Preparatory study to establish the Ecodesign Working Plan 2015-2017 implementing Directive 2009/125/EC

Draft Task 3 Report

In collaboration with:

Öko-Institut e.V. Institut für angewandte Ökologie Institute for Applied Ecology

ERA Technology

European Commission, Directorate-General for Enterprise and Industry
16 June 2014

Document information

CLIENT	European Commission – DG ENTR
REPORT TITLE	Draft Task 3 Report
PROJECT NAME	Preparatory Study to establish the Ecodesign Working Plan 2015-2017 implementing Directive 2009/125/EC
DATE	16 June 2014
PROJECT TEAM	BIO by Deloitte (BIO), Oeko-Institut and ERA Technology
AUTHORS	Dr. Corinna Fischer (Oeko-Institut) Mr. Carl-Otto Gensch (Oeko-Institut) Mr. Rasmus Prieß (Oeko-Institut) Ms. Eva Brommer (Oeko-Institut) Mr. Shailendra Mudgal (BIO) Mr. Benoît Tinetti (BIO) Mr. Alexis Lemeillet (BIO) Dr. Paul Goodman (ERA Technology)
KEY CONTACTS	Corinna Fischer c.fischer@oeko.de Or Benoît Tinetti btinetti@bio.deloitte.fr
DISCLAIMER	The project team does not accept any liability for any direct or indirect damage resulting from the use of this report or its content. This report contains the results of research by the authors and is not to be perceived as the opinion of the European Commission.

Please cite this publication as:
BIO by Deloitte, Oeko-Institut and ERA Technology (2014) Preparatory Study to establish the Ecodesign Working Plan 2015-2017 implementing Directive 2009/125/EC – Draft Task 3 Report prepared for the European Commission (DG ENTR)

Contents

Foreword

BIO by Deloitte is pleased to submit this first draft of the Task 3 report for the project “Preparatory study to establish the Ecodesign Working Plan 2015-2017 implementing Directive 2009/125/EC”, on behalf of the project team composed of Oeko-Institut, BIO by Deloitte, and ERA Technology.

Please note that the present document is a preliminary report that does not yet constitute the full draft Task 3 report. It reflects the state of our work as of 9th June 2014. Specifically, it does not yet contain preliminary assessments of all selected product groups. An updated version of this report will follow by end of June 2014, containing the remainder of the product groups. As it is work in progress, stakeholder input is highly welcomed.

The report is structured as follows:

Chapter 1 contains a description of the pre-screening methodology which the study team used in order to choose no more than 30 product groups from over 100 for a preliminary analysis. Chapter 2 provides a short introduction to the methodology and structure of the preliminary analysis. Chapters 3 to 12 are dedicated to the analysis of the first 10 product groups.

1. Pre-Screening

At the beginning of Task 3, a pre-screening was conducted. The goal of the pre-screening was to narrow down the list of currently product groups to no more than 30 groups that would be subject to the preliminary analysis in Task 3. Of these 30, the 20 most promising groups will be chosen for further analysis in Task 4. Section 1.1 describes the methodology used for the pre-screening. Section 0 presents the results.

1.1 Pre-screening methodology

1.1.1 Step 1: Product rating

In a first step, all product groups (PG) were rated independently by four experts from within the consortium with respect to the categories described below. A score of “1” indicates a positive judgment (product suitable for further study), a score of “0” a negative statement (product unsuitable), a score of 0.5 means “don’t know”. Raters were asked to judge on the basis of available information (e.g. from existing Working Plan studies, Preparatory Studies or own other work); no extensive research was conducted at this stage. Furthermore, raters were asked to provide data and qualitative arguments to back up their judgement where possible. If the rating seemed to differ between various subgroups of a product group, raters were asked to enter the answers for the most promising subgroup and indicate which one that was.

The following categories were used:

- Feasibility of study: Does it seem feasible to study the PG in Task 3 and 4 of this Working Plan study without disproportionate effort? (for example, with respect to availability of data, standards and methods; complexity)? Rating: 1=study seems feasible; 0,5= don't know; 0=study does not seem feasible.
- Suitability for review: Can the PG be taken up in the course of a review of an existing Ecodesign Regulation (or Voluntary Agreement, VA)? Rating: 1=cannot be taken up in a review; 0,5=don't know; 0=can be taken up in a review. The reasoning behind this rating is the following: If the product can be taken up in the review of an existing Regulation (or VA), it does not need be considered in a future Working Plan.
- Sufficient sales: Is the product group as a whole, or at least one subgroup of it, likely to hit the indicative 200.000 mark, today or until 2030? Rating: 1=it is likely to hit the mark (already today, or because sales are rising); 0,5=”don't know”, OR: “it may not hit the mark, but is not an obvious niche market either”; 0=obvious niche market (far from the mark today, sales not significantly rising).
- Energy impact and improvement potential: Does the product present both a significant energy consumption and a significant improvement potential? Rating: 1=sufficient impact and improvement potential (improvement potential likely to be above the indicative figure of 7 PJ/year); 0,5=don't know OR: undecided (improvement potential likely to be below 7PJ/year,

but consumption likely to be above 7 PJ/year); 0=insufficient impact and improvement potential (consumption below 7 PJ/year).

- Non-energy impact and improvement potential: Does the product present a relevant non-energy impact and a relevant improvement potential? Rating: 1=relevant impact and improvement potential; 0,5=don't know; 0=insufficient impact and improvement potential.
- Regulatory coverage: Are all the relevant environmental aspects of the product group, to your knowledge, covered by other legislation without leaving any substantial gaps? Rating: 1=substantial regulatory gaps are existing; 0,5= don't know; 0=all important aspects are already covered.
- New topics: Does the product group present new topics that have not been taken into consideration when previous Working Plans were set up, and might be subject to an Ecodesign Regulation? It is not about new data for existing topics, but entirely new topics (e.g. issues such as possible horizontal measures for material efficiency, recent technical / economic / political developments, totally new product group) Rating: 1=it presents new topics; 0,5=don't know; 0=it does not present new topics.
- Suitability for Ecodesign measures: Is any of the Ecodesign-related tools (Regulation, VA, generic requirements, specific requirements, horizontal measures, product-related measures) a suitable instrument to regulate the issue? The answer can be considered to be NO, if, for example:
  - There are no design-related improvement options;
  - There is no sufficient differentiation between products;
  - Improvement options are related mainly to the type of substances used, so they should be regulated by cross-cutting substance-related legislation; or
  - The PG is strongly integrated into a system, and its performance depends on the design of the system, so instruments that target the system are more suitable.

Rating: 1=PG seems suitable for Ecodesign measures; 0,5=don't know; 0=PG does not seem suitable for Ecodesign measures.

- Feasibility of Ecodesign measures: Does it seem feasible to implement Ecodesign measures for this product? E.g. regarding issues such as:
  - Excessive purchase cost;
  - Increased life cycle cost
  - Market surveillance issues (e.g. most important environmental impacts are "embedded impacts" for which no tracking system exists);
  - High product variability, rapidly evolving technology; or
  - High variability between EU Member States.

Rating: 1=Ecodesign measures seem feasible; 0,5= don't know; 0=Ecodesign measures do not seem feasible.

In addition to the rating with respect to these categories, each rater indicated a maximum of 30 “favourite” products. Two additional experts also indicated their favourite products without filling in the whole table.

1.1.2 Step 2: Prioritization

First, prioritization was conducted at the level of the individual raters. For each product and each individual rater, it was calculated whether products were excluded. A product was considered "excluded" if it had received the value "0" in any of the following categories which were considered to be knock-out criteria:

- Feasibility of study (knock out if not feasible);
- Suitability for review (knock out if not suitable);
- Sufficient sales (knock out if obvious niche market);
- Energy impact and improvement potential (knock out if overall consumption below 7 PJ); or
- Regulatory coverage (knock out if all relevant aspects covered by other legislation).

After that, an overall score was calculated for each individual rater and each product that had not been excluded by this rater. The score was achieved by adding up the ratings for all criteria with numerical ratings (that is, excluding "favourites").

The individual rater results were now aggregated to achieve a prioritization at the aggregated level. The results are shown in Annex 1.

- For each product, the number of "excluded" judgments across all raters was calculated by adding them up (resulting in a Score from 0 to 4). Products that have not been excluded by anyone are shown in green in the table in Annex 1.
- For each product, the number of "favourite" judgments across all raters was calculated by adding them up (resulting in a Score from 0 to 4). Products that have been chosen by at least two people are shown in light green; products that have been chosen by at least three people are shown in dark green.
- For each product, the sum of "don't know" was added to see if much information is missing. The higher the score, the darker the red.

It had been planned to also calculate a total score per product by adding up all scores. However, this exercise turned out to be of limited use because the scores were distorted by missing values.

