction hob

The electromagnetic induction generates Eddy currents within the metal and its resistance leads to Joule heating and also generates losses due to the hysteresis of the magnetic material in the pan. An induction cooker consists of a copper coil (generally), through which a high-frequency alternating current (AC) is passed. The frequency of the AC used is based on the maximum switching frequency of the switch of the power converter. The main components of an induction hob are shown in Figure 91:

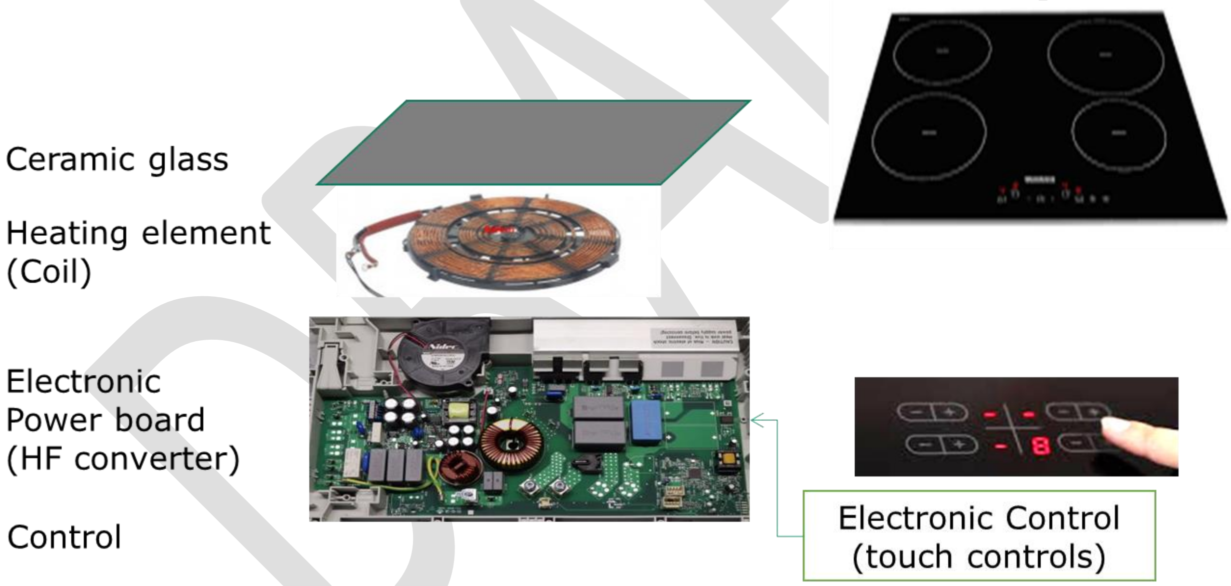


Figure 91. Components of induction hobs (APPLIA)

The most common topologies for induction heating are the Half-Bridge series-resonant converter and the Single switch Quasi-Resonant. The Resonant Half-Bridge is the most employed topology in induction cookers for multiple burner, high-power systems due to its simplicity, its cost-effectiveness, and the electrical requirements of its components. Quasi-Resonant converters require only one switch, and only one resonant capacitor. Quasi-resonant converters might be considered as a good compromise between cost and energy conversion efficiency (Semiconductor Components Industries, LLC, 2014)

In terms of required cookware, any ferromagnetic steel flat-bottomed pot is suitable. However, especially design cookware is also used. These have ferromagnetic metallic bases that couple efficiency to the alternate current signal. Cooking area size is much less important in these hobs, as induction only heats the actual size of the pan being used. Heat losses are therefore reduced significantly with these appliances. The medium frequency coil needs to be located at a certain distance from the pan base for optimum coupling efficiency. The heat energy generated in the pan is inversely proportional to the square of the coupling distance. Therefore, the hob needs to be designed with the correct distance between the coil and the pan.

The main materials used in an induction hob are glass-ceramic, stainless steel, carbon steel, aluminium alloy, polypropylene and a considerable amount of copper –for induction coils and power cables- and electronics. A detailed Bill of Materials of an induction hob system is shown in (Favi et al, 2018).

Focusing on electronics, they fundamentally are resistors, inductances, capacitors, transistors and microcontrollers, attached on top of printed circuit boards (PCBs). A detailed inventory of the materials used in such PCBs can be seen in Elduque et al (2014).

In terms of energy efficiency, induction hobs tend to have very fast response and better performance than the rest of technologies, particularly during heat up, as the pan is heated directly and energy is not waste heating the cooker itself. During subsequent cooking, the difference in energy consumption is slightly lower, as the hob does warm up a little due to heat losses from the induction electronics and conduction of heat away from the pot to the hob surface. Certain energy losses happen as well from the induction electrical control circuitry that generates the medium frequency current applied to the coil. These occur during heat up at full power and during simmering. Furthermore, as technological development advances, overall efficiency of induction hobs keeps improving.

Since induction technology is generally top-end in the segment of hobs, innovative features are usually offered together with this technology. This is the case with air venting hobs, where a cooktop and a range hood are combined into a single appliance (described in more detail in a subsequent section) or other innovations such as hobs which allow to weigh foods directly into the pot and at any temperature level (Corti, 2019).

However, it needs to be taken into consideration that induction hobs are more complex, in terms of number of parts and technology, than conventional electrical or gas hobs. This may lead to shorter lifetimes than other hob technologies (more similar to other consumer electrical products). Another drawback is that the performance is affected by the material of the pot, which needs to be compatible with the induction technology.

4.2.4.5 Technology area 5: Air venting hobs

Air venting hobs are relatively new in the cooking appliances market, offering an alternative option to the traditional extraction methods. They are generally commercialized with high-end products such as induction cooktops.

An air venting hob is a ceramic or induction hob with an integrated extractor fan in the centre of the hob. They are designed to remove cooking vapours and lingering odours as soon as they appear, by drawing the air directly from the cooking vessel. Instead of sucking air up –as a range hood does-, venting hobs have a cross flow which is greater than the rising speed of the cooking vapour (typically 1 m/s), therefore they capture them before escaping around the kitchen area, creating a transversal flow (Corti, 2019).

Air venting hobs tend to correct fan settings automatically without user input, regulating it continuously during the cooking process. There are models with the aspirator positioned in the center of the cooktop (with a circular or rectangular grid) or versions which the extraction takes place through lateral slits (**Figure 92**).

Figure 92. Air venting hobs (Bora; Siemens)

Air venting hobs are complex appliances as they combine cooktops and extraction systems in one. This generally has an impact on price. Also, having the extraction system in the centre of the cooktop reduces the surface available for cooking. Additional space is also required below the cooktop, in order to locate the extraction and ventilation unit (**Figure 93**).

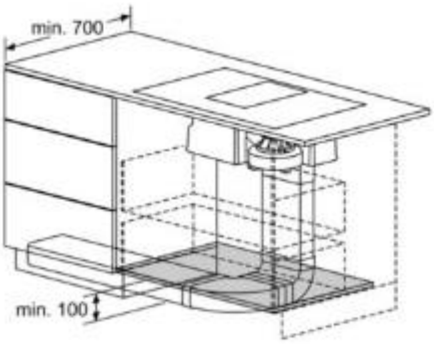


Figure 93. Air venting hob installation diagram (NEFF)

These are considered versatile products, since they offer the possibility of choosing between suction or filtering versions. In the first case, the fumes are conveyed outside the house through piping system, while in the second, the air is filter and cleaned from grease and then returned to the kitchen. Some other models combine suction and filtering systems.

The most direct advantage of an air venting hob is that it combines two appliances in one: cooktop and range hood. It makes a good use of space in the kitchen and has aesthetical benefits, particularly when the cooktop is placed on an 'island' in the middle of the kitchen, where placing a traditional range hood would be difficult. However, this type of range hood needs more suction power for the same ventilation results, as the fumes naturally tend to go up, requiring therefore more energy for the same results. They are also noisier than typical hoods due to this increase in power demand.

4.2.4.6 Technology area 6: Smart and connected hobs

A smart hob is broadly understood as a cooktop with a built-in Wi-Fi module that can be synchronised with an application managed from a portable device such as a smartphone or tablet. The benefits of a smart hob are very similar to those of a smart oven and can be summarised as it follows:

- A connected hob may have access to an extensive **database of recipes**. The user may select a recipe from the database and load it onto the device, which automatically sets the right temperature and timing for the selected dish.
- A connected hob can be **manipulated** from an application on a smartphone or tablet, making it easier for the user to access the functions and basic settings. It is worth noting that, unlike ovens, cooktops are not designed to be left unattended and the cooking process must be monitored at all times. The goal of a connected hob is not to be managed remotely.

- A connected hob may be also **operated via voice control** devices. While the user is preparing other food in the kitchen, the hob may be turned-off via voice command, without the need of approaching the cooktop or touching the controls. This may help reduce cooking time and also avoid leaving fingerprints on the surface.
- A connected hob with a failure may send a notification to the user when it detects something is not working properly, and can also be **diagnosed remotely**. With remote diagnosis, customer service can obtain online access to the device, identifying the cause of any problems and giving advice on what needs to be done.
- Having a hob connected to the Internet can also be considered a **safety feature**: the user can check remotely if it has been left on accidentally, turning it off remotely, if needed. The hob can also be locked remotely if there may be children in the surroundings.

4.2.5 Best Available Technologies in domestic hobs

In this section, the Best Available Technologies (BAT) in terms of energy efficiency for domestic hobs are investigated. Data for this investigation will be taken from TopTen database.

In terms of domestic hobs, Topten provides data only regarding induction hobs, so no comparison can be made with other electric or gas hobs. The list of most efficient induction hobs is provided in terms of energy consumption per kg of water, according to a criteria set that is regularly updated. The energy consumption of the 37 models listed in TopTen database are displayed in Figure 94.

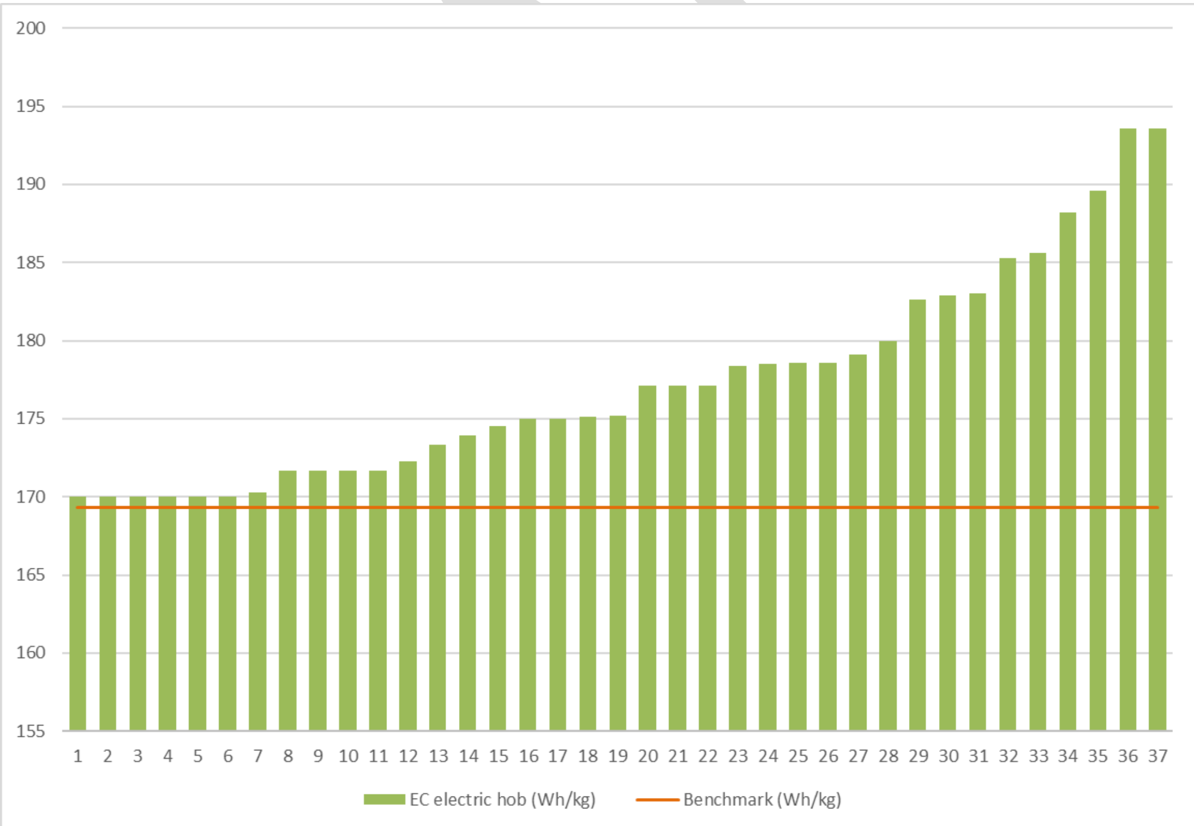


Figure 94. Energy consumption of induction hob models presented on www.topten.eu in January 2020

As it can be observed, only six models are close to the benchmark set by Regulation 66/2014 (169.3 Wh/kg). There is only a 14% difference in terms of energy consumption between the worst and the best performing models of the database (193.6 versus 170 Wh/kg).

Apart from the data provided by TopTen, manufacturers shared the range of energy consumption that the three types of electric hobs (solid plate, radiant heater and induction) typically perform (Figure 95). In a red line, the ecodesign limit for energy consumption after 2019 is displayed (195 Wh/kg).

Figure 95. Energy consumption ranges of electric hobs (APPLIA)

From the analysis of Figure 95, it can be concluded that **Best Available Technology (BAT) for domestic hobs is induction**. It can also be seen that the range of energy consumptions that solid plates can provide are very close to the minimum requirements of ecodesign regulation.

4.2.6 Best Not Available Technologies in domestic hobs

In this section, the Best Not Available Technologies (BNAT) in terms of energy efficiency for domestic hobs are investigated. Data for this investigation will be obtained from scientific literature and feedback from industry and stakeholders.

From the analysis of scientific literature, there is no obvious technology for domestic hobs, currently not available in the market, which could improve drastically energy efficiency in the near future. Feedback from manufacturers also points at the fact that there are no significant technology developments expected in terms of energy efficiency for the upcoming years. In their view, as it happens for ovens, the biggest potential for energy efficiency improvement is more related to user behaviour than to the actual appliances. Best practices for energy savings when cooking with hobs have been mentioned in Task 3 of this report.

Also according to stakeholders, cookware used has a very significant influence on the energy efficiency of the appliance. A very energy efficient appliance can deliver a very poor performance in terms of energy consumption if an inappropriate or low quality cookware is used.

The most significant technology development in the near future regarding hobs may be related to changes in terms of uses of gas. This is explained in more detail in the next sub-section.

4.2.6.1 Hydrogen as an energy source for domestic appliances

Currently, there is a growing interest in understanding how hydrogen-based technologies could contribute in the decarbonisation of heat supply sector for households (either for cooking or warming). Recent research indicates that hydrogen technologies for these purposes may be economically and technically feasible (H21, 2019). On this topic, a manufacturer highlights that the reduction of GHG emissions such as CO_2 is particularly important. The replacement of the current gases of fossil origin (like natural gas or butane) by “green gases” (like biomethane or hydrogen) with a low carbon footprint, will be the trend in the near future. The impact of such new gases in the efficiency of the burner is unknown at this moment, although they believe it should be negligible.

Focusing on domestic appliances, the industry up to date is very immature, with only a small amount of industrial and academic research. For the coming years, there are basically three options for the adoption of hydrogen as an energy source (Frazer-Nash, 2018):

> a) Developing new appliances from scratch, which would use only hydrogen as a fuel. This offers the freedom of designing and optimising a new solution, with the associated challenges of rolling out a completely new product.
>
> b) Adapting existing appliances, currently running with natural gas, to run on hydrogen. This option could soften the challenges of a completely new roll-out, but would also come with technical and operational issues.
>
> c) Developing dual fuel appliances, capable of operating on natural gas and hydrogen.
>
> > c1) in one case, it would mean appliances being able to use both fuels for their whole life cycle
> >
> > c2) in a second case, it would mean appliances designed to be used first with natural gas, and then with hydrogen when surrounding infrastructure is ready. In this case, it would require certain components to be changed at the point of switchover from natural gas to hydrogen.

Considering the characteristics of current gas cooking appliances (ovens and hobs), switching from natural gas to hydrogen would mean challenges in several areas, mainly around combustion, heat transfer, controls, piping, seals and casings. A detailed analysis of these challenges is conducted in Frazer-Nash (2018).

In terms of technology availability, elements of current natural gas hobs can be classified in different levels according to their readiness to be used in equivalent hydrogen-fuelled appliances. Burners are in a low level of readiness, since preliminary work needs to be undertaken to demonstrate a proper combustion of hydrogen, both from performance and safety point of view. This has not been actively applied and tested on current domestic gas appliances. In a medium level of readiness, pipeworks to carry hydrogen at high pressure are widely used in other industries. For the domestic appliance sector, work is still required to bring affordable low pressure hydrogen fittings. In the same level, pilot lights, heat exchangers, flue systems, casings and flame sensors are well understood, but components need to be re-optimised for the particular combustion characteristics of hydrogen. Finally, spark ignitors and controls currently used for natural gas appliances should be directly applicable for hydrogen domestic appliances.

In Frazer-Nash (2018), a comparison is completed for several aspects between natural gas (NG) appliances and the different options for potential hydrogen (H) installations (new, adapted, dual). This analysis is summarised in Table 36.

Table 36. Comparison between Natural Gas cooking appliances and Hydrogen alternatives

Aspect	Natural Gas benchmark	New Hydrogen appliance	Adapted Hydrogen appliance	Dual Natural Gas - Hydrogen appliance
Lifetime (years)	10-15 years	same as NG	less than NG	same as NG
Efficiency (%)	85-90	same as NG	less than NG	slightly less than NG
Maintenance / availability	50 £/ 30 min task	Increased cost than NG	Increased cost than NG	Similar cost than NG
Reliability	Considering burner, oven fan, thermocouple	same as NG	less than NG	same as NG
Size of appliance – oven (mm)	900 x 550 x 550	same as NG	same as NG	same as NG
Size of appliance – hob (mm)	550 x 550 x 50	same as NG	same as NG	same as NG
User controls	Considering dials, thermostats, digital control	same as NG	same as NG	same as NG
Internal control system	Thermoelectric Flame Failure Device (FFD)	Fast acting FFD	Fast acting FFD	Fast acting FFD
Noise	40-55 dB	slight increase	significant increase	slight increase
Warm up / cool down period	almost instant	similar to NG	similar to NG	similar to NG
Flame aesthetics	Blue, yellow, orange	similar to NG (would require adding colourant)	similar to NG (would require adding colourant)	similar to NG (would require adding colourant)
Production cost - ovens	120 £	20% higher than NG	20-40% of new one H	20% higher than new one H
Production cost - hobs	150 £	20% higher than NG	20-40% of new one H	20% higher than new one H
Retail - hobs	100-200 £	110-240 £	difficult to estimate	110-240 £

Retail - ovens	200-400 £	220-480 £	difficult to estimate	220-480 £
Domestic installations	80-150 £	similar to NG	appliance specific	similar to NG

As a summary from this section, it can be concluded that from the environmental point of view, hydrogen is a promising technology for domestic gas cooking appliances, if hydrogen fuel has been generated from zero or low carbon processes such as electrolysis using renewable electricity. The technologies in this sector are not mature and further research is required to ensure that appliances using hydrogen as main fuel perform at the same level in terms of energy consumption, safety and cooking capacities as their current natural gas counterparts. In the coming years, manufacturers will need to face several challenges mainly related to combustion, heat transfer, controls, piping, seals and casings.

4.3 Domestic range hoods

4.3.1 Technical product description: range hoods

Cooking is a significant source of indoor pollutants. Fumes generated during cooking processes usually comprise sub-micrometer-sized particles, such as oil droplets, combustion products, steam and condensed organic pollutants (Abdullahi et al, 2013). Exposure to cooking fumes has been recognized to cause adverse health effects. As an example of, the World Health Organization (WHO) recommends that mean PM2.5 concentrations in ambient air (including indoor environment) are less than 10 μg/m3 per year and 25 μg/m3 per day. Minimizing the presence of those pollutants in kitchens is the fundamental reason to use range hoods.

A range hood can be defined as an appliance hanging above the cooktop in the kitchen which uses a blower to collect steam, smoke, fumes and other airborne particles that may be generated while cooking. Its main purpose is therefore to control smoke, smells and temperature changes that are associated with cooking at the stove. Range hoods also contribute in reducing the risks of food contamination and fire (Han, 2019). It has been demonstrated experimentally that making use of a range hood reduces the peak concentration of ultrafine particles by 50% (Rim et al., 2012).

Using a range hood is not the only strategy that can be used to remove pollutants from cooking. Natural ventilation –also known as infiltration- can help to reduce those pollutants in households. However, it has been estimated that 98% of houses (in England) are too airtight to provide sufficient infiltration to dilute PM2.5 emissions from cooking to be below the WHO guidelines. It is not desirable to increase infiltration because it is positively correlated with heating energy demand, and current policies seek to improve energy performance of housing stocks. Therefore, controlled ventilation is required in kitchens to mitigate against negative impacts on occupant health from cooking (O'Leary et al, 2018).

The extraction system of a range hood consists of a centrifugal blower composed on an conveyor, a fab and an electric motor, both housed inside a scroll (Figure 96). The energy is provided to the exhausts to expel the fumes.

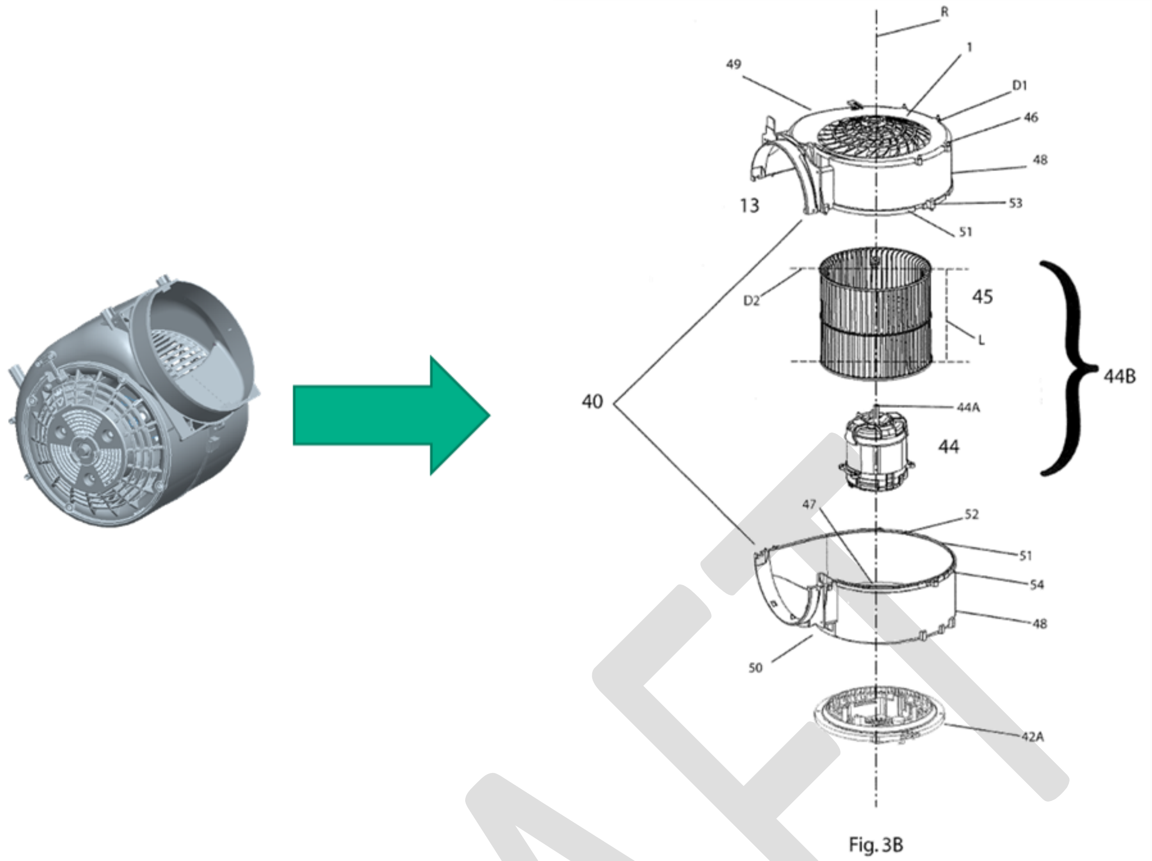


Figure 96. Illustration of a blower and its three components (APPLIA)

The system can work in multiple conditions of airflow rate, velocity and pressure (Bevilacqua, 2010). Generally, range hoods are manufactured with a combination of stainless steel, copper, bronze, nickel, zinc, tempered glass, aluminium, brass and heat resistant plastics. The main components of a range hood are:

- Capture panel and effluent plume, which are the elements that direct the thermal plume coming out of the cooking area towards the filter and ducting
- Filters, which are the elements of the range hood that capture the impurities when the cooking appliance is in operation
- Fans, which provide an active pressure gradient for ventilation
- Lighting, which provide a illumination onto the cooking area

Due to their predominantly visible location in kitchens, range hoods are increasingly seen not only as an appliance, but more as a piece of furniture. This is the main reason why a market for decorative hoods has been growing in the past years. Some hoods are also being offered with the ability to hold tools and objects, distributed on different levels. They may include hooks, shelves and even electrical outlets and USB ports capable of charging electronic devices (Di Meo, 2018).