- Afterwards, the following rules were applied to arrive at a first rough prioritization:
- A product was considered "top priority" if it was excluded by no one, and at least three raters' favourite;
- A product was considered "second priority" if it was excluded by no one and at least two people's favourite;
- A product was considered "to be discussed" if it was at least one person's favourite, or if it was more persons' favourite, but excluded by maximum one person;
- A product was considered "not to be studied" when it was nobody's favourite or excluded by more than one person; and
- Industrial machinery made an exception to these rules as it was only rated by one rater and needs more discussion. It was considered "to be discussed" if this rater considered it as a favourite.

1.1.3 Step 3: Qualitative discussion of the preliminary results

The preliminary product list was now circulated in the consortium, and consortium members could mark further products for discussion, for example with the aim of up- or downgrading them. Also, comments were sought from the Commission. For all products that had been marked for discussion, additional data and information was researched. All these products were discussed in the consortium on the basis of the additional data. In some cases, this exercise resulted in an up- or downgrading or in a split of product groups.

A few product groups that had been rated as priority product groups in the first steps were excluded or modified at this stage. This is the case for:

- **Domestic and commercial cooking equipment not yet covered:** The re-inclusion of portable ovens, steam ovens and grills was discussed on the grounds that they had not been regulated in the follow-up of ENER Lots 22 and 23. In the end, it was decided to not include any of them:
  - For steam ovens, sales and improvement potential are too low, as shown in the base-case of Lot 22.
  - Grills are split into various different types with low improvement potential each. Domestic and commercial designs are different and there are at least three main types of grill - electric radiant, electric contact and gas (radiant). For commercial grills, sales were low (about 15,000 with stocks of 150,000) and annual energy consumption is unclear with very little data available. Commercial grill annual energy consumption was calculated by Lot 23 as base-case 5 for electric at 1,5 TWh/y and base-case 6 for gas at 0.94 TWh/y. Annual energy savings were estimated to be 0.27 and 0.30 TWh/year totalling 0.57 TWh/year. Therefore, the group needs not to be reincluded due to low potential. For domestic grills, there is a great variety, and some data (not available during the Lot 23 study) indicates that they might consume between 12.8 kWh/year and 69.5 kWh/year, but the data is very scattered. However, evidence from stakeholders indicted that there is a significant energy saving potential of 20 – 30 %. Therefore, if the annual energy consumption of domestic grills is 40 kWh/year, the total energy consumption is 10.2 TWh per year. If the saving potential is 20 %, then savings of 2 TWh per year may be achievable. However, this is for at least three designs and more than three new energy consumption standards would be needed. Thus, it is decided that the group is not worth the effort.
  - Portable ovens are, according to the Lot 22, a relevant group, so it is not clear to the study team why no Ecodesign Regulation has been considered. The Lot 22 study suggests yearly sales of 10 million portable ovens. If product lifetime is at least 10 years, EU stocks will be about 100 million. The Lot 22 study also suggested an annual energy consumption of 164 kWh per year for BC1 electric ovens. 100 million stock would consume 16.4 TWh. Although portable ovens are smaller than average range or built in ovens, they are mostly poorly designed and are not in scope of the electric oven energy label so they will probably not consume much less than a built-in or range oven. The study assumed that removal of less efficient models from the market would reduce total energy consumption by 20 %. This would amount to savings of 3 TWh/year, probably similar to the savings for built-in and range ovens. The lack of a suitable standard should not prevent tp regulate. In fact, the energy consumption measurement standard for built-in and range ovens is suitable for ovens as small as 12 litres and could be used for measuring portables.
    However, the study team does not think that a new study is necessary as these issues

have been discussed in the Lot 22 study. The team however wishes to highlight that a regulation would be desirable.

- **Lasers**: There are many different types of lasers. Of those, metal-cutting and welding laser machine tools have been covered by ENTR Lot 5. These applications are the main energy-consuming types. Remaining applications such as laser diodes, measuring, or medical equipment, have low energy consumption and improvement potential.
- **Mobile power generators:** Mobile power generators had been suggested on the grounds that energy performance is often very poor. However, in the meantime, they have been the object of the ENER Lot 35 scoping study on small power generation, and therefore do not need to be studied again. After the scoping study, the product group was put on hold.
- **Home audio / video equipment not yet covered:** The product group is very broad and includes products such as sound amplifiers, video projectors, video monitors, loudspeakers, or headphones. Some of them, such as loudspeakers or headphones, have very low energy consumption, others, such as cathode ray video monitors, declining markets. However, a preliminary review of sales and trade data suggested that video projectors and sound amplifiers are product groups with very significant and rising sales. Sound amplifier manufacturing seemed to be at around 20 million per year for many years, and apparent consumption even higher. It was therefore decided to study them. Video projector manufacturing seemed to rise from 6,000 in 2008 to 1,6 million in 2012, imports being relatively constant at 2 million per year, apparent consumption at 3,2 million in 2012. However, video projectors had been studied in ENTR Lot 3. They had been suggested as priority product, but for unknown reasons had not been taken up. The study team therefore concluded that no complete study would be necessary, but market data would be updated as apparent consumption in 2012 was already 50% higher than what had been projected for 2015 in the preparatory study.
- **Hot vending machines:** It was suggested by the Commission to include in the scope vending machines that have both hot and cold functions, or that include a food processing function such as ice or ice cream makers. However, the study team concluded that combined vending machines re a niche market. Regarding cold machines with processing element, ice makers were considered in ENTR Lot 1 and savings in 2020 were estimated at 0.38 TWh/year (see Table 1-56 of Task 1). Regarding ice cream makers, ENTR Lot 1 does not present market data. The scope was therefore not extended. On the other hand, the product group was merged with commercial coffee machines as the products are very similar: a hot vending machine is basically a coffee machine with a vending function.

The following product groups were added to the list:

- **Imaging equipment**: Imaging equipment was included on the grounds that the draft version 5.0 of the existing Voluntary Agreement might not be endorsed by the Commission. In this case, it might be necessary to launch a new study and restart the Ecodesign process. However, it is at present not clear whether this process would be launched automatically, in the way the review of a Regulation is, or whether the product group would have to be included in the Working Plan.
- **Set top boxes:** It became apparent that a few product groups might fall in between the Regulation for simple set-top boxes (SSTB) and the VA for complex set-top boxes (CSTB). The current VA on CSTB covers the devices with conditional access (cryptography card of services bound to a specific provider), whilst the Regulation on SSTB covers exclusively devices converting from digital to analogue, which are going to disappear in the near future. The "grey area" includes new decoders, providing services such as Over-the-Top-Content or Media

Gateway, which is an emerging market in the USA. The Omnibus study recommends an extension of scope of the SSTB Ecodesign Regulation, but is not very precise about the potential and relies on incomplete studies by others. A study should clarify whether these products will have an important market in the EU and whether there is a potential for savings.

Furthermore it was decided to currently not include industrial machinery in Task 3 for the following reasons:

- Industrial machinery generally shows a great variety of custom-made products which are also highly integrated in systems, which makes it difficult to approach them with Ecodesign measures. This is confirmed by the recent experience in the context of ENTR Lot 4 and 5 which shows the difficulty of establishing meaningful Ecodesign measures.
- There are generally other instruments in place or applicable which are more suitable for these products, such as the Emissions Trading System, Industrial Emissions Directive or EMAS.

Stakeholder input is welcomed to indicate whether there are, in spite of the above considerations, types of industrial machinery that should be considered.

1.2 Pre-screening results

The results of the pre-screening exercise are presented in Annexes 1 and Table 1. Annex 1 presents the results of the rating and prioritization, with an additional column DI added that sums up the results of the qualitative discussion. Table 1.shows the consolidated product list in alphabetical order and with new numbering.

Table 1: Product groups for study in Task 3

PG no. (new)	PG no. (old)	Product group (PG)	Remarks
Priority List			
1	15	Anti-legionellae filters	Are used as an alternative to heating the water to a certain degree. Used in huge numbers (e.g. one per hospital room) and only last for a month. Trade-off between using them and heating the water to higher temperatures more often.
2	75	Aquarium equipment	Predominantly lighting and heating, maybe filters. An aquarium can consume between 150 and 400 kWh/year; lighting is up to 45%. Sufficient sales to be verified.
3	49	Base station subsystems	High energy consumption because they are running around the clock
4	61	Domestic kitchen appliances	Same logic as DIY tools: huge variety, huge numbers, focus should be on motor power if that is an issue. Paul verifies with Kenwood.
5	63	Electric kettles / water cookers	Focus on durability
6	66	Elevators, escalators, and moving walkways	Sales around the threshold, but high improvement potential; initial consultation with colleague at Oeko: lighting in elevators could be an interesting avenue + hydraulic fluids/ resource efficency in general
7	84	Energy using equipment used in means of transport	Car air conditioning, electronics etc. Big market. Is not covered by fuel efficiency legislation because measurement standards foresee that it is turned off when measuring fuel consumption. Risks problem shifting between legislations. Is not a means of transport itself, so we should consider it here.
8	5	Garden huts	If heated (check how many actually are heated). Labeling could make sense.