4.3.2 Basic product types

Depending on the characteristics of the main components, domestic range hoods can be classified in different ways. Considering their ventilation system, range hoods can be either ducted or ductless. In **ducted** systems (also known as **air-extraction** range hoods), the output collar of the extractor hood's blower motor is attached to a ducting system which terminates outside of the building. The cooking fumes are pushed through the duct-work to the exterior of the building and vented outside (Dooley, 2019). This is the most common configuration in European kitchens, as they tend to be more efficient in the removal of airborne contamination and they eliminate the need for regular replacement of filters. However, ducted systems require a more complex installation as they need more ducting and venting elements. This limits the areas where such a configuration can be installed, which could be impractical if lack of space in the kitchen is an issue. (Gannaway, 2015)

On the other side, **ductless** hoods (also known as **recirculating-air** range hoods) make use of a strong air filtration system and then pump out the air back into the room. The fumes are therefore pushed through filters that remove odour and smoke particles from the air before venting it back into the kitchen. In this configuration, the use and periodical replacement of filters is essential. Recirculating heat and moisture into the kitchen might cause increasing the levels of humidity in the kitchen fairly quickly. It is worth taking into account that filtering might not be 100% effective, so odours might not be completely removed in ductless hoods. Moreover, ductless hoods tend to be noisier, as they often require more fan power. However, ductless systems have the advantage of versatility: since they need fewer amounts of ducting and venting elements, they require a simpler installation and can be placed in more locations within the kitchen.

In terms of **installation** method (**Figure 97**), range hoods can be defined as:

- **Built-in**: hoods are built into or concealed within a cupboard or fitted kitchen so they are less noticeable to the eye.
    - **Under cabinet**, when it is mounted underneath of the cabinets which are positioned above the stove. This is one of the most common and compact options: the design of the venting system is simple; it is versatile enough with almost any kitchen style and tends to save some wall space.
    - **Built-in** means an under cabinet hood fully integrated in the kitchen cabinet.
    - **Telescopic** means an under cabinet hood fully integrated in the kitchen cabinet and one of the grease filters slides out of the cabinet. .
- **Non built-in:** they are stand-alone units, which have not been integrated into a fitted kitchen. Non Built-in Cooker Hoods can be installed against a wall or directly below a cabinet above the hob.
    - T-shape hood and **chimney** hood, when it is attached to the wall above the cooktop. In this case, the range hood is installed instead of a cabinet in the space over the stove. They often come with a chimney that helps with ventilation, typically venting out through an exterior wall behind them. This configuration can serve as a design element in the kitchen.
    - **Vertical** hood, when the hood is installed vertically almost in parallel to the wall.
    - **Island mounted or suspended**, for kitchens where the cooktop is located on an island or not against a wall. This is the configuration generally used for larger, professional style cooktops, in order to handle the extra output.
    - **Downdraft**, when the range hood is kept inside the cook space, integrated into the worktop and hidden away until it is used. According to manufacturers, their main advantage is that they eliminate steam and odour right at the source. This is a less common configuration, a good solution for kitchens with limited space and when maintaining a clear sightline is a priority.
    - **Downdraft integrated**, as already described in previous section regarding air venting hobs. This is an appliance that combines range hood and hob –usually induction- in just one. The working principles are similar to a downdraft hood.

- **Ceiling** mounted, when the hood is installed directly into the ceiling. The configuration is similar of that of an island mounted hood, but in this case the result is a completely smooth surface rather than a hanging appliance in the centre of the kitchen.

Under cabinet

Built-in

Telescopic

Chimney hood

Vertical hood

Ceiling hood

Suspended

Downdraft

Integrated venting

Figure 97. Types of range hoods in terms of installation (pictures provided by APPLIA)

Range hood are equipped of two types of filters, depending on the installation:

- The grease filter protects the hood by retaining grease particles. It is present in all range hoods regardless their installation.
- The activated charcoal filter which is used in recirculating hoods only, captures and retains air odorous particles.

There are different **grease filters**, such as aluminium filters (the most common ones), stainless steel filters, steel filters and paper filters. Paper filters need to be replaced once a month while metal filters must be cleaned once a month using mild detergents, either hand-washed or in the dishwasher at low temperatures and short cycle. This cleaning may fade the metal grease filter though the filtering performance is not affected.

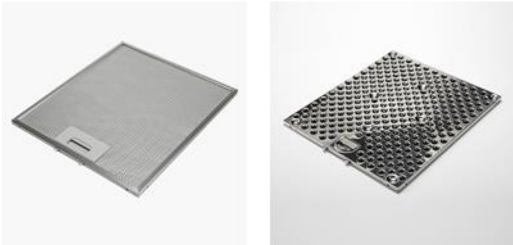


Figure 98. Grease filters (APPLIA)

Charcoal filters contain a fine powdered activated charcoal material, mounted in a honeycomb structure. Activated charcoal is a carbon-based compound that has been treated with oxygen to make it very porous. Impurities that are attracted to carbon become absorbed through the pores of the mineral and are kept trapped inside. These filters are used in ductless configuration for filtration of odours. They cannot be cleaned, so need to be replaced approximately every 3 or 4 months. If the charcoal filter is not regularly changed, a significant decrease of indoor air quality can be expected.

Figure 99. Charcoal filters (APPLIA)

According to stakeholders feedback, the most common range hoods that could be considered base cases have the features shown in Table 37:

Table 37. Typical features of most common range hoods

Ventilation (ducted/ductless)	ducted
Airflow rate MAX (m3/min)	700 - 800
Airflow rate MIN (m3/min)	260 - 300
Noise at Airflow rate MAX (dB(A))	66 - 73
Noise at Airflow rate MIN (dB(A))	40 - 60
Installation	cabinet / wall

(under cabinet/wall/island/downdraft/ceiling/integrated with hob)	
Type of filter (mesh/baffle/charcoal/none)	mesh
Lighting (LED/other/none)	halogen / LED
Lighting power (W)	3 - 40
Grease Filtering Efficiency (%)	70 - 90
Smart features (remote control & diagnosis/voice activation)	none - remote control and diagnosis
Packaging materials (list of materials)	Cardboard, wood, EPS, foil
Mass (kg)	8.3 -21
Annual energy consumption (kWh/year)	36 - 68

4.3.3 Capture efficiency in range hoods

Capture efficiency can be defined as the ability of a range hood in collecting grease-laden cooking vapours, convective heat and other products of cooking activities (CEC, 2012). This parameter can give a direct, quantitative measurement of the exhaust hood performance. It quantifies the fraction of generated pollutants removed either directly or over the duration of exhaust fan operation. As a general rule, it can be calculated as:

$$Capture\ efficiency = \frac{Contaminant\ produced\ at\ source - \ Contaminant\ escaping\ from\ hood}{Contaminant\ produced\ at\ source}$$

Capture efficiency is currently no part of the ecodesign or energy labelling regulations for range hoods. According to certain stakeholders, a revised or new test for the evaluation of the capture efficiency of pollutants could improve the consumer relevance of the performance test. As explained in Task 1 of this report, performance of range hoods is mostly based on airflow, but same airflow rates could lead to different capture efficiencies, depending on the shape of hood and where it is positioned in relation to the source of pollutants (the hob). It would require a test method with a standardized kitchen and a source of pollution that is representative for cooking fumes. This test currently does not exist within European harmonized standards, although ASTM standard E3087-18 gives a procedure to measure capture efficiency for wall mounted cooker hoods (still not applicable to island hoods or downdraft devices).

Capture efficiency is a function of different parameters such as airflow rate, installation height, hood capture volume and fraction of cooktop covered by the hood, among others (O'Leary et al, 2019). As it depends on a wide variety of factors and there is no harmonised standard to calculate it, current capture efficiency of range hoods is unknown. According to Dobbin et al (2018), it can vary between 12% and 98%.

4.3.3.1 Capture efficiency and airflow rate

Typically, hood performance has been evaluated by looking at **airflow rate (or exhaust rate)** only. This parameter expresses the strength of the hood in capturing air. It is generally measured in cubic meters per hour (m3/h). It is worth noting that more airflow means faster venting, although this does not guarantee better smoke capture and removal, as this will be related to other aspects such as the presence and type of filters, as well as to ducting and venting configuration.

Airflow rate in a range hood needs to be carefully designed. If part of the thermal plume generated by cooking is escaping from the hood, the exhaust airflow is too low. On the contrary, an excessive airflow may result in large initial investment and operating costs of the exhaust system (Han, 2019).

Although not the only one, airflow rate is one of the main factors affecting hood performance. It has been proved experimentally that larger airflow rates have a higher ability of reducing the concentration of ultra-fine particles in the kitchen area. Airflows around 120 m^3/h are not able to capture any particles around 5 nm, whereas airflows around 660 m^3/h would capture almost 100% of those particles (Rim et al, 2012). For heavy cooking practices involving the use of steam, at least 600 m3/h of airflow would be required (Lowes, 2019). Another aspect of interest is that generally, higher level of airflow means louder hood operation.

Airflow rates are on occasions lower than the manufacturer specified, potentially due to installation errors. Manufacturers need to provide installation instructions and details of how the hood performance might be affected.

4.3.3.2 Other parameters affecting capture efficiency

Reservoir volume of the hood is determined by its depth and its height. A deeper hood will have a better ability to capture and contain the thermal plume, since it will cover better the surroundings of the cooktop area. However, it has been demonstrated that reservoir volume is not as relevant to hood performance as air velocity (Swierczyna et al, 2006). This is why the use of **baffle plates** –which increase the capture velocity by reducing the opening area of the hood-, has a beneficial effect on hood performance.

4.3.4 Technology areas: range hoods

4.3.4.1 Technology area 1: Fans

Blowers are typically equipped by one of these two types of fans (Figure 100), depending on the dimension and installation of the hood:

- Tangential fan with **two air inlets**. This type of fan can have different dimensions, and thus the hood can reach higher efficiencies, since the efficiency increases with its overall dimension.
- Radial fan with **one air inlet**. Due to the space limitation, under cabinet range hoods or range hoods with small dimensions are usually equipped with this type of fans. For this reason, efficiencies are usually lower.

Figure 100. Illustration of types of fans (APPLIA)

4.3.4.2 Technology area 2: Electric motors

The key component that influences the energy efficiency and the price of the hood is the electric motor. Range hoods are equipped with one of these three types of electric motors: brushless, asynchronous capacitors and asynchronous shaded poles. The main features of these motors are described below:

- **Brushless motors**: they are components of high-end models that can reach energy classes between A+ and A+++. They perform high motor efficiencies, within the range of 70 and 85%. They are smaller and lighter than capacitor or shaded poles motors.
- **Asynchronous capacitor motors**: they are components of middle and high-end models that can reach energy classes between D and A+. They perform lower motor efficiencies than brushless motors, within the range of 55 and 70%.
- **Asynchronous shaded poles motors:** they are components of low-end models whose energy classes are between D and C. They perform the lowest efficiencies, within the range of 20 and 30%, and they are the most economical ones.

4.3.4.3 Technology area 3: Filters

Odour filters

Charcoal filters are usually disposable devices, however there are **long life filters** with a duration of 3 years. The charcoal filter is able to be regenerated by a cleaning and drying cycle every 2 or 3 months. The cleaning is done in the dishwasher at 65 ° or by hand with hot water and a neutral detergent. Then it is dried in the oven at 100 ° for 10 minutes.

A specific type of long life filter is the **ceramic filter.** The charcoal filter is mounted in a ceramic frame and can be thermally regenerated every 2 or 3 months in the oven at 200° for 45 minutes, reaching a maximum of 5 years of lifetime.

Plasma filters are an alternative to carbon filters in recirculating range hoods. As explained earlier, active carbon filters retain cooking fumes particles and need to be replaced when they become saturated. According to manufacturers, plasma filters aim at removing all foreign particles from air by eliminating and not storing them in a filter (which eventually would need to be replaced). This technology, also known as non-thermal plasma (NTP) is a flexible electrical technique for exhaust air treatment. Typical features of an NTP are the acceleration of free electrons in an external electrical field, the formation of activated chemical species by collisions between electrons and gas molecules and chemical reactions of these species with other gas constituents, such as the cooking pollutants.

In a laboratory study, Holzer et al (2018) showed that the model substances as representatives for odorous organic compounds being produced in cuisine processes like roasting, baking and cooking can be completely eliminated by a homogeneous gas phase plasma. However, the relative large contents of CO and O_3 are not acceptable and require further treatment steps. Also, energy efficiency in the laboratory experiments is still too low for practical use, especially when running the system in a continuous mode. These limitations require further investigations.

According to stakeholders, plasma filters might be in disadvantage when compared to other filtering technologies if the standard odour removal test EN 61591 is followed. As indicated in Task 1 of this report, this test is to determine how efficiently the carbon filter stores MEK molecules. This test is not intended for recirculation filters based on plasma and ionization, since they require more time to remove all MEK molecules from air. However, in its inherent process, Plasma filters destroy all MEK molecules (and not store them in a carbon filter). Also according to stakeholders, plasma filters have been used in certain applications of commercial products, where the extraction always is towards the exterior of the building. These filters are not appropriate for domestic environment as issues with Ozone generation may arise.

Grease filters

The basic principle of **centrifugal filters** is the use of centrifugal force for air cleaning. In these range hoods, cooking vapours are sucked through a narrow gap into extractor hood. Once inside, the vapours are accelerated and the flow is diverted in two bends which create centrifugal force. This force hurls fats and oils out of air. A subsequent integrated residue separator removes the finest particles of fat and traps them, allowing the air to escape clean at the end. According to stakeholder feedback, this technology is not common in the Europe and is mostly used in markets with significantly different cooking styles. They also have considerably lower efficiencies than conventional range hoods with filters.

4.3.4.4 Technology area 4: Smart and connected range hoods

A smart range hood is broadly understood as a hood with a built-in Wi-Fi module that can be synchronised with an application managed from a portable device such as a smartphone or tablet. The benefits of a smart range hood are similar to those of a smart oven or hob, and can be summarised as it follows:

- A connected range hood may be **connected to other cooking appliances** such as the hob. When the system detects that food is being cooked, it automatically connects at the required airflow, depending on temperature and other factors. When cooking activity ends, the range hood automatically switches off or remains in idle state.
- A connected range hood may be equipped with sensors that **detect pollutants** and be able to activate automatically to restore air quality in the kitchen. Some models may provide visual information regarding the state of the air and the progressive improvement of environmental conditions as it operates.
- A connected range hood can be **manipulated** from an application on a smartphone or tablet, making it easier for the user to access the functions and basic settings.
- A connected range hood may be also **operated via voice control** devices. While the user is preparing other food in the kitchen, the hob may be turned-off via voice command.
- A connected range hood may let the user know when the grease or activated charcoal **filter** needs cleaning, changing or regenerating, providing tips and instructions on how to change it.
- A connected range hood may send a notification to the user when it detects something is not working properly, and can also be **diagnosed remotely**.

4.3.5 Best Available Technologies

In this section, the Best Available Technologies (BAT) in terms of energy efficiency for domestic range hoods are investigated. Data for this investigation will be taken from TopTen database.

Topten shows the availability of efficient range hoods, according to a criteria set that is regularly updated. Range hoods currently listed are within energy efficiency classes A (< 55), A+ (< 45) and A++ (< 37), and within fluid dynamic efficiencies and lighting efficiencies of A (> 28). The grease filtering efficiencies range from C (> 75) to A (> 95). The energy efficiency classes (coloured dots, left axis) and grease filtering efficiencies classes (grey bars, right axis) of the 137 models listed in TopTen are shown in Figure 101.

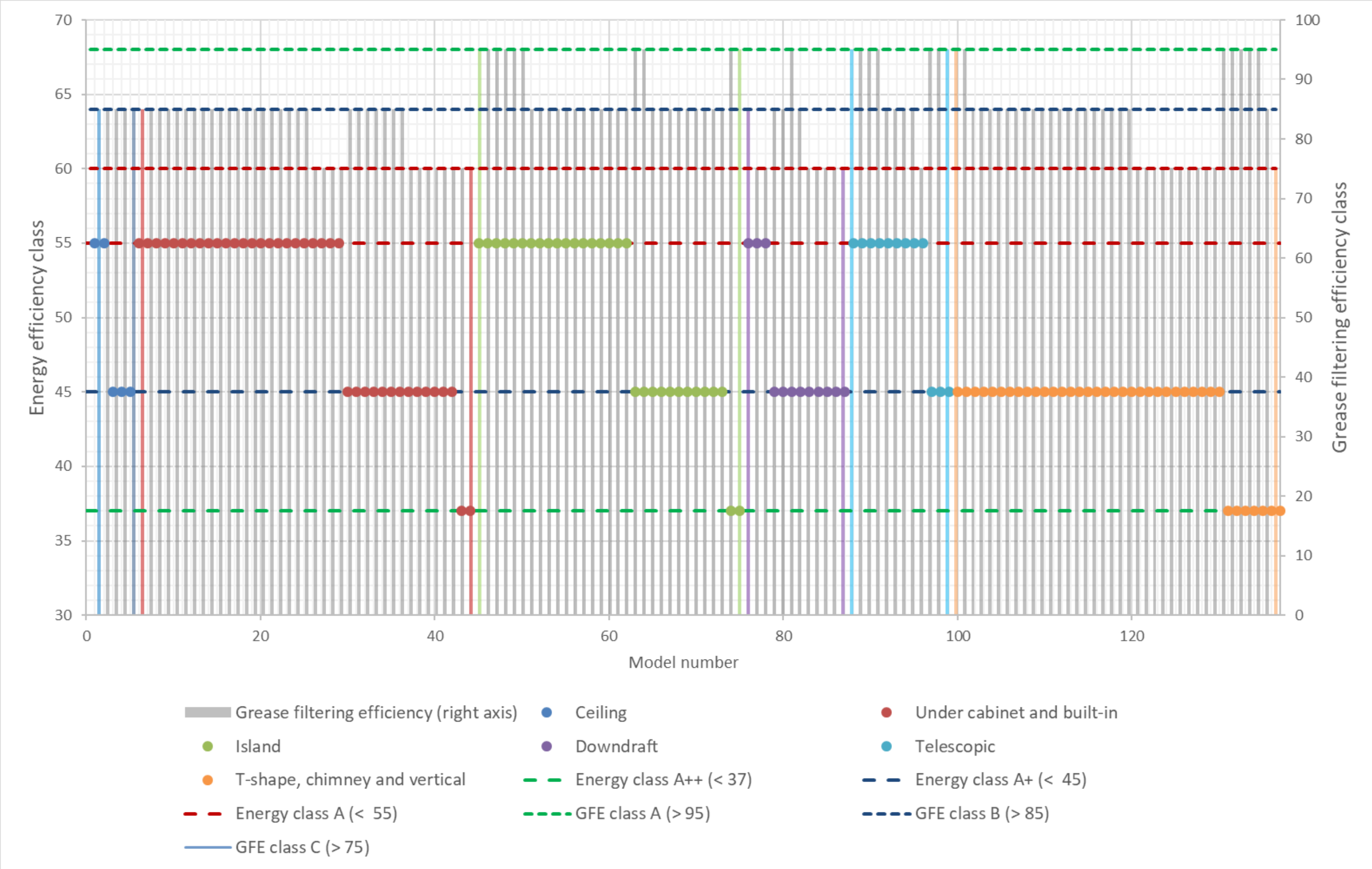


Figure 101. EEI and GFE of range hoods in Topten

As can be observed, 11 models reach the energy class A++, 2 of which are under cabinet or buit-in, 2 island mounted and 7 T-shape or chimney (wall mounted). This contradicts the findings from Task 2, where best performing hoods were worktop vent (downdraft), while under cabinet did not reach good energy classes.

From this set of wall mounted range hoods, 5 models perform grease removal efficiency classes of A. In the case of the most energy efficient under cabinet or built-in hoods, grease removal efficiencies only achieve C class. The two island mounted hoods reach grease removal efficiency classes of A.

4.4 Production, distribution and end-of-life of domestic appliances

Domestic cooking appliances under the scope of this study are products with high energy consumption in comparison to other home appliances. For that reason, from a life cycle assessment perspective, in the previous sections more focus has been put on the analysis of the use stage, which is where energy consumption contributes the most. The significant contribution of the use stage in the life cycle impact is confirmed in scientific literature in the case of ovens (Landi et al, 2018), gas hobs (Favi et al, 2018), induction hobs (Elduque et al, 2014) and range hoods (Bevilacqua et al, 2010).

Despite this preponderance of the use stage, other life cycle stages such as production, distribution and end of life also have their relevance, such as metal depletion potential or marine eutrophication potential (Landi et al, 2018). The relevance of end of life stage is even higher if Circular Economy principles want to be incorporated into future product design.

In this section, aspects affecting production, distribution and end of life are presented. Some of these aspects are product weight and materials, primary scrap production, packaging materials and volumes, means of transport and shipment, product lifetimes and waste material flows.

4.4.1 Aspects affecting production of domestic cooking appliances

4.4.1.1 Product weight and materials

When considering the impact of production and manufacturing, a product Bill of Materials is a key piece of information required to conduct a robust environmental and economic assessment. However, without access to data from manufacturers, it is usually difficult to find data available regarding mass and material breakdown of specific products. Even in LCA or LCC scientific literature, BoMs are usually published partially, providing only breakdown of materials in percentage, number of components, etc. For instance, in Magalini et al. (2017), an average material composition of kitchen appliances is published (Table 38), but it is not clearly specified whether it refers to a cooktop, an oven or an average of those and more kitchen appliances. In some other cases, only a list of materials (without masses or percentages) is provided.

Table 38. Average material composition of cooking appliances (Magalini et al, 2017)

Material	%
Aluminium	1.8
Copper	1.9
Copper + Aluminium	0.01
Electronics	0.51
Glass	14.4
Polyvinyl Chloride	0.19
Stainless Steel	19.5
Steel	54.3
Other plastics	1.7
Other	5.6

In this section, it is presented a summary of data available published in scientific papers regarding material breakdown of cooking appliances (ovens, hobs and range hoods).

A detailed BoM for domestic gas and electric ovens is presented in this section in Table 39 (gas) and in Table 40 (electric). Source of data is Landi et al (2019).

Table 39. Bill of Materials of gas oven (Landi et al, 2019)

kg of material	Cavity	Chassis	Door	Front panel	Hot air fan	Tangential fan	Packaging	Cables	Total
Galvanized steel	1.71	5.58	0.48	0.54	1.16	1.72	0.00	0.01	**11.20**
Enamelled steel	7.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**7.91**
Stainless steel	0.22	0.00	0.17	0.01	0.00	0.00	0.00	0.00	**0.40**
Nickel/Chrome alloy	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.02**
Ferrite	0.00	0.00	0.00	0.00	0.14	0.06	0.00	0.00	**0.21**
Aluminium	0.12	0.00	0.23	0.00	0.00	0.07	0.00	0.00	**0.43**
Glass	0.03	0.00	4.53	0.00	0.00	0.00	0.00	0.00	**4.56**
Glass fibre	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.40**
Rock wool	1.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.63**
Brass	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**
Copper	0.02	0.00	0.00	0.01	0.12	0.08	0.00	0.05	**0.28**
Nylon	0.00	0.00	0.00	0.04	0.02	0.17	0.00	0.00	**0.22**
Polypropylene	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.02	**0.05**
Ethylene vinyl acetate	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	**0.02**
Magnesium	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.09**
Ceramic	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.03**
Glass fibre polyamide	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00	**0.39**
Polystyrene foam	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.00	**0.88**
Polyethylene low density	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	**0.29**
Other plastics	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.11	**0.16**
Total	**12.19**	**5.59**	**5.85**	**0.60**	**1.46**	**2.11**	**1.17**	**0.18**	**29.17**

Table 40. Bill of Materials of electric oven (Landi et al, 2019)

kg of material	Cavity	Chassis	Door	Front panel	Hot air fan	Tangential fan	Packaging	Cables	Total
Galvanized steel	0.97	5.63	0.48	0.26	1.02	1.72	0.00	0.01	**10.10**
Enamelled steel	8.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**8.82**
Stainless steel	0.41	0.00	0.17	0.45	0.00	0.00	0.00	0.00	**1.03**

Nickel/Chrome alloy	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.05**
Ferrite	0.00	0.00	0.00	0.00	0.13	0.06	0.00	0.00	**0.19**
Aluminium	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	**0.23**
Glass	0.03	0.00	4.53	0.00	0.00	0.00	0.00	0.00	**4.56**
Glass fibre	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.40**
Rock wool	1.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.63**
Brass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Copper	0.00	0.00	0.00	0.01	0.10	0.08	0.00	0.00	**0.19**
Nylon	0.00	0.00	0.00	0.05	0.01	0.17	0.00	0.00	**0.23**
Polypropylene	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	**0.02**
Ethylene vinyl acetate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Magnesium	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.20**
Ceramic	0.04	0.00	0.00	0.01	0.00	0.00	0.00	0.00	**0.05**
Glass fibre polyamide	0.00	0.00	0.39	0.04	0.00	0.00	0.00	0.00	**0.43**
Polystyrene foam	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Polyethylene low density	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	**0.29**
Other plastics	0.00	0.00	0.06	0.03	0.00	0.00	0.84	0.11	**1.04**
Total	**12.55**	**5.63**	**5.85**	**0.87**	**1.26**	**2.03**	**1.13**	**0.12**	**29.44**

In Favi et al (2018), a BoM is provided for gas and induction hobs. A list of assemblies, components, quantities and materials is provided for both types of hobs. No mass data is presented. Table 41 contains data on gas hobs and Table 42 on induction hobs.