PG no. (new)	PG no. (old)	Product group (PG)	Remarks
9	4	Greenhouses	Focus on pre-fabricated ones including heating systems. Check sales data (identify major manufacturers via DIY store websites). If no data on sales or if sales are irrelevant, drop. Consider heating lamps? AT (COM): To be checked if intelligent LED lighting already allows creating greenhouses underground or in non-transparent buildings, which could dramatically reduce heating demand.
10	76	Gym or athletics articles (treadmills, home trainers etc.)	Sales and trade data to be found
11	79	Hand- and hairdriers	(Broader group “Personal care” had been marked as “for future consideration” by VHK.)
12	39	Handheld power tools	Already investigated by VHK (with a focus on chainsaws). Focus should be on drills and grinders. Product for DIY sector are probably not relevant because of short usage times, only products for commercial sector. But they are difficult to distinguish, therefore difficult to regulated. Main issue might be motor power. Only pursue if there is sufficient indication that motor power actually is an issue.
13	65	Hot food presentation and storage equipment	Heating platters and vessels for canteens, buffets etc. Consumption must be in the area of refrigerating equipment. Refrigerating equipment is covered in Lot 12
14	8	Humidifiers and dehumidifiers	Marked as “for future consideration” by VHK
15	35	Inductors	Inductor charger sales may increase and they may be very inefficient
16	50	In-house networking: routers, modems, internet boxes, WiFi access points.	Standby covered by networked standby regulation, but are probably in on-mode for considerable time. To clarify: domestic and / or commercial? Make sure there is no overlap with CSTB or ENER Lot 9. Energy Star V.1 for "small network equipment" going to be added to the EU-US agreement, as suggested by the EUESB
17	33	Inverters and converters	Sales and trade data partly missing and partly (for rotary converters) weird, but production data ok. Excluded: rotary converters: old, declining technology, low production figures. Section on possible horizontal issues for converters plus focus on PV converters. Corinna to send data sources to Alexis.
18	40	Lawn and riding mowers	focus on electric ones as they haven't been analysed by VHK (lack of data). Quick check whether data situation has changed. Focus would be on limiting motor power.
19	51	Mobile phones, smartphones	Reason for including: Resource and durability issues. Reasons for not including other equipment: Tablets covered by computer regulation. Portable landline phones much more durable (and declining). Pagers / callers: no sufficient sales. Problem to extract sales and trade data as no separate Prodcom category exists. Update VHK study with resource considerations. Consider energy (also in manufacturing phase), durability, recyclability.
20	13	Patio heaters	highly popular, very inefficient, sensor-controlled on/off function could be helpful
21	56	Sound amplifiers	Was: Audio and video equipment. We excluded - declining markets such as turntables, magnetic tape recorders, video cameras, cathode ray tubes, b/w monitors - products with low consumption and improvement potential such as microphones, head/earphones and loudspeakers without amplifier included - small markets such as professional equipment

PG no. (new)	PG no. (old)	Product group (PG)	Remarks
22	17	Swimming pool heaters	Check sales (manufacturers?). We did not take up COM suggestion to include lighting, as lighting is better taken up in upcoming lighting review.
23	64	Tertiary hot beverage equipment (with or without vending function).	VHK investigated them; significant potential; why have they not been taken up? We did not follow the COM's suggestion to take up cold / combined vending machines: combined are probably a market niche, ice makers have low savings of 0.38 TWh/year, and for ice cream makers there is not data.
24	56	Video projectors	Was: Audio and video equipment. We excluded - declining markets such as turntables, magnetic tape recorders, video cameras, cathode ray tubes, b/w monitors - products with low consumption and improvement potential such as microphones, head/earphones and loudspeakers without amplifier included - small markets such as professional equipment. Were recommended in ENTR 3 and not taken up by Commission. No new full study, but update on market data and market development, and reminder.
25	90	Water, steam and sand cleaning appliances (power washers)	includes patio cleaners; as well as floor and carpet cleaners. Also called pressure washers made by Karcher, Black & Decker, etc. See Steam cleaners seem to be increasingly popular as clothes, curtains and as floor cleaners. Industrial types are also made but are very different designs.
If not covered by review			
26		CSTB	Products that fall in the "grey area" between CSTB VA and SSTB and that manufacturers may not wish to include in the VA: - devices not provided by service providers and available off-the-shelf, such as OTT and Media GTW. This is an emerging market in the USA (AppleTV, Chomecast, , FireTV, Roku) with new providers not only in the USA (Popcorn, DISH Hopper Comcast X1, Horizon Liberty Global, Freebox Revolution, ARRIS Moxi Gateway...). The Omnibus study recommends and extension of scope of the SSTB but is rather foggy about the potential and relies on incomplete studies by others. Find out with COM whether they would need to be included in a new WP or are dealt with in the course of a "review".
27		Imaging equipment	If the draft VA 5.0 is not endorsed by the COM (CF on 12 June). Find out with COM whether they would need to be included in a new WP or are dealt with in the course of a "review".
Not included			
		Grills	Don't include. Savings potential unsure and small for domestic ones (2 TWh divided across at least 3 types), sommercial even smaller. Probably not worthwhile. Have been studied in Lot 22. No new study necessary, COM will decide. Report why not included.
		Lasers	Don't include. 80% of all lasers are for metal cutting or welding, covered by ENER Lot 5. For the rest, sales are not very far above the threshold, applications very varied (Measuring, medical equipment, printing) and energy consumption is low. Report why not included.
		Mobile power generators	Don't include. Sales are apparently low according to VHK study (90.000 in 2005). Scoping study ENER Lot 35 recommends a preparatory study for all combustion engine power generation below 50 MW, which should cover them. Report why not included.

PG no. (new)	PG no. (old)	Product group (PG)	Remarks
		Portable ovens and steam ovens	Commercial kitchen equipment marked as “for future consideration” by VHK. Don't include steam ovens (sales and improvement potential too small, see base case in lot 22). Report why not included. Portable ovens seems to make sense, but no new study necessary. Include in report as a reminder (flag the issue)
Backup list			
	12	Building control and access	May be increasingly important with the advent of passive houses
	91	Industrial process heating equipment, other than ENTR 4	Only if not covered by IED

2. Product Groups – Introduction

The remainder of this report is dedicated to the preliminary analysis of the selected product groups. According to the Terms of Reference, the preliminary analysis covers the following issues:

- Volume of sales and trade;
- Resource consumption (energy consumption and other resources); and
- The potential for improvement without entailing excessive costs (with regard to resource consumption, particularly energy consumption).

Based on these tasks, the study team has developed a slightly more detailed structure for the analysis that will be the same for all product groups:

Section 1, "Product group description" contains a description of what the study team understands by this product group. It describes the purpose and main technologies of the product and also mentions possible variants (e.g. different technologies, different fuels, home / tertiary / industrial use, describe them here). If necessary, it contains a clarification of what is in the scope and what is out of the scope of the present analysis, and a justification for the choice of scope.

Section 2, "Market and stock data", reports at least the following data, if available:

- EU Production Sold (for the latest full year for which at least half of the Member States have reported; calculated from production, exports and imports);
- Stock (installed base) for latest available year;
- Stock forecast, if possible for 2030 to allow comparability, else for 2020:
    - It uses PRODCOM data if possible. If the data is not available or not of good quality, other sources are sought.
    - Section 3, "Resource consumption" contains the sub-sections "Energy consumption" and "Other resource consumption".
    - For energy consumption, the following information is presented, if available:

At individual product level:

- For energy using products: Gross energy requirement (GER); alternatively primary energy use during use phase;
- For non-EuP (indirect ErP), (primary energy savings that would be lost by not using an advanced product, calculated as the difference of energy savings in the related system between the use of an average product and the best performing product. The GER of the product itself would be subtracted from the savings it generates.);
- If necessary, ranges are given and / or it is distinguished between different product variants or subgroups; and
- If necessary, energy consumption is broken down according to different fuels.

At aggregate level:

- Energy consumption of EU stock, today and in 2020 / 2030 (based on stock data from 1.2), in PJ/ of primary energy use/year. Electricity use in TWh/year may be added as an indicator in order to enable comparability with other studies.
- If appropriate, also past development (upward / downward trend).

For other resource consumption, the most relevant resource aspects are identified for the respective product group, considering both quantity and quality of resources used. The resources in question may, for example, include:

- Bulk materials (renewable or non-renewable): metal, plastics, glass, wood, paper, etc.;
- Precious or rare resources (rare earth metals, precious metals);
- Water; and
- Hazardous substances.