Table 41. Bill of Materials of gas hob (Favi et al, 2018)

Assembly name	Component name	Quantity	Material
Hob grill	Grills	2	Carbon Steel
	Rubber feet	8	Synthetic rubber (EVA)
Flame spreaders	Ausiliario	1	Aluminium alloy
	Semirapido	2	Aluminium alloy
	Rapido	1	Aluminium alloy
Caps	Ausiliario	1	Carbon Steel
	Semirapido	2	Carbon Steel

	Rapido	1	Carbon Steel
Main bodies	Ausiliario	1	Aluminium alloy
	Semirapido	2	Aluminium alloy
	Rapido	1	Aluminium alloy
Gas taps	Main body	4	Aluminium alloy
	Valve body	4	Copper
	Nut	4	Brass
	Bottom brackets	4	Aluminium alloy
	Screw TORX M4x8	16	Carbon Steel
	Cable clips	4	PA (Nylon)
	Tap brackers	4	Carbon Steel
Thermocouples	Probe	4	Chrome (90%Ni - 10%Cr)
	Body	4	Copper
	Cables	4	Wire (Copper). Insulation/Jacket (PVC)
Spark plugs	Spark plug	4	Ceramic
	Cables	4	Wire (Copper). Insulation/Jacket (PVC)
	Spring	4	Carbon Steel
Metal plate	Plate	1	Stainless Steel
	Screw TORX M4x8	8	Carbon Steel
	Caps	6	PA (Nylon)
	Plate protection	1	Carbon Steel
	Brackets	4	Carbon Steel
	Screw M2.9 x 16	8	Stainless Steel
Knobs	Knobs	4	Acrylonitrilebutadiene-styrene (ABS)
	Reinforcement	4	Carbon Steel
	Metal inserts	4	Aluminium alloy
	Rubber feet	4	Synthetic rubber (EVA)
Piping	Main hose	1	Carbon Steel
	Screw TORX M4x8	3	Carbon Steel
	Rapido hose	1	Aluminium alloy

	Semirapido hose	2	Aluminium alloy
	Ausiliario hose	1	Aluminium alloy
Electric cables	Electric cable	1	Wire (Copper). Insulation/Jacket (PVC)
	Bands	1	PA (Nylon)
	Transformer cable	2	Wire (Copper). Insulation/Jacket (PVC)
	Transformer	1	Different materials

Table 42. Bill of materials of induction hob (Favi et al, 2018)

Assembly name	Component name	Quantity	Material
Glass-ceramic top	n/a	1	Glass-ceramic
Support brackets	n/a	7	Stainless Steel
Bottom plane	n/a	1	Carbon Steel
Electronic board housing	n/a	1	Polypropylene (PP)
Touch screen housing	n/a	1	Polypropylene (PP)
Cable connection	n/a	1	Polypropylene (PP)
Cooling fan	n/a	2	Various materials
Main coil (210 mm)	Electrical insulator top sheet	1	Potassium Aluminium Silicate (Mica)
	Springs	2	Aluminium Alloy
	Sensor	1	Aluminium Alloy
	Diode	1	Diode
	Coil	1	Copper
	Cables	2	Wire (Copper). Insulation/Jacket (PVC)
	Plastic support	1	Low density polyethylene (LDPE)
	Ferrite elements	8	Ferrite
	Electrical insulator bottom sheet	1	Potassium Aluminium Silicate (Mica)
	Bottom cover	1	Aluminium Alloy
Medium coils (180 mm)	Electrical insulator top sheet	1	Potassium Aluminium Silicate (Mica)
	Springs	4	Aluminium Alloy
	Sensor	2	Aluminium Alloy
	Diode	2	Diode
	Coil	2	Copper

	Cables	4	Wire (Copper). Insulation/Jacket (PVC)
	Plastic support	2	Low density polyethylene (LDPE)
	Ferrite elements	16	Ferrite
	Electrical insulator bottom sheet	1	Potassium Aluminium Silicate (Mica)
	Bottom cover	2	Aluminium Alloy
Small coil (140 mm)	Electrical insulator top sheet	1	Potassium Aluminium Silicate (Mica)
	Springs	1	Ceramic fibres
	Sensor	2	Aluminium Alloy
	Diode	1	Aluminium Alloy
	Coil	1	Copper
	Cables	1	Wire (Copper). Insulation/Jacket (PVC)
	Plastic support	1	Low density polyethylene (LDPE)
	Ferrite elements	6	Ferrite
	Electrical insulator bottom sheet	1	Potassium Aluminium Silicate (Mica)
	Bottom cover	1	Aluminium Alloy

In Elduque et al (2014), a detailed BoM of the electronic components of an induction hob is provided. Table 43 contains data on the electronic induction printed circuit board assembly located on the left (ELIN LPCBA) and on the right (ELIN RPCBA) of the appliance. Table 44 contains data on the touch control printed circuit board assembly (TC PCBA).

Table 43. BoM of left and right PCBAs (Elduque et al, 2014)

	ELIN LPCBA		**ELIN RPCBA**	
Component	**Units**	**Total mass (g)**	**Units**	**Total mass (g)**
Electrolyte capacitor	9	18.36	6	5.43
Film capacitor	28	126.37	26	134.40
0402 capacitor	50	0.06	48	0.05
Diode	8	32.36	5	31.23
Inductor ring core	4	188.90	3	179.32
Relay	3	34.35	2	22.84
Transformer	3	25.05	2	12.25
0402 Resistor	60	0.03	73	0.04
Total		425.48		385.56

Table 44. BoM of touch control PCBA (Elduque et al, 2014)

Component	Units	Total mass (g)
SMD resistor 0603	79	0.15
SMD capacitor 0603	52	0.28
SMD transistor	28	0.24
8 segment display	6	4.50
IC logic	5	0.51
IC memory	2	0.11
Total		5.79

Up to date, no Bill of Materials has been found in scientific bibliography regarding range hoods. The closest data to a BoM is published in Bevilacqua et al (2010), where a list of materials present in a domestic range hood is shown (Table 45). No mass data is provided.

Table 45. List of materials in domestic range hood (Bevilacqua et al, 2010)

Materials in domestic range hood
Steel
ABS-PP
EPS
Cardboard
Electronic board
Glass
Aluminium

4.4.2 Aspects affecting transport of domestic cooking appliances

As already seen in previous sections, the main environmental impact of cooking products is during the use phase. In comparison, transport and packaging tend to have a low environmental impact in these products. For information on transport activities, manufacturers tend to provide information in their annual sustainability reports.

4.4.2.1 Packaging materials

Typical packaging materials in the domestic cooking appliances industry are cardboard, wood, EPS, foil and paper. According to a stakeholder, for 3 different ovens, volume of packaged products are as in Table 46.

Table 46. Volume of packaged oven

	Oven 1	Oven 2	Oven 3
Capacity of oven (litres)	70	50	70
Volume of oven (m3)	0.22	0.16	0.31
Volume of oven with packaging (m3)	0.34	0.27	0.47

In terms of built-in hobs, the volume of packaged products are as in Table 47.

Table 47. Volume of packaged built-in hob

	Hob 1
Number of cooking areas	4
Volume of hob (m3)	0.02
Volume of hob with packaging (m3)	0.05

In terms of wall range hoods, the volume of packaged products are as in Table 48.

Table 48. Volume of packaged range hood

	Range hood 1	Range hood 2
Volume of range hood (m3)	0.21	0.31
Volume of range hood with packaging (m3)	0.32	0.49

4.4.3 Aspects affecting end of life of domestic cooking appliances

4.4.3.1 Critical parts and failures in domestic cooking appliances

The study conducted by Evans et al (2015) for the European Commission had as a purpose to identify priority products and develop a method to measure their durability; and to estimate the benefits and costs of more durable products. A remarkable list of definitions of the concept of durability is provided in this study.

In European product policy, durability is usually addressed by the provision of spare parts for around 10 years after then end of production of an appliance to enable appropriate repair. When addressing durability –or lifetime- of products in product policy, it is essential to have data on which are the key critical components in terms of failures.

Domestic ovens are appliances which make use of critical components to deliver their main function, which will be subject to abrupt temperature variations. It has been proved difficult to find reliable figures regarding the reasons that domestic ovens fail or need repairing. In Evans et al (2015), an analysis of the critical components failing in an oven is conducted for domestic ovens. Data provided by Which and UK Whitegoods -consumer organisations in United Kingdom- and UK retailer repair records, there are little differences between built-in and free-standing cookers/ovens. These are appliances generally reliable and not prone to breaking down or developing faults. The most common problems in domestic ovens are in:

- Failure of fan. These components are prone to failure since they are subject to stress of quick heating and cooling.
- Failure of thermostat, the most probable cause being oven overheating.
- Light not working
- Dials or controls not working, potentially due to faulty thermostat or thermal fuse
- Door not closing properly, potentially due to failure in sealing, rollers or hinge runners. This may cause uneven cooking, higher energy use and damage to adjacent units.
- Oven cutting out after being ON for a while
- Noise, potentially due to moving parts being misaligned or due to bearing failures
- Glass door breaking, potentially due to overheating or the presence of temperature differentials
- Handles breaking

In the mentioned report, some data is provided regarding frequency of failure and main components requiring attention. However, this data needs to be taken with caution as figures do not seem consistent between them.

Table 49. Percentage of appliances recorded with each type of fault

(Which, published in Evans et al (2015)

Fault	Built in oven	Free standing oven
Light not working	32%	9%
Door not closing properly	8%	9%
Dials/controls broken	7%	12%

Table 50. Percentage of appliances recorded with each type of fault

(UK Whitegoods, published in Evans et al (2015)

Component	Percentage of appliances with fault in component
Thermocouples	8%
Knobs and controls	6%
Thermostats	3%
Door gaskets or seals	4%
Hotplates	4%
Heating elements	2-3%
Selection switches	2-3%
Glass lid assembly	2-3%
Hinges	2-3%

According to a manufacturer, they have no reliable data available about the most frequent occurring failures and defects, as they do not receive repair information over the entire usage lifetime of the appliances. Repair of appliances is performed by the manufacturer within the legal guarantee period. After that, repairs are mostly conducted by independent professional repairers.

The same manufacturer highlights it is part of their core business to extend lifetime of product as much as possible, also through repair. They develop appliances with the aim of longevity and durability. Cooking appliances are appliances which are typically used for a long time. These appliances are not fashion or trend related. In principle every failure/defect can be repaired. The decision for repair lays by with the end-user. In terms of the most common failures in components for ovens, hobs and range hoods, their feedback is:

- **Ovens**: a very wide variety of technologies is used. From very basic models up to highly complex appliances with integrated microwave and/or steam function with TFT displays and Wifi connection (e.g.). Therefore, any general recommendation about most failing components cannot be made.
- **Hobs**: as there are many hob technologies available (radiant, gas, induction) and different solutions are offered within one technology, a general answer about occurring failures/defects cannot be given.
- **Range hoods**: the main recurrent complaints are "the appliance is too loud" and "does not evacuate well". In most of the cases this is due to incorrect installation.

4.4.3.2 Product lifetime of domestic cooking appliances

Lifetime of a product ends when it is replaced by another product that takes over the original application. A concept directly related with this is durability, understood as the ability of a product to endure to its lifetime. Regarding lifetime of domestic cooking appliances, there is a significant lack of data available in the form of scientific research or national/regional statistics. There is consensus in the fact that life expectancy of typical appliance depends to a great extent on the use it receives. Also in the fact that nowadays appliances are often replaced long before they are worn, since changes in styling, technology and consumer preferences make newer products more desirable. According to a study conducted by Bank of America (2007), the average life expectancy for cooking appliances is:

- Electric Oven with hob: 13 years
- Gas Oven with hob: 15 years
- Range hoods: 14 years

More recent research conducted for the development of previous Ecodesign regulation on cooking appliances (Mudgal et al, 2011a; 2011b) provides data as well on expected lifespan of domestic cooking appliances (Table 51).

Table 51. Product lifetime for cooking appliances (Mugdal et al, 2011)

(Lot 23, Task 3, p21; Lot 22, Task 3, p30)

Appliance	Lifetime average (years)
Domestic electric hobs – solid plates	19
Domestic electric hobs - radiant	19
Domestic electric hobs – induction	15
Domestic gas hobs	19
Electric ovens	19
Gas ovens	19

In their Annual Energy Outlook, the EIA (2019) provide slightly different lifetime ranges (minimum and maximum) for different household appliances, including domestic ones (Table 52).

Table 52. Product lifetime for cooking appliances (EIA, 2019)

Appliance	Lifetime range (years)
Natural gas and propane cooking ranges, cooktops and ovens	9 – 15
Electric cooking ranges, cooktops and ovens	10- 20

According to a manufacturer, there is no reliable data available on product lifetime of domestic cooking appliances. Their internal testing shall ensure a minimum lifetime of 10 years, but there are appliances in households which are much older. The lifetime depends on the usage and maintenance of the appliances. It is their experience that maintenance is a bigger concern for cooking appliances than for dishwashers, for instance. Maintenance is a bigger concern for range hoods, especially related to filter cleaning and changing. A commonly accepted average lifetime they highlight is 19 years for ovens and hobs.