A short qualitative discussion presents the nature of the problem. For example, this discussion may include

- Quantity of resource use (e.g. Total Material Requirement):
- Properties of the resource itself, e.g.:
  - Renewability
  - Recyclability
  - Environmental impact, as described by the MEErP indicators (Water, Waste, Emissions to Air and Water)
  - Hazardousness
  - Criticality (based on EU list of critical raw materials)
  - Ecological / social problems in the extraction phase, including conflict minerals)
  - Intrinsic material value
- Design aspects of the product (e.g. durability, recyclability, reusability, recoverability, recycled content, possibilities for substitution of the resource in question, conflicting objectives (e.g. minimizing the input of a certain resource may affect energy performance).

Where possible, quantitative data is provided on whichever impact has been identified as relevant in the discussion above, and impacts are calculated on individual product level and, based on stock data, on aggregate EU level.

Section 4, “Improvement potential”, is also divided into sub-sections on energy and other resources. A short qualitative discussion is provided on technical options to improve energy efficiency and / or to lower energy consumption and / or to increase the savings made possible by the product (if it is an ErP). In doing this, the focus is on Best Available Technology (BAT). Also possible obstacles are considered, for example if BAT is proprietary technology. The average improvement potential is estimated per individual product and extrapolated to the EU stock.

Other resource consumption is only considered if relevant impact has been identified. A short qualitative discussion is provided, dealing with technical options to improve resource efficiency and / or to lower resource consumption and / or to lower the environmental impacts connected with resource consumption (e.g. by substitution, minimizing content, using recycled material, using design for recyclability). Also here, the focus is on Best Available Technology (BAT), and estimates are made on individual product level and EU level.

Section 5, "Cost calculation", is added where possible. The aim of this section is to estimate whether certain improvement options present excessive cost. It is indicated whether improvement options are considered to entail excessive cost. This is the case when life cycle costs for the consumer, inflation-adjusted and taking into account future energy price, is likely to significantly exceed current LCC. Also, possible impacts on the purchase price.

Finally, a section **"Topics for discussion"** is added to highlight uncertainties or need for stakeholder input.

If the structure is not possible to maintain due to lack of data, the gaps are indicated and alternative indicators are sought.

The following chapters present the preliminary assessment of the first ten product groups. They are presented in alphabetic order with no specific priority. Stakeholder input is highly appreciated in order to fill in missing information.

3. Electric kettles

3.1 Product group description

This "Product Group" can be defined as: Appliances for heating water, e.g. for making hot drinks, etc. Products are referred to as "kettles", "water heaters" and "hot water dispensers". The applicable Prodcom category **27.51.25.60** includes "kettles" and is defined as:

"Electric water heaters (including storage water heaters) (excluding instantaneous)"

Kettles are used to heat water either to boiling or to a pre-set temperature. Most are "jug" designs which allow the user to heat only the amount of water needed. Heating water in this way is more energy efficient than heating water in a saucepan on a hob.

All designs are powered by mains electricity. There are several variants:

- Corded or cordless
- Concealed element below a metal plate or an immersed heating element coil
- Designed to boil water then automatically switch off or to heat water to a pre-set temperature or temperatures and maintain at this temperature.
- Size (litres capacity) and power input. The three size ranges available are i) small portable kettles of c. 0.5 litres, ii) the most common size is about 1.7 – 2 litres and iii) larger appliances which are usually fitted with a tap to dispense hot water.
- Metal or plastic body

A related product type with Prodcom category **27.51.25.70**." Electric water heaters and immersion heaters (excluding instantaneous water heaters)" refers to electrical devices that are installed into hot water storage cylinders to provide hot water in buildings. Electric water heaters and immersion heaters (excluding instantaneous water heaters) are excluded from this product group.

Another related group is **27.51.25.30** "Electric instantaneous water heaters". This category includes two types of devices. One type is installed into a building's water supply to provide hot water when a tap is opened. These heat cold water as required and have no reservoir of hot water. The other type is self-contained domestic appliances that heat and dispenses a pre-set amount of hot water to fill a cup or mug. The USA, Canada and Australia have adopted Energy Star energy efficiency standards for built-in instantaneous hot water dispensers[1]. Instantaneous hot water dispensers are considered here.

3.2 Market and stock data

[1] http://www.energyrating.gov.au/wp-content/uploads/Energy_Rating_Documents/Product_Profiles/Other/Water_Dispensers/200416-mepswaterdisp.pdf

Data is available from Prodcom Eurostat Nace Rev 2 code , **27.51.25.50** which includes kettles (data up to 2010 only) and **27.51.25.30** which include instantaneous water heaters (data available up to 2012)

The most recently available Prodcom market data is shown in the table below

Table 2: Market data (1,000's)

	EU production sold		Imports		Exports		Apparent consumption	
Product group	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**
27.51.25.50	8,919	8,336	18,764	19,880	4,241	4,827	23,442	23,388
	2010	**2012**	**2010**	**2012**	**2010**	**2012**	**2010**	**2012**
27.51.25.30	2,328	2,213	806	4,339	310	1,955	2,824	4,596

3.2.1 Future Sales

Kettles are used in homes, offices and other businesses and in hotel rooms. Based on Prodcom apparent EU consumption data, between 2006 and 2010, shows no obvious increasing or decreasing trend; it appears likely that the current market is close to being saturated and so new sales will predominantly be replacements. Therefore any future sales growth would be linked to increases in the number of domestic dwellings and EU population. However there are likely to be local variations as favoured beverages differ between Member States. One report for the UK market indicated that sales of kettles in the UK decreased by 7 % between 2007 and 2012 from 8.1 million to 7.5 million, allegedly as consumers increasingly use coffee machines to make drinks instead of kettles[2]. Hot water dispensers may also replace kettles.

Sales of instantaneous hot water dispensers are smaller than kettles, but may be increasing. This Prodcom category probably also includes "direct piping water dispenser" and "hot water tank dispensers" as well as the relatively new domestic kitchen appliances referred to as "hot water dispensers", so the number of each type cannot be determined. However, the increase in imports and EU consumption since 2010 may be at least partly due to increasing sales of self-contained hot water dispensers. Overall, however, at present kettles are far more numerous than hot water dispensers.

3.2.2 EU Stocks

Manufacturers of better quality kettles with concealed elements, design their products to survive for seven years with eight uses per day (up to 20,000 uses). The number of uses per day will vary considerably so that some will have much longer lifetimes and some much shorter. Many kettles do not however survive 7 years as can be seen from the many complaints on Internet review sites and it is common for kettles to fail after only 1 – 2 years. Durability can be very poor as many types of defect can develop if the kettle is not designed correctly and fully tested to ensure durability. Although no accurate data exists, kettles may be one of the most unreliable type of kitchen appliance on the EU market. Therefore, to estimate stock levels an average lifetime of less than the expected 7 years

[2] http://www.telegraph.co.uk/finance/newsbysector/retailandconsumer/9798786/Kettle-sales-lose-steam-as-coffee-machines-grow-ever-more-popular.html

would seem prudent and so if five years has initially been assumed to be more realistic, EU stocks of kettles in 2010 were:

5 x 23.4 million (sales) = 117 million (stocks).

Table 3: EU Stock (millions)

	EU Stock			
Product group	**2010**	**Today**	**2020**	**2030**
Kettles	117	117	117	117
Hot water dispensers	Not known, no data			

3.3 Resource consumption

Electric kettles appear to be relatively simple appliances in terms of materials and parts used, consisting mainly of plastics and metals but these are very unreliable if not correctly designed and manufactured. Energy consumption in the use phase is likely to be the most significant, but energy consumption in other phases will be more significant if the kettle has a short lifetime due to poor durability.

3.3.1 Energy consumption

As an illustrative example, a 1.7 litre capacity plastic body kettle with a concealed element and a power rating indicated on the label of 2.5–3 kW, was used to boil 1 litre of water. This took 120 seconds to begin boiling and another 17 seconds for it to automatically switch off. Assuming that the energy input was 2.5 kW, the final energy used to boil 1 litre of water was 0.038 kWh (2.5 kWh for 137 seconds). During one year with eight uses per day[3], the annual use phase electricity consumption would be **111.7 kWh**. Of course, this is only a random example and actual energy consumption will depend on the amount of water boiled, how long after boiling that the kettle switches off, the thermal mass of parts that are also heated as well as the water, etc. This illustrative example is however similar to the annual energy consumption measured by the UK Energy Saving Trust[4], based on kettles in 412 households. Average kettle annual electricity consumption was **167 kWh**. This is correct for the UK, but consumption in other EU States will be different, higher or lower, depending on user behavior. However, no data is available on EU kettle usage.

Large-size kettles that keep water hot will consume more energy per litre of water. These will use a similar amount of energy per litre to heat water to the maximum temperature, but they then keep the water hot and so continue to consume energy for as long as the appliance is left on by the user. The total energy consumption will therefore depend on the size of the dispenser and the quality of its thermal insulation, as well as the volume of water being heated. Another type of water heater is the “hot water dispenser”. These heat and dispense only the amount of water needed for one cup so do not waste energy heating water than is not used.

[3] Information from kettle control manufacturer is that 8 uses per day is typical.

[4] Energy Saving Trust (2010), Powering the Nation.

At individual product level

The Gross energy requirement (GER) has been calculated, using the EcoReport tool, with the average annual energy consumption measured by the UK Energy Saving Trust and the materials of the example plastic body kettle with a concealed element from the composition data in Table 5. Two scenarios are considered; one with a kettle lifetime of 5 years and the other where the lifetime is 2.5 years so that during the five year period, two kettles are needed. This is to show the difference in total primary energy consumption for these two scenarios.

The EcoReport Tool gives the total GER primary energy consumption as well as primary energy consumption for each life cycle phase and these are shown below.

Table 4: Energy consumption individual product level (MJ) based on Energy Saving Trust energy consumption measurement in use phase

Product group	Average total energy (GER)	Average total energy consumption (GER) in use phase	Average total energy consumption (GER) in production phase	Average total energy consump-tion (GER) in distribution phase
One plastic body kettle with 5 year lifetime	7,759	7,516	84	138
One plastic body kettle with 2.5 year lifetime	4,001	3,758	84	138
Energy consumption over 5 years for two kettles each with 2.5 year lifetime	7,960	7,516	168	276

The use phase energy consumption is the same for both scenarios as only one kettle is used at any time. However, all other lifecycle energy consumption will be double for two kettles than for one and this significantly increases the production and distribution phase energy consumption when kettles with shorter lifetimes are used.

Aggregated energy consumption data for the EU-27 from EcoReport are given in section 3.3.2 together with other environmental impacts.

3.3.2 Other resource consumption

There are two main types of kettle, those with metal bodies (mild steel coated with nickel / chromium) and those with plastic bodies (usually polypropylene)

A bill of materials (BOM) for a polypropylene jug kettle having an immersed coil heating element has been published[5], although this appears to be quite an old design. This gives a detailed composition which includes many materials that are not included in the EcoReport tool such as nichrome and nickel alloys. In this BOM, polypropylene was 0.86 kg (66%), stainless steel was 0.09 kg (7%), the mains power cable consisted of rubber (0.06 kg, 4.6%) and copper (0.015 kg, 1.1%), although PVC insulation is now more commonly used. The mains plug was 0.037 kg of phenolic polymer and 0.03 kg of brass.

Two fairly new example kettles with concealed elements were dismantled by ERA and the main parts weighed to determine the total plastic and total metals contents, as shown below.

Table 5: Composition of typical kettles (metal and plastic only) measured by ERA

Kettle type	Total mass (grams)	Weight of metal	Weight of plastic
Metal body	1213 g	772 g (64%)	441 g (36%)
Plastic body	1033 g	340 g (33%)	693 g (67%

Metals used in kettles are mainly steels and this includes the heating element, which consists of alumina insulation, a stainless steel sheath and a nichrome heating coil. The plastic used for most plastic body kettles is polypropylene. The EcoReport tool inputs include polypropylene and both mild and stainless steels, but there is no input for the nichrome heating element or alumina insulation. As EcoReport has no inputs for; alumina, nickel alloys, phenolic resin or nichrome; the following were used instead; concrete, CuZn, PP and stainless steel, respectively, as alternative inputs for these materials.

- The only scarce raw material used is chromium used in stainless steel, in nichrome and for chromium plating of metal body kettles
- Water - Used in the production phase. EcoReport calculates 15 litres per kettle are used (excludes cooling water) for production of one kettle using the BOM from Ashby's book (n.b. only 4 litres with the simplified BOM – plastic body kettle using data from Table 5, although this will be less accurate).
- Hazardous substances – Hexavalent chromium compounds may be used for chromium metal plating although alternatives are available. Nickel plating (of steel bodies) uses nickel salts (e.g. $NiCl_2$) that are category 1A carcinogens. Kettles are in scope of RoHS and REACH so should not contain hazardous substances.

An issue with electric kettles is their poor durability. There are many discussions and complaints on the Internet about poor reliability, although very little rigorously researched data. The UK consumer organization has carried out surveys of its members and found that most consumers expect kettles to last at least seven years but only 9% of their members had kettles older than six years. ERA has surveyed its employees and found that kettles are the least durable kitchen appliance with many failing in less than two years. Information from a UK kettle control manufacturer is that reputable kettle manufacturers aim to achieve less than 3% failures within the first year, although this is not always achieved. Many are far worse though, with extreme examples of over 30% failing within one year having occurred. Most kettles sold in the EU are manufactured by Asian companies on behalf of European brands. This is a very price competitive market with new kettle factories opening recently.

[5] M. F. Ashby, Butterworth-Heinemann (2013), Materials and the Environment: Eco-informed Material Choice.

Although kettles appear to be fairly simple devices, achieving high reliability is far from straightforward and requires a high level of expertise in both design and manufacturing. Good durability is more likely if new designs are comprehensively tested before launch and standard industry test methods are used in which kettles are tested for up to 10,000 cycles to simulate seven years of normal use (this is for concealed element kettles, much shorter life testing is used with immersed coil elements as these have shorter lifetimes). This testing is carried out by many of the reputable European brands and by two EU based kettle control manufacturers, but there is an increasing trend to cut costs by not testing new designs. As a result design flaws are not detected and durability is often poor. Kettle failures within 1–2 years are common and this will have an impact on raw materials consumption and on the distribution phase. EcoReport tool calculations for several environmental impacts are shown below for a plastic bodied kettle and the kettle BOM from Ashby:

Table 6: Resource consumption (or environmental impact) individual product level (all life cycle)

Product group	Total Primary Energy (MJ)	Waste, non-haz / landfill (kg)	Heavy metals emissions to air (mg Ni eq)	Particulate matter (g)
ERA plastic body kettle, 5 year lifetime	7,759	4.37	83	41
Plastic body kettle using BOM from Ashby (5 years lifetime)	7,800	4.27	104	43

The calculated 5 year lifetime values in Table 6 are similar for the kettle BOM from Ashby and the simplified BOM from Table 5.

For the EU-27, the corresponding values are:

Table 7: Resource consumption (or environmental impact) at EU level (all life cycle phases)

Product group	Total Primary Energy (PJ)	Waste, non-haz / landfill (tonnes)	Heavy metals emissions to air (tonnes Ni eq)	Particulate matter (tonnes)
Plastic body kettle, 5 year lifetime	181.6 (primary electricity = 176.4 PJ)	102,250	1.94	968
Plastic body kettle using BOM from Ashby, 5 year lifetime	182 PJ (primary electricity = 176 PJ)	100,000	2.4	1,000

However, if durability is poor, for example during a five year period, each user will need two kettles with lifetimes of 2.5 years instead of one kettle with a 5 year lifetime, the production, distribution and end of life impacts are doubled, although use phase energy consumption is unchanged.

The EcoReport tool calculations indicate that use phase impacts are the largest proportion of the total primary energy consumption GER, which agrees with Ashby's calculations[5] that indicate that the use phase electricity consumption is the most significant accounting for at least 87% of GER (although based on a 3 year lifetime). EcoReport tool calculation, using Ashby's BOM, over a 5 year lifetime shows that use phase energy consumption is much higher at 98% of total GER. It is possible that the EcoReport tool under-estimates production phase impacts as has been shown by several life cycle assessment studies, e.g. of computers[6].