4.4.3.3 Trade-off between durability and efficiency in the use phase

There is a clear relationship between the durability of a product, the resources consumed and the emissions generated during its lifetime. In the specific case of electrical and electronic appliances, extending product life is considered an effective means to contribute to resource conservation: fundamentally materials and energy. In principle, with extended lifetimes of products, fewer appliances will have to be produced to cover consumer demand. However, there is a trade-off that needs to be taken into account, which is the potential savings achieved in the production/manufacturing stage versus energy consumed during the use phase (Truttman et al, 2006). According to several authors, extending lifetime – also referred to as 'reuse' end of life strategy in literature review, should not be an a-priori goal-oriented strategy, but analysed case by case. In this line, there are certain factors related to the practical limits on lifetimes that need to be taken into account:

- A very durable product may have cost implications in terms of changes to materials, components and manufacturing processes
- Innovation rates in certain markets may cause that extended lifetime products become quickly obsolete
- Consumer buying habits and expectations may divert them from very durable products
- Durable products may have a negative effect on the product's potential second life

The environmental performance of end of life strategies which consider extended lifetime of products has not been widely covered in scientific research. Studies addressing the potential benefits of reuse and remanufacturing of products has been limited to a small number of papers published over the past three decades, according to Zanghelini et al (2014). Some of this research is summarised in this section.

In Truttman et al (2006) the authors investigated the potential benefits of reusing –extending lifetime- of several home appliances (refrigerator, washing machine, dishwasher, microwave, PC, video, monitor and TV), taking into account use of materials and energy consumption. In terms of materials, it was observed that increasing product lifetime by a factor of 1,5 decreased all material flows in the system by the same factor. However, these factors were based on assumptions, and different values should be considered for different types of products and substances. Also regarding materials, the authors analysed the potential benefits of extending lifetime versus the benefits of improving recycling efficiency. They observed that material use is more sensitive due to changes in recycling efficiency. Even doubling product lifetimes could be offset by comparably small losses of 10% in the recycling efficiency. In terms of energy consumption, the authors observed that around 10% less energy is consumed in extended-life scenarios. However, the benefits in energy use were very different between appliances: higher benefits were obtained in PCs and washing machines and lower in videos and monitors.

Along similar lines, in Tasaki et al (2013) the authors refer to parameters which may have an influence on the potential benefit of extending lifetime of a product or replacing it by a more efficient one, such as size of the two products (the old one and the new one), their function, the patterns of use and the time of replacement. According to their findings, whether product replacement is preferable from the viewpoint of reducing energy consumption depends substantially on how often a consumer uses the product and the characteristics of the particular replacement product. As specific examples, they indicate that replacement of refrigerators after 8-10 years of use is preferable, even if the replacement product is larger. On the contrary, the replacement of TVs tends to be not preferable if it is not used often or if the consumer replaces it by a larger one (which tends to be the case).

Specifically on cooking appliances, in Iraldo et al (2017) an analysis was carried out to understand the potential benefits of durable ovens. Two scenarios were defined for that purpose: a scenario where a Product A was substituted by a more energy efficient Product B after a certain period of time; and a scenario where Product A was not substituted and was being used for an extended period of time, as described in **Figure 102**.

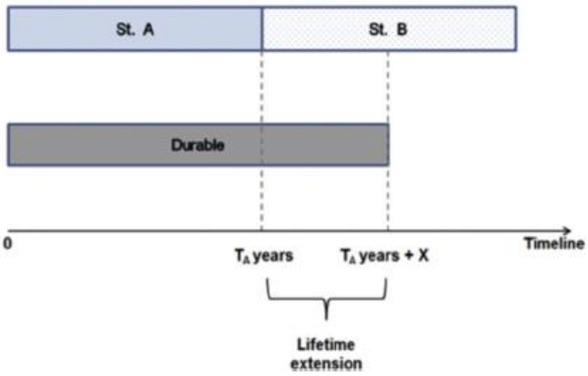


Figure 102. Product substitution versus product durability (Iraldo et al, 2017)

Results from this study –using data from available scientific literature- showed that the durable option had lower environmental impact in four impact categories. In the rest of impact categories analysed, if a certain energy efficiency improvement (energy efficiency threshold) is achieved in Product B, replacing the Product A by Product B is preferable than maintaining Product A by a longer period of time. In **Figure 103**, these energy efficiency improvement thresholds are presented.

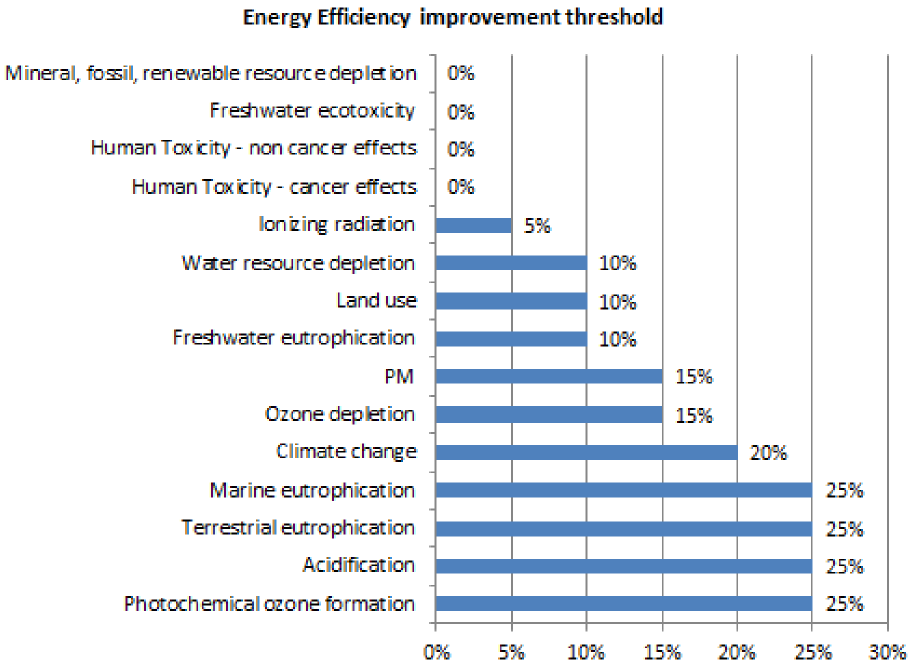


Figure 103. Energy Efficiency improvement threshold in domestic ovens (Iraldo et al, 2017)

Essentially, for the impact categories whose significant contribution comes from production and end of life, the durable option is always preferred, even with improvements in energy efficiency. However, for most of the impact categories, a small improvement in the energy efficiency of the replacement product is sufficient to deliver environmental benefits by substituting the product. For instance, in the case of climate change, if the new oven (Product B) is 20% more energy efficient than Product A, it is preferable to substitute it than to extend its lifetime.

4.4.3.4 Product design in relation to durability and reparability

In terms of reparability of domestic cooking appliances specifically, there is little data regarding the habits of consumers or on the number and success of repairs performed in this sector. There is also limited information regarding the disassembly and reassembly properties (key aspects in reparability) of home appliances in general. Related to this topic, Dindarian et al (2012) investigate quality and costs of remanufacturing microwaves and propose design changes based on that. Some of their recommendations, which may be applicable to domestic cooking appliances such as ovens, hobs and range hoods, are:

- Reduce the complexity of how printed circuit boards are assembled
- Facilitate the access to internal parts
- Redesign how key component are fitted to make them more accessible
- Change painting characteristics to make it more durable
- Change the design of mains cables and plugs to make them removable or interchangeable
- Reduce the number of different designs of mechanical parts to make them more interchangeable

Along the same lines, using a sample of 749 units of small household WEEE, an analysis of the current situation in terms of their disassembly properties and material characterisation was conducted in Bovea et al, 2016b. It was observed that the most problematic aspects regarding disassembly in small WEEE were easiness of material identification and easiness of separation of individual components. Some of the joints used needed to be broken in order to disassemble them; whereas others required two people to avoid having to break them. In order to improve the reparability of these appliances, the authors recommended reducing the number and variety of types of joints, along with the utilization of more intuitive snap-fits, clips or sliding connections. These recommendations are also applicable in the case of large domestic appliances such as ovens, hobs and range hoods.

When a consumer needs to repair their faulty appliance, one of the options is to get in touch with the manufacturer. According to data collected from members of APPLIA, 81% of the requests to manufacturers for a repair of a product resulted in an actual repair in 2016. The breakdown of costs of repair activities in large home appliances can be seen in **Figure 104**.

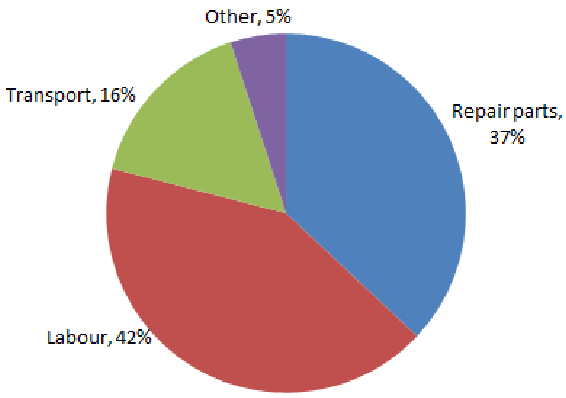


Figure 104. Cost breakdown for repair activites in large home appliances (APPLIA, 2018)

As it can be observed, the most significant contribution to the cost of repair is related to labour. A product design with a view on reparability and disassembly has the potential of reducing significantly time and energy spent in repairing the appliance, as well as in the capacity of recovering valuable materials at end of life. Barriers for reusability and reparability of home appliances have already been addressed in Task 3 of this report.

In terms of the technical benefits of repairing domestic cooking appliances, no data has been found on the topic. On their analysis on home appliances, Hennies et al (2016) indicate that when a washing machine has taken place, its lifespan is significantly higher by 2 years. The authors also observed that the more expensive the washing machines, the more times they are repaired across their lifetimes, potentially because they last longer or because the cost of the repair relative to the cost of acquisition is lower. Repairs due to early failures in appliances under warranty period are very rare (5%). They also recommend that increasing the awareness of environmental factors could change the attitudes of consumers and push the market economy in a direction towards a more sustainable lifespan.

On reparability, a manufacturer indicated they can support the approach with respect to spare part availability for professional repairers and end-users, as for washing machines, washer-dryers, dishwashers and refrigerating appliances in their revised eco-design regulations. This can be implemented for domestic ovens, hobs and range hoods. The specific content of the requirements for these appliances should be discussed with industry.

4.4.3.5 Material flows and collection effort at end-of-life

In Magalini et al (2017), data is presented regarding home appliances waste in general. It is reported that home appliances waste is mostly made up of:

- Electrical and Electronic Waste (WEEE)
- Packaging Waste, mainly in distribution phase
- Batteries, particularly for small home appliances

Considering all size home appliances, it can be observed that WEEE flows are steadily increasing (Figure 105), for a total of 5 million tonnes in 2016 (30% increase in 9 years). It is estimated that nearly 50% of that mass corresponds to large home appliances (where ovens, hobs and range hoods are accounted).

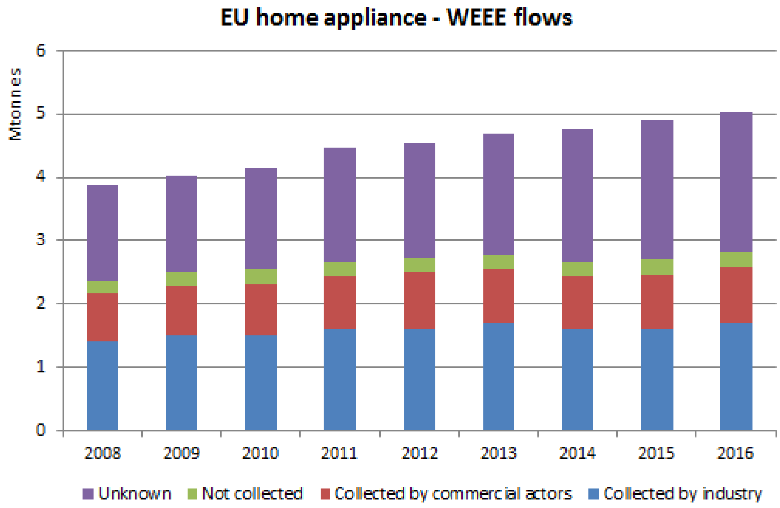


Figure 105. Home appliances WEEE flows

Four main streams are identified for home appliances waste:

- Collected by industry
- Collected by commercial actors
- Not collected
- Unknown

In 2016, only 34% of the total was actually collected by the home appliance industry. The reason for this low amount is related to the high metal content of this waste stream and the presence of a mature recycling industry even before WEEE Directive was implemented. Commodity prices play a fundamental role in how home appliances are collected and treated. This causes that a large share of this waste is handled by commercial actors, outside of the industry-driven recycling schemes. Appropriate tracking mechanisms are still not in place, as a significant 44% of the home appliances waste destination is currently unknown. The remaining 5% is not collected separately in any form, therefore can be considered as sent to landfill.

In terms of materials, steel is the material which is recovered the most for large, small and cooling/freezing appliances (Figure 106). Approximately 0.15 million tonnes of concrete are recovered from large home appliances, presumably from built-in devices. Plastics, copper, aluminium and glass are other materials with significant presence in this waste stream.

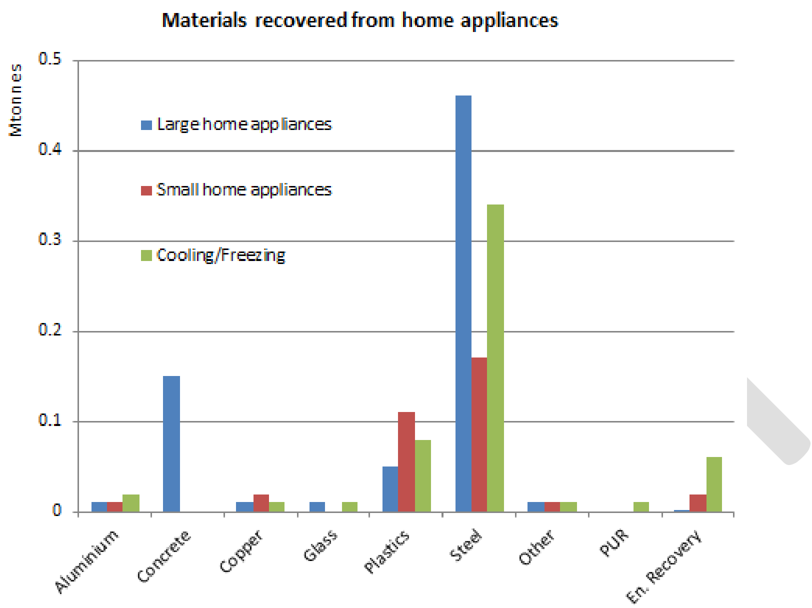


Figure 106. Materials recovered from home appliances waste

Based on the figures above, adapted from Magalini et al (2017), an analysis of material flows of home appliances is conducted for a given year (Figure 107).

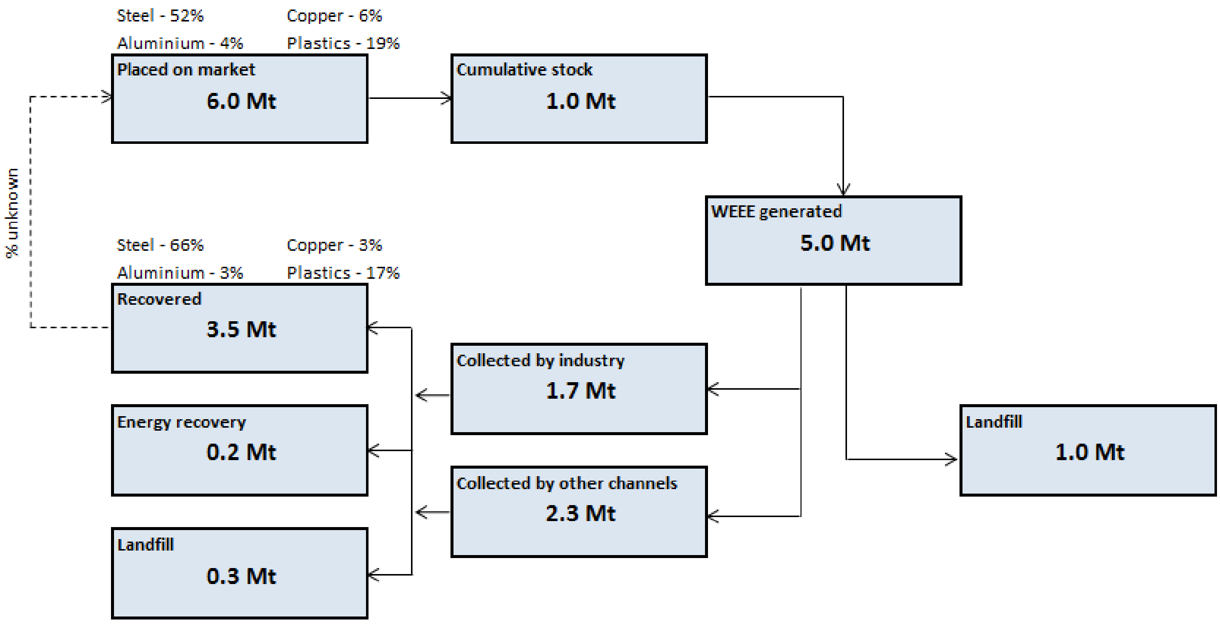


Figure 107. Analysis of materials flows, using data from Magalini et al (2017)

Every year, 6 Mt of home appliances are placed on the market in the EU and 5 Mt exit the households in the shape of WEEE. Therefore, the cumulative stock of home appliances in European households is approximately 1 Mt every year. Circa 4 Mt of this WEEE are collected, either by industry (43%) or by other channels (57%). From this amount of collected material, around 3.5 Mt is actually recovered, mainly as Steel (66%) and Plastics (17%). These recovered materials may be used again to produce new home appliances (% unknown) or in other industries. Material not recovered is either used for energy recovery (0.2 Mt) or lost –assumed as landfill- (0.3 Mt).

4.5 Recommendations

4.5.1 Ovens

- There is a limited improvement potential in conventional ovens with convection and fan force functions. Ovens with steam function are the ones that reach higher energy classes.
- Microwave function could potentially reduce the energy consumption, however, there is not test method available to quantify the effect of the microwave function in a heating cycle

4.5.2 Hobs

- There is still a limited differentiation in terms of energy efficiency which prevents the introduction of energy labelling measurers.
- Improvement developments are only apparent in induction technologies, while there is a potential reduction of energy consumption for solid plate hobs (and some radiant hobs) by replacing the switch control to energy regulator control.

4.5.3 Range hoods

- There is a significant improvement potential related to the type of electric motors of the blower. Brushless motors are more efficient and are able to reach the highest efficiencies, however, they are the most expensive and therefore, they are currently only present in high-end models.
- The type of fan used in the blower plays a role in the energy efficiency of the range hood, however, it is often limited by the space available to install the range hood.

Annexes

- **Ecodesign Directive version 2.0 – from energy efficiency to resource efficiency by Bundgaard et al.**

Bundgaard et al. (2015) reviewed in their study "Ecodesign Directive version 2.0 – from energy efficiency to resource efficiency" in total 23 currently adopted implementing measures and voluntary agreements under the Ecodesign Directive, criteria for resource efficiency in voluntary instruments such as ecolabels and Green Public Procurement as well as recent Commission projects with regard to implementation of resource efficiency aspects into the Ecodesign Directive.

In the study, Bundgaard et al. generally subsume under "resource efficiency" the following measures:

- Reducing materials and energy use in the entire life cycle of products (mining of materials, production / use / final disposal of the product)
- Improving possibilities for maintenance and repair (e.g. guidelines)
- Ensuring re-use or redistribution, i.e. multiple use cycles.
- Increasing the potential for remanufacturing or refurbishment of the product, i.e. multiple use cycles (e.g. improving reparability, access to spare parts)
- Improving recyclability of materials used in the product

The review of existing instruments revealed that resource efficiency is already widely applied in voluntary instruments covering energy related products. The instruments include following criteria which were also assessed by the study team with regard to their transferability to the Ecodesign Directive (Bundgaard et al. 2015):

Declaration and threshold of RRR ratio (reusability, recyclability and recoverability)

According to Bundgaard et al. (2015), transferring declaration and threshold requirements with regard to RRR ratio to the implementing measures and voluntary agreements of the Ecodesign Directive first needs a common methodology to be developed on how to calculate the RRR ratio for products and materials to verify the requirements based on technical information provided by the producers.

However, setting requirements for the RRR ratio of the material or the product only reflects the theoretical potential and will not ensure that the materials or products are in fact reused, recycled or recovered which depends on the infrastructure for collection and treatment and the technologies available.

In case of future requirements to RRR ratio it is recommended to make them according to the waste hierarchy, by prioritising reuse before recycling, and recycling before recovery.

Declaration and/or threshold of recycled content

According to Bundgaard et al. (2015), setting criteria for the threshold of recycled materials can help create a market for these materials. The environmental benefits of using recycled materials would depend on the type of material. However, before transferring these requirements to the Ecodesign Directive, it is important to assess if the manufacturers of recycled materials can handle the increase in demand that a requirement would create. A possibility could be to begin by setting declaration requirements and then tightening them continuously by setting threshold requirements.

Setting criteria for recycled materials, however, first needs reliable technologies for an analytical assessment of the recycled content in the products to enable verification and market surveillance.

Bill of materials (BOMs)

BOMs are an important source of information to conduct LCAs, assess the product's recyclability, recoverability and recycled content and identify priority resources in the product to ensure their reuse and recycling; all of these activities are the basis for other requirements to improve resource efficiency.

However, Bundgaard et al. (2015) conclude that due to the complexity of the supply chain of electronic and electrical equipment, a mandatory requirement on providing BOMs would be especially challenging to comply for small producers, as they might not have the ability to force these requirements on to their larger suppliers. Further, the implementation of such a requirement might first need the setup of a system that can ensure the companies' property rights, e.g. with regard to the use of rare metals.

Identification of plastic components

Marking of plastic components according to ISO 11469 shall help recyclers identifying different plastic types and parts to ensure correct handling during waste recovery or disposal, when the plastic parts are manually sorted. Also, the visual marking of plastics parts according to certain ISO standards might be quite easy to verify visually by market surveillance authorities when dismantling the product.

On the other hand, there are certain drawbacks shown by the literature research of Bundgaard et al. (2015): A certain percentage of the labels were found to be incorrect and, mainly, for automatic sorting (currently the large majority of treatment) systems the ISO labels had no effect as these systems sort according to the plastic's mechanical, optical and electrostatic properties.

Thus, Bundgaard et al. (2015) recommend that before setting criteria for visual marking of plastics in the Ecodesign Directive it should be further examined to what extent the waste is manually sorted for the product group in question, and how the future waste treatment of the product might look like. Furthermore, alternative marking methods should be examined (e.g. Radio Frequency ID), which could be applied for example in automatic sorting systems.

Contamination of materials / plastics

Requirements regarding contamination of materials are relevant for the recyclability, as the potential for recycling is reduced if incompatible materials are combined, e.g. painting, coating or metallizing large plastic parts making them not compatible with recycling. Depending on the specific requirement, it could be verified visually.

Mono-materials

Using compatible or a reduced number of plastics can improve the recyclability of e.g. thermoplastics, as a mixture of different polymers or a contamination of the plastic fractions can significantly decrease the plastics properties and thereby the use of the recycled materials.

Bundgaard et al. (2015) recommend that setting these types of requirements should be supplemented with a dialogue with the stakeholders from the recycling industry to ensure the effectiveness of these types of requirements which depends on the recycling system that the products enter into.

Efficient use of materials during the use phase

For washing machines, the Ecodesign Regulation 1015/2010 sets specific Ecodesign requirements with regard to the water consumption. For dishwashers, no such requirement is in place. According to Bundgaard et al. (2015) an example of Ecodesign requirements within this category could be to set a requirement to an automatic detergent dosing system for washing machines avoiding over-dosage and overconsumption of detergents. Several manufacturers have already such systems in place, based on the use of liquid detergents. Some manufacturers require the use of a specific detergent, while others can adapt to different detergents. None of them offers currently the option of using powder detergent, as it is more prone to clogging and requires more maintenance. Therefore, two liquid containers are necessary for cycles where bleaching is required, making the system more complex. This limits also the usability of the system for the cycles where powder detergent is necessary, or recommended, including during testing.

Durability requirements (incl. extended warranty, upgradability and repair, spare parts, modularity)

All criteria strive to extend the lifetime of the product thereby preventing electronic waste. Durability is also related to the previous category disassembly, where criteria targeting easy disassembly for repair and upgradability were included.

The length of the warranty should be product specific and it is also strongly related to the availability of spare parts, which is also an issue for reparability. Determining how long spare parts should be available taking into account both economic and resource efficiency aspects: On one hand components should be available to enable repair, but on the other hand the risk is that a too large inventory of components will be out-dated and never utilized. Modular design and easy disassembly enable upgrading and repair and are thus prerequisites for lifetime extension. Upgradability can potentially reduce the frequency of replacement against the background of rapid technological product developments.

Bundgaard et al. (2015) conclude that durability should be included as possible resource efficiency requirements in the Ecodesign Directive, also due to the requirements being possibly verifiable by market surveillance authorities. However, it is important to ensure that prolonging the lifetime of the product is the environmentally best solution in a life cycle perspective, e.g. that possible environmental benefits are not evened out by increased energy consumption of the older product compared to a new more energy efficient product.