3.4 Improvement potential

There are two options for reducing environmental impact;

A. Reduction of energy consumption (electricity) in the use phase
B. Improvements to durability would reduce energy consumption in other phases as well as reductions in other environmental and health impacts

3.4.1 Improvement potential – Energy consumption

Evidence that reduction of energy consumption is possible is available from the UK consumer organization, "Which?". Their website states[7].:

"Energy efficient boiling? - Our scientists have been busy working out exactly how much energy a hot water dispenser uses in comparison to boiling the same amount of water in a kettle. To heat a 250ml mug of water, for instance, a hot water dispenser uses roughly the same amount of electricity as a kettle, **but it can vary according to the kettle**"

The energy consumption of a kettle depends on

- Thermal mass of materials that are heated while the water is heated. New thick film heating elements are available and have a much smaller thermal mass than traditional concealed elements and immersed coil elements. A manufacturer of thick film elements estimates that up to 20% energy saving may be achievable[8], although this may partly be because automatic switch off times can be shorter. Thick film elements weigh 105 grams instead of 210 grams for typical standard elements. A deterrent to using thick-film elements is that they are more expensive at present, although their price would decrease due to economies of scale if sales were much larger.
- Heat loss from external surfaces. This is dependent on the wall's thermal conductivity, so low thermal conductivity plastic is superior to higher thermal conductivity metal. Outer surface colour also has a small effect on heat loss with white / silver being superior to dark colours and black. Heating time is important so fast heating to boiling losses less heat than kettles that take longer to heat water (as there is less time for heat to be lost).
- Ability to heat a small amount of water and no more than is needed. The accuracy of the level indicator is important, but education of the user is most important.
- Heat input continues after the water reaches required temperature (boils) until the automatic cut-out actuates. The time this takes depends on the overall kettle design and so can vary considerably. It is important that this time does not increase with use, however, it is one of the

---

6 http://www.goodcampus.org/files/files/57-LCA_of_computing_equipment_v7_final_June_2011.pdf and http://www.twosides.info:8080/content/rsPDF_126.pdf

7 http://www.which.co.uk/news/2012/01/hot-water-dispensers-vs-kettles-in-new-which-test-276382/

8 Otter Controls "ECO element" http://www.ottercontrols.co.uk/marketing-packs/ECOElementMarketingPackCARBONSAVINGVERSION.pdf

more common complaints that automatic switch off times tend to lengthen with use and for some models this will continue until the kettles will not switch off at all.

- Designs that heat to a pre-set temperature and then keep the water hot will use more energy as continued heating is needed to compensate from heat losses through the kettles walls, etc. In these designs, thermal insulation effectiveness will be important.

The improvement potential is not known but possible values have been used below to estimate EU annual energy saving (1,504 MJ per year use phase primary energy consumption was calculated using the EcoReport tool using annual 167 kWh electricity consumption determined by the Energy Saving Trust.)

Table 8: Improvement potential individual product level

Product group	Improvement potential (primary energy use) with respect to energy consumption in use phase
Reduce switch off time by 10 seconds (heat time 8.5% less)	1,504MJ x 8.5% = 128MJ per year
Reduce thermal mass of kettle by 105g of steel (assume reduces heat input by 3%)[9]	1,504MJ x 3% = 50MJ per year
Reduce outer surface heat loss by 2.5%	1,504MJ x 2.5% = 37.5MJ per year
Heat 10% less water	1,504MJ x 10% = 150 MJ per year
Total improvement potential	366 MJ per year

The calculated EU-27 primary energy saving for stocks of 117 million kettles are therefore estimated to be **42.8 PJ**;

- This is equivalent to **11.9 TWh/year** primary energy saving and
- Final (electricity) energy saving of **27 TWh/ year**[10].

3.4.2 Improvement potential – Other resource consumption

Other benefits, as well as energy consumption, would benefit from improved durability. Manufacturers do not publish early failure rates, but anecdotally, there is evidence that a significant proportion fail within 1 – 2 years whereas, according to a kettle control manufacturer, an average 7 year lifetime is achievable for a concealed element kettle with good design and production quality. As an illustrative example, we compare a poor design with 20% failures within 1 year and a good design with only 2% first year failures; the benefit would be as follows:

Scenario 1: 20% failures in 1 year:

- In year 1, for every 100 kettles in use, 20 fail within 1 year and have to be replaced, so 120 kettles are manufactured and transported.

---

[9] This example uses thick film element instead of a concealed element. This reduces the metal content by 105g (according to Otter Controls). The heat capacity of polypropylene is 1.8J/˚C/g and steel is typically 0.47 J/˚C/g, so based on the plastic kettle composition in Table 5, 105g less steel results in a 3.3% reduction in heat capacity. In practice, larger savings may be possible.

[10] Final electricity energy calculated from primary energy by multiplication factor of 2.5.

- In year 2, two of the replacement kettles has to be replaced
- Over 7 year period, 122 kettles are made and delivered

Scenario 2: 2% failure in year 1

- In year 1, for every 100 kettles in use, 2 fail within 1 year and have to be replaced, so 102 kettles are manufactured and transported. In year 2, 0.004 (2 x 0.2%) kettles are replaced, do over 7 years, about 102 have to be made.

So comparison of scenarios 1 and 2 shows that with poor durability, about 18% more kettles are consumed if durability is poor.

Calculations with EcoReport using the Ashby's BOM for kettle materials, show that production and distribution energy consumption and two other environmental impacts are reduced by scenario 2 as follows

Table 9: Improvement potential individual product level – manufacture and distribution phases only

Product group	Production and distribution phase energy consumption	Non-haz waste	Heavy metals emissions
20% failures in year 1 (100 users)	122 kettles = 122 x 258MJ = 31.5 GJ	48.7kg	3.42 g Ni eq.
2% failure in year 1 (100 users)	102 kettles = 102 x 258MJ = 26.3 GJ	40.7 kg	2.86 g Ni eq.
Improvement / user	45MJ/kettle	80g/kettle	5.6 mg Ni eq.
Improvement EU-27 total / year	45MJ x 23.3 million (sales) = 1.05 PJ/year	1,864 tonnes	130 kg Ni eq.

3.5 Summary

Table 10 presents a summary for the product group "Electric kettles".

Table 10: Electric kettles – Summary

	Year	Kettles	Instantaneous water heaters
Market data			
Sales (million)	**2009** **2010**	23.4 23.4	2.8 4.6
Stock (EU-27, million)	**2010** **2014** **2020** **2030**	117 117 117 117	n.a. n.a. n.a. n.a.
EU-27 Annual primary energy consumption			

	Year	Kettles	Instantaneous water heaters
Over the life cycle	**n.a.**	181.6 – 182 million	n.a.
In use phase	**n.a.**	176 – 176.4 million	n.a.
EU-27 Annual primary energy savings			
Over the life cycle	**n.a.**	42.8 PJ	n.a.
In use phase	**n.a.**	n.a.	n.a.

3.6 Topics for discussion

The calculations used in task 3 have used several assumptions. These are likely to affect the energy saving potential and more data is needed to determine more accurate results. These assumptions include:

- The average energy consumption of kettles in the 28 EU Member States will be very variable and the UK value used here may not be typical.
- The improvement potential options are estimates based on limited research.
- The numbers of self-contained hot water dispensers is not known so has not been included in improvement option calculations.

Industry standard test methods are used for kettle durability assessment but energy consumption is not necessarily measured as part of these investigations. However, measurement of energy consumption during these standard test cycles could form the basis of a standard energy measurement method that could be the basis of an EU energy label.

The impact of poor durability on total primary energy consumption (GER) is not large although other impacts may be more significant. Consideration of options to improve durability would be beneficial in reducing several environmental and health impacts as well as reducing the quantity of EU waste. Mandatory durability requirements may also benefit those reputable EU-based kettle manufacturers that already make significant efforts to achieve high reliability durable products.

The calculations reported here indicate that the primary energy saving potential is very significant at **11.9 TWh per year** and so prioritization in working plan 3 should be considered. Use phase environmental impacts are higher than necessary due to poor durability. However, the production phase energy consumption is only a small proportion of the total. Process water consumption, waste and emissions from production could be reduced by improved durability and so the quantities calculated here should be considered to determine if they are sufficient to justify an eco-design obligation.

4. Gym and athletics articles

4.1 Product group description

A general definition of this product group would include any equipment used for the purpose of physical exercise. Yet gym and athletics articles form a quite broad product group. First of all, gym articles can be used both at home and in fitness clubs (also known as fitness centres, and commonly referred to as a gym).

Moreover, not all devices consume energy. As a matter of fact, "many commercial-grade elliptical trainers and stationary bikes are completely self-powered these days. The energy the rider or strider generates feeds back into the machine to power the brake and the electronic display."[11] More and more initiatives even happen to turn energy burnt in a fitness centre to electric power supplying the centre[12].

Hence the ordering below distinguishes between energy-consuming articles (in scope) and self-powered articles (out of scope).

In scope

Treadmill. A treadmill is a device for walking or running while staying in the same place. Not all treadmills require electricity to power the machine, although most of them.

Stepmill. A stepmill looks like a mini staircase. Also called "stair climber", a stepmill is like a miniature escalator, with the machine's steps moving downward and collapsing within the machine, similar to the way a treadmill's track moves round and round. A stepmill simulates stair climbing.

Figure 1: Treadmill[13]

Figure 2: Stepmill[14]

Out of scope

All articles presented in this section have no energy consumption from an external source, in a sense that they are fully self-powered).

---

[11] Palmer (2010), Is There a Greener Way To Work Out?, Slate, The Green Lantern.

[12] See for instance: http://www.dailymail.co.uk/news/article-2430771/Worlds-self-powering-gym-uses-energy-WORKOUT-lights-dont-break.html

[13] http://www.fitness-fan.co.uk/treadmill-mistakes/

[14] http://stairmaster.com/products/stepmill-5/

Exercise bike. An exercise bike is an indoor bike, which is used as exercise equipment rather than transportation means. Regular exercise bikes are considered in this category, as well as "spinners" or "spinning-bikes", which have a heavy, weighted flywheel that is directly mechanically linked to the pedals. This makes them like fixed-gear bikes, in that if the user stops pushing on the pedals, they will tend to keep spinning due to the inertia of the flywheel[15].

Bicycle or home trainers can also be included in the "exercise bike" category, as a piece of equipment that makes it possible to ride a bicycle while it remains stationary.

Figure 3: Regular exercise bike[16]

Figure 4: Spinning-bike[17]

Figure 5: Home trainer[18]

A discussion may occur on exercise bikes, as they probably represent a significant amount of sales and stock. Yet it really seems that the vast majority of them are self-powered. The sole energy consumption is due to the console, which usually works on a battery charged by the cycling itself.

Stepper. Steppers, however basic or complicated, always have two platforms, or pedals, where to place the feet. As the user pushes one foot down, the other foot will rise, giving him/her the sensation of climbing stairs.

Elliptical trainer. Elliptical trainers are a combination of stair-climbing and a treadmill.

Bench. A gymnastic bench is designed for various fitness exercises, including muscle-development exercises.

Rower. As the name indicates, a rower simulates rowing.

4.2 Market and stock data

A 2013-report from the International Health, Racquet and Sportsclub Association (IHRSA) states that "roughly 44 million members frequent 48,000 clubs in Europe, where revenues are an estimated €25 billion. […] Germany leads all markets observed in number of clubs with more than 7,500 facilities as Norway claims the greatest membership penetration rate at nearly 16% of the total population, 25% of

[15] http://ask.metafilter.com/81620/What-is-the-practical-difference-between-a-spinning-and-regular-stationary-exercise-bike

[16] http://www.lifefitness.com/commercial/cardio/lifecycleexercisebikes/integrity-series/integrity-series-upright-lifecycle-exercise-bike-clsc.html

[17] http://www.diytrade.com/china/pd/10417805/Hot_salse_professional_manufacture_spinning_bike_fitness_equipment_gym_equipment.html

[18] http://www.decathlon.fr/home-trainer-crono-mag-force-gel-pack-id_8231436.html

Norwegians over the age of 15."[19] Although the scope of Europe is not explicitly defined in this report, it includes at least Russia and Turkey that we should exclude, and probably a few countries of Eastern Europe which are not EU Member States today.

A careful estimate of 43,000 fitness centres in Europe can be taken as a basis. Another rough estimates, based on a sample of fitness clubs in various cities, indicate that each club counts about 15 treadmills, what results in an installed base of 645,000 treadmills in Europe (in fitness centres).

At home, the stock of treadmills is probably lower. An estimate of 305,000, which tops up to the 645,000 above to reach 950,000 units, is equivalent to 0.6 treadmill for 1,000 inhabitants in Europe. This is perhaps a bit low, but the mostly urban population of EU-27 lacks space to host a treadmill at home; moreover, this careful estimate for stock is compensated by a rather large estimate for use (see below). This means that all in all, forecast in energy consumption will appear reasonable.

As for stepmills, they do not seem to be much popular in Europe – and even in the USA, they turn out to be still a niche market. Current stock for stepmills in EU-27 is then assumed to be negligible (both at home and in fitness centres), whereas forecasts would mention an increase in stock (in fitness centres exclusively).

Regarding stock forecast indeed, all sources indicate a rising trend. Sales data above indicated that the global "sports" industry is either growing, or at least resisting the economic crisis. Yet on the specific "gym and athletics" market, further information indicates that the trend is upwards. The graphic below shows the growth in revenues of fitness centres in France (Xerfi – all rights reserved), which is +6 % a year on average[20].

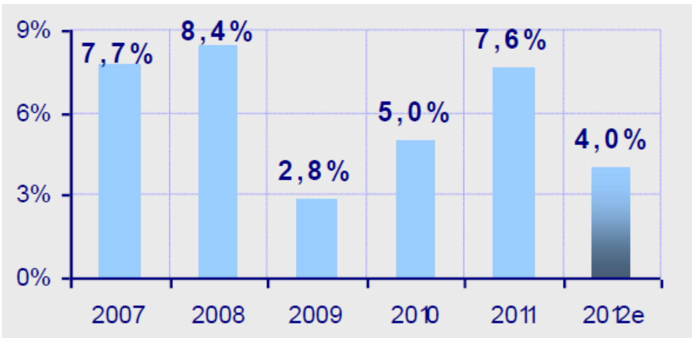


Figure 6: Changes in revenues of fitness centres in France

Another indicator of the growing trend in the gym market is the relatively low penetration rate in some regions of Europe (Portugal, Greece), as compared to the EU average (6%), signifying potential for growth[21].

The graphic below summarises stock forecasts for treadmills and stepmills in EU-27.

[19] IHRSA (2013), IHRSA releases new European Health Club Report: http://www.ihrsa.org/media-center/2013/10/16/ihrsa-releases-new-european-health-club-report.html.

[20] Xerfi (2013), Gestion privée d'installations sportives.

[21] IHRSA (2013), IHRSA releases new European Health Club Report.

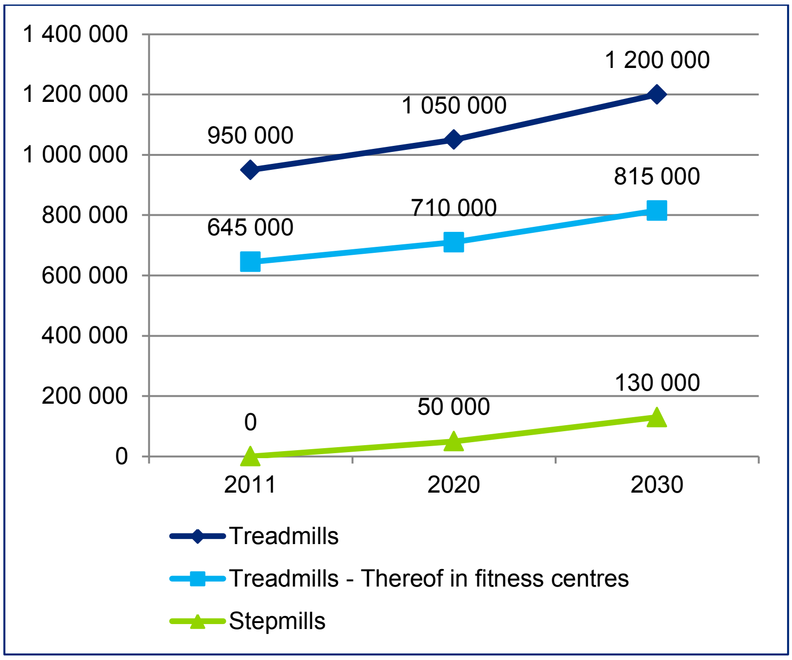


Figure 7: Estimates for current and future stock

True, Prodcom data is available for “Gymnasium or athletics articles and equipment” (Prodcom code 32.30.14.00). This corresponds to two former Prodcom categories, namely “Exercising apparatus with adjustable resistance mechanisms” and “Articles and equipment for general physical exercise, gymnastics or athletics (excl. exercising apparatus with adjustable resistance mechanisms)”. Although they show an indubitably stable or growing market, global statistics from Prodcom have a too broad scope. Indeed, Prodcom code 32.30.14.00 corresponds to ISIC Rev.4 code 3230[22], which includes all sporting and athletic goods (except apparel and footwear). This is 12 categories, thereof one is “gymnasium, fitness centre or athletic equipment”[23].Hence, the Prodcom category includes non-energy using equipment, which makes it non-relevant for the study.

Sales may be estimated through stock and lifetime data. Treadmill manufacturers usually issue a lifetime warranty for frame and deck, but a maximum 10 years warranty for motor and less for other parts. If we take reuse into account, an average lifetime of 10 years may be considered as a reasonable estimate. When dividing the current stock by this estimated lifetime, we find an approximate figure of 100,000 treadmills sold each year.

4.3 Resource consumption

4.3.1 Energy consumption

The focus has been put on treadmills. For simplicity’s sake, and considering that data is difficult to gather, we will assume that the average energy consumption of a stepmill is the one of a treadmill. The same assumption will go for improvement potential. Yet both assumptions are not impactful, as the stock of stepmills in Europe is low anyway.

Data is difficult to gather as well on Gross Energy Requirement (GER), since no LCA analysis has been carried out so far, and materials used in manufacturing phase are not precisely known either.

[22] http://unstats.un.org/unsd/industry/commoditylist3.asp?Co=38430-0&Lg=1

[23] http://siccodesupport.co.uk/sic-division.php?division=32

At individual level

Two major figures have to be estimated:

- The average energy consumption of one treadmill in one hour; and
- The average use time of a treadmill in a year.