Easy disassembly

Easy or manual disassembly can help improve reparability and upgradability of the product improving the durability of the product. Criteria might be detailed with regard to the components to be separated, the type of connections or the tools to be used.

Regarding end-of-life treatment, Bundgaard et al. (2015) conclude that it is not possible based on the finding of their study to assess whether or not requirements for manual disassembly will improve the recyclability and recoverability of electrical and electronic equipment in the future. This is due to the reason that manual disassembly in the waste treatment process of electrical and electronic equipment (EEE) is increasingly being replaced by automatic or destructive disassembly in many developed countries which questions if requirements for easy or manual disassembly will improve the recyclability and recoverability of EEE if they are fed into an automatic or destructive disassembly system. However, manual disassembly is still performed when economically feasible, e.g. components or materials containing valuable resources, or when Regulations such as the WEEE Directive require it, e.g. by removal for separate treatment of components containing hazardous substances. Bundgaard et al. (2015) propose requirements in addition to manual disassembly which might target automatic or destructive disassembly, however, without further specifying this proposal.

Waste from manufacturing

By including requirements to the manufacturing, the scope would be expanded from a product focus towards a production focus which is applicable to the Ecodesign Directive which mainly sets requirements to the design of the product, however targeting the environmental performance of the entire product life cycle. Therefore, design requirements to the product that might improve the manufacturing process would be highly relevant. However, as many electronic products are produced outside Europe, it might be difficult to enforce these criteria. (Bundgaard et al. 2015)

Further requirements

Further requirements on hazardous substances, take-back schemes and packaging identified in voluntary instruments such as ecolabels are not recommended to be transferred to the Ecodesign Directive as there are rather large overlaps with existing legislations such as REACH and RoHS, WEEE and the European Directive on packaging and packaging waste.

Information requirements related to resource efficiency

With regard to information and specific requirements targeting resource efficiency in Ecodesign, Bundgaard et al. (2015) recommend in their study the following:

- Information and specific requirements on durability (e.g. on lifetime of the product as for lamps, or for components, such as minimum loading cycles for batteries in computers)
  - Relevant for consumers to enable them selecting the most durable product.
- Information requirements with regard to resource consumption in the use phase
  - Relevant for consumers: e.g. to stipulate consumers choosing the most efficient programmes in terms of energy and water consumption and the best suitable detergents.
- Information requirements on hazardous substances, precious metals or rare earths
  - Relevant for recyclers to a) avoid contamination of the materials when they are recycled or b) ensure a more optimal recovery of precious materials.
- Information relevant for disassembly, recycling or disposal at end-of-life
  - Relevant for end-users to know how to correctly dispose the product at its end-of-life.
  - Relevant for recyclers to know how to disassemble and recycle the products in the best possible way, for example to ensure that hazardous substances are removed and treated correctly. As in case of the information on hazardous substances, precious metals and rare earths it is suggested that such information could be made more easily available, by embedding it in the product in e.g. a Radio Frequency Identification (RFID). This results in a higher benefit for the recyclers compared to information provided on webpages or in user instructions. Furthermore, it could be specified in the Directive which type of information the recyclers may need. This could be done in close collaboration with the recyclers to ensure that the information is indeed relevant for their processes.
- Information and specific requirements on easy disassembly:
  - Relevant for consumers / repair facilities to help improving maintenance and repairs. Generic information requirements for non-destructive disassembly for maintenance could be supplemented by requirements for the producers to make repair and service manuals public. It may also be relevant to set specific requirements for easy disassembly of the product for maintenance purposes.
  - Relevant for recyclers to help improving end-of-life treatment, for example the removal of certain components which have to be treated separately in accordance with the WEEE Directive (batteries, heat pumps etc.).

Material-efficiency Ecodesign Report and Module to the Methodology for the Ecodesign of Energy-related Products (MEErP)

BIO Intelligence Service (2013) conducted a study to clarify the implications of material efficiency from the pragmatic perspective of its practical application for Ecodesign purposes, and the elaboration of recommendations for the MEErP methodology (Part 1); and undertook an update of the MEErP methodology and its component EcoReport tool, to include the necessary means for better analysing material efficiency in MEErP (Part 2). Part 2 also contains a guidance document for analysing material efficiency in ErP; as well as an updated version of the EcoReport Tool and a report of the test of the updated methodology on two case studies.

The project identified from available evidence the most significant parameters regarding material efficiency that may be used in MEErP, in order to analyse the environmental impacts of ErP, and assessed their suitability and robustness for Ecodesign purposes, together with associated information parameters.

The parameters selected as most suitable were:

– Recyclability benefit ratio, describing the "potential output" for future recycling, based on a formula considering the recyclable mass per material and its recycling rate and a down-cycling index. It implies that it is possible to assess the potential benefits of recyclable plastic parts in a product. However, due to data constraints only data on recyclability benefit rate for bulk and technical plastic is included.

– Recycled content, describing the "input" of materials with origin on waste, based on new data sets for materials. The dataset makes it possible to model products with recycled material as input material. However, again due to data constraints, only data on paper, Polyvinyl Chloride (PVC), Polyethylene Terephthalate (PET) and High Density Polyethylene (HDPE) has been included in the EcoReport Tool.

– Lifetime, a mechanism to display impacts not only as a total over the whole lifespan, but also per year of use, allowing an easier comparison of products with different lifetimes or analysing the effect of lifetime extension. The product lifetime can refer to:

  - The technical lifetime is the time that a product is designed to last to fulfil its primary function (technical lifetime).

  - The actual time in service is the time the product is used by the consumer (service lifetime). The actual time in service is not a typical parameter in industry and depends more on the user than on the manufacturers of the product design.

– Critical raw materials, a tool to analyse products including critical raw materials to display differences between different product designs and improvement options.

A key end result of this project was that the new features within the MEErP, enabling further analyses of material efficiency aspects in products, are fully functional and ready to be used in future Ecodesign preparatory studies. However, Bundgaard et al. (2015) conclude in their study:

> *The MEErP methodology has not been changed significantly. The alterations made to the EcoReport Tool are minor and to some extent updates of existing elements. Hence, despite the good intentions to include material efficiency into MEErP, the current update and expansion of MEErP will properly not be enough to ensure a focus on material efficiency in future implementing measures and voluntary agreements.*

- **The durability of products**

Ricardo-AEA, in collaboration with Sustainability Management at Scuola Superiore Sant'Anna di Pisa (SuM) and Intertek, has been commissioned by the European Commission – DG Environment to conduct a study on the durability of products. The purpose of the study is to identify two priority products and develop a methodology for measuring their durability. The study also aims to estimate the benefits and costs of more durable products. The outputs from this work can then be used in relevant product policies. (Ricardo-AEA 2015)

Within the durability study, the authors undertook a literature analysis to develop an appropriate definition of durability. For example, the Ecodesign Directive 2009/125/EC in Annex I, Part 1.3 defines parameters which must be used, as appropriate, and supplemented by others, where necessary, for evaluating the potential for improving the environmental aspects of products. According to European Parliament (2009a), this includes inter alia

> *"Extension of lifetime as expressed through: minimum guaranteed lifetime, minimum time for availability of spare parts, modularity, upgradeability, reparability."*

The following definition has been developed by Ricardo-AEA (2015) proposed to be potentially also applied to other policy interventions in Europe aimed at improved durability of products.

"<u>Durability</u> is the ability of a product to perform its function at the anticipated performance level over a given period (number of cycles – uses – hours in use), under the expected conditions of use and under foreseeable actions.

Performing the recommended regular servicing, maintenance, and replacement activities as specified by the manufacturer will help to ensure that a product achieves its intended lifetime."

The authors further discussed the possibility of creating an extended definition of durability that encompasses repair, design for repair and remanufacturing, and that such an extended definition of durability could be developed for inclusion within for example the EU Ecolabel and Green Public Procurement (GPP) criteria requirements.

"A product to maintain its functions over time and the degree to which it is repairable before it becomes obsolete."…. "In other words, a product should not cease to function after relatively little usage and <u>its reparability should not be hindered by its design</u>."

It is thus worth considering that, within this context, extended durability is the aim to extend the life of a product past its first life by ensuring a product can be easily repaired, upgraded, remanufactured and, at end of life, dismantled and recycled.

Beyond the above definitions on durability, Ardente et al. (2012) concluded their literature review, cited in Ricardo-AEA (2015), the following definitions for a number of relevant terms:

- <u>Design for durability</u>: considering the product's longevity, reparability and maintainability; considering environmental improvements emerging from new technologies (ISO/TR 14062 2002).
- <u>Operating time</u>: average time frame during which the product is supposed to be used. Operating time can be derived from product statistics or from estimating models.
- <u>Extension of operating time</u>: estimated time frame extension of the operating time that can be achieved due to specific design and maintenance actions.

Within the study of Ricardo-AEA (2015), domestic refrigerators and freezers, and ovens were selected for further analysis. The selection is based on the assumption, that they might also be applicable to other products with similar components. The study results are expected to be transferable to a large extent as following components are similar: outer casing, pumps, filters, heating elements, mechanical elements such as hinges and catches and electronics, including controls and displays

- **<u>Addressing resource efficiency through the Ecodesign Directive. Case study on electric motors</u>**

Dalhammar et al. (2014) conducted a case study in 2012 on the potential inclusion of permanent magnet (PM) motors in the Ecodesign requirements for electric motors (permanent magnet motors are also used in household dishwashers). The objective was to see how the Ecodesign Directive could promote eco-innovation for resource use in PM motors, and to:

- Investigate what kind of requirements related to resource use of rare earth elements (REE) are of relevance for permanent magnet electric motors, and
- Obtain input from experts on the feasibility of outlined potential requirements, and the most important drivers for eco-innovations.

Against the background of increased demand for REE, combined with global supply imbalances and unavailable post-consumer recycling options for REE, their substitution in the magnets is currently being investigated in several pilot projects. Replacing REEs with other materials however can come with a performance loss in the PM motor (i.e. reduced energy efficiency due to a reduced energy density in the magnet and more material use). Therefore, increasing the recyclability of PMs is of interest, if technically and economically feasible at the point in time of interest, as it could provide a stable supply of REEs and thus, enhances their continued use to achieve more energy-efficient motors.

Based on interviews with material experts, Dalhammar et al. (2014) outline potential implementing measures facilitating recycling of REE.

– Generic requirements that producers should show how they take design for recycling into account in the design process.
– Design for dismantling, e.g. modularisation; or preventing that permanent magnets are for instance covered by plastic, which would ease recycling practices.
– BOMs providing information about key materials and their positions to promote future recycling (when new technologies may allow for profitable recycling if the motors are easy to disassemble).
– Additional information to recyclers that are relevant for allowing cost-effective recycling.
– Take-back obligation; it might provide incentives to design a motor from which materials can more easily be recycled.

Dalhammar et al. (2014) conclude that it appears as if a more developed set of requirements cannot be set under the Ecodesign Directive until pilot projects and ongoing research have provided more insights on the technical and economic viability of REE recycling. The long-time scales involved (i.e. time before the motors are at the EoL stage) however mean that future recycling options and associated costs and benefits are rather uncertain compared to products with shorter life spans, e.g. laptops or cell phones.

- **Resource efficiency requirements in Ecodesign: Review of practical and legal implications**

This study for the Dutch Ministry of Infraestructure and Environment explores the potential role of material resource efficiency, except energy efficiency during use, in the Ecodesign of ErP Directive. This study strengths the role of material efficiency in Ecodesign, beyond energy efficiency and concludes that Ecodesign measures regarding savings on non-energy resources consumption in the use-phase have proven to be enforceable, at least for directly consumed resources, legally and in practice. Methodology and measures regarding weight-saving measures in Ecodesing would need to be developed. Measures on product durability (lifetime extension) have proven to be enforceable when formulated in terms of minimum technical life of the product or components according to harmonised test and calculation procedures. Also minimum warranty times and the time period during which spare parts are available can be enforced.

Should Ecodesign preparatory studies be able to provide robust evidence that justifies introduction of specific RRR measures in legislation (a set of) specific or tailor-made requirements should be introduced in Ecodesing legislation that could meet legal and practical criteria enforceability. Amongst others this means that the requirements should be technically and economically feasible and preferably relate to parameters that can be assessed with an accurate, reliable and reproducible test and calculation methods at product-level. If they would depend on input from upstream actors (suppliers) or downstream (end-of-life) processes, the administrative burden would be considerable and still the accuracy and reproducibility of measurements would require robust test standards to be in place to guarantee a level playing field.

International trade agreements emphasize the relation between the proposed measure and its means of verification. Measures that can be verified on the product itself are considered to constitute less of a (potential) barrier to trade than measures that can only be verified indirectly as they relate to non-product related production and process methods.. There are however measures that may relate solely to the product, such as parameters dealing with durability, light-weighting, presence of substances (hazardous or critical raw materials, etc.)

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