As far as the use is concerned, there is a huge difference between home and fitness centre. A fitness centre in Europe has large opening hours, commonly from 6 am to 10 pm in the week and from 9 am to 6 pm in the weekend. Some fitness brands like McFit in Germany are even open 24 hours a day, 7 days a week[24] – yet the average opening hours mentioned seem a reasonable estimate, which add up to 98 hours a week, rounded to 100 hours a week. However, in any fitness centre, there are peak and off-peak hours, and professionals state that all treadmills are never used at the same time (treadmills or gym machines in general). One single treadmill is probably used between two and three hours a day, not more. This is 15 hours a week, out of 100 – hence 85 hours are spent in standby mode.

At home, the use time is definitely lower. An estimate of 30 minutes a day, 5 days a week, is already a rather high estimate. As a matter of fact, even if two or more people can use the same treadmill at home, the experience shows that treadmills are less and less used as time goes by. This source is probably not the most reliable, yet the trend is true: over 92% of people who own treadmills do not use them[25]. Finally, an average use of home treadmills of 2.5 hours a week appears as a comfortable estimate, which makes up perhaps for a careful stock estimate (see above). Yet one interesting point is that treadmills at home are probably always on standby mode, whereas fitness centres can switch off the general power supply at nights.

Hence the energy use times of treadmills is summarised in the table below.

Table 11: Average energy use times in a year

	Fitness centre	Home
On-mode	780 hours	130 hours
Standby mode	4,420 hours	8,606 hours
Total	5,200 hours	8,736 hours

The average power of one treadmill in standby mode is said between 3[26] and 5.6[27] W, based on sources in North America. However, the Ecodesign Regulation 1275/2008 indicates that power consumption in standby mode shall not exceed 1 W for products put on the EU market after January 2013. This maximum power consumption value will be taken as a basis for future calculation.

When used, one treadmill consumes much more energy. The power consumption in on mode is generally between 950 and 3,000 W. Yet this nominal energy power is not equal to the used energy power, since treadmills are rarely operating at maximum capacity.

---

[24] http://www.howtogermany.com/pages/fitness.html

[25] http://www.fastexercise.com/?LP=6

[26] http://www.canada.com/globaltv/calgary/features/consumer_advocate/story.html?id=7a342063-e292-49b2-9617-e75cb820a3fc

[27] http://www.mnenergysmart.com/how-much-phantom-energy-do-your-electronics-use/

A first trial has been done by a private person in the US, leading to a 320-380 Wh energy consumption for a 68 kg runner on a Merit Fitness 725t Plus of 1,875 watt of maximal power[28]. Yet the most serious test has been done by Life Fitness on various treadmill models, with a 100 kg runner – this test is still controversial, as the best model singled out by Life Fitness… is a Life Fitness. All results anyway are summarised in the table below[29].

Table 12: Average power consumption of various treadmills (in Watts)

Speed (mph)	Life Fitness 95T Engage ®	Technogym 900E ®	Precor 923i ®	Star Trac P Series ®	Matrix T7XE ®
3.5	284.69	508.40	383.61	343.40	319.95
5.0	303.50	673.80	505.80	505.80	360.60
7.0	354.49	883.30	710.10	645.97	455.38
9.0	572.36	1082.50	927.80	872.40	612.09
Average	378.76	787.00	631.83	591.89	437.01

The range of power consumption of those five treadmills in use phase is quite broad, with an average of 565 W. Therefore, at individual product level, the yearly energy consumption of a treadmill is given in Table 13.

Table 13: Annual (final) energy consumption of treadmills

Product group	Average energy consumption in standby mode	Average energy consumption in use phase	Average total energy consumption
Used in fitness centre	4.4 kWh/yr	440.7 kWh/yr	445.1 kWh/yr
Used at home	8.6 kWh/yr	73.5 kWh/yr	82.1 kWh/yr

At aggregate level

At aggregate level, the energy consumption of EU-27, today and in 2020 / 2030 is based on stock data and energy consumption at individual level. The Gross Energy Requirement (GER) has been calculated through the EcoReport tool, with the (assumed) bill of materials presented in the next section and with an average lifetime of 10 years. This is compiled in Table 14.

[28] http://www.thegeoexchange.org/Power-Consumption/treadmill-power-consumption.html

[29] http://www.lifefitness.com/static-assets/document/Energy_Savings/Energy_Efficiency_Test_Details.pdf

Table 14: Aggregate annual EU (primary) energy consumption – Gym and athletics articles

Product group	Energy indicator	2011	2020	2030
Treadmill in fitness centre	EU-27 GER	3.2 PJ	3.5 PJ	3.9 PJ
	EU-27 Energy consumption in use phase	0.72 TWh	0.79 TWh	0.91 TWh
Treadmill at home	EU-27 GER	0.9 PJ	0.9 PJ	1.0 PJ
	EU-27 Energy consumption in use phase	0.06 TWh	0.07 TWh	0.08 TWh
Stepmill (in fitness centre exclusively)	EU-27 GER	0 PJ	0.4 PJ	0.7 PJ
	EU-27 Energy consumption in use phase	0.00 TWh	0.06 TWh	0.14 TWh

4.3.2 Other resource consumption

Resources used to manufacture treadmills and stepmills include mostly bulk materials like metal and plastics. Whereas frames are usually made out of steel or aluminium, decks are most commonly in plastics. They include some electronics components and sometimes a LCD screen, which could introduce concerns in terms of recyclability.

Also rubber is used to manufacture the running area. The total weight of a treadmill varies between 50 and 150 kg; stepmills seem to weigh a bit more (typically 100-200 kg). There is not much else to say about other resource consumption, since no comprehensive study has been made on the topic. Some user's manuals provide an overview of all parts of a treadmill[30], but they always fail to indicate corresponding weights. We can do only estimates, based on an average treadmill of 100 kg.

Table 15: Assumption for materials used in an average treadmill

Material	Weight [kg]	Share [%]
Polypropylene	4	4%
Polyvinyl chloride (PVC)	15	15%
Electronics	1	1%
Iron-nickel-chrome alloy	3	3%
Steel	59	59%
Aluminium	7	7%
Rubber	11	11%
Total	100	100%

[30] See for instance: http://ecx.images-amazon.com/images/I/B1xhsaIKF3S.pdf

For stepmills, we made the assumption that the shares of materials were the same, although the total weight was 150 kg instead of 100 kg. This results into the GER to be found in Table 14.

Gym and athletics articles are generally covered by the WEEE Directive as “Toys, leisure and sports equipment”.

4.4 Improvement potential

4.4.1 Improvement potential – Energy consumption

Improvement potential can be measured through the range of energy consumptions observed above. As a matter of fact, the best treadmill tested by Life Fitness had an average consumption over the different speeds of 378.76 Wh, whereas the worse model had an average energy consumption of 787 Wh. The average power savings are further indicated in the table below[31].

Table 16: Average power savings, as compared to Life Fitness 95T Engage ®

	Life Fitness 95T Engage®	Technogym 900E®	Precor 923i®	Star Trac P Series®	Matrix T7XE®
Average energy consumption	378.76 W	787.00 W	631.83 W	591.89 W	437.01 W
Percentage savings	-	52%	40%	36%	13%

Based on data included in the table above, the average energy savings, as compared to the best available model, are 35%. This figure may be taken as a basis for improvement potential. A qualitative reason of this relatively high improvement potential may be that motors are a bit over-estimated, although it is difficult to assess it properly without any manufacturer’s feedback.

Improvement potential at EU-27 aggregate level is not significant, attending that the energy consumption was not significant either. This is summarised in Table 17 (in primary energy).

Table 17: Improvement potential at EU-27 aggregate level – Gym and athletics articles

Product group	EU-27 improvement potential (PJ/year)		
		2020	2030
Treadmill in fitness centre	with respect to GER	-	-
	with respect to consumption in use phase	0.28 TWh = 1.00 PJ	0.32 TWh = 1.14 PJ
Treadmill at home	with respect to GER	-	-
	with respect to consumption in use phase	0.02 TWh = 0.09 PJ	0.03 TWh = 0.10 PJ
Stepmill (in	with respect to GER	-	-

[31] http://www.lifefitness.com/static-assets/document/Energy_Savings/Energy_Efficiency_Test_Details.pdf

fitness centre exclusively)	with respect to consumption in use phase	0.02 TWh = 0.07 PJ	0.05 TWh = 0.18 PJ

4.4.2 Cost calculation (where possible)

The price range of a treadmill in Europe is 300-3,000€. Yet treadmills turn out to be more expensive in the USA. The best model tested (Life Fitness 95T Engage ®) is priced much diversely, from 7,500[32] to 11,000[33] US dollars (5,500-8,000€). As a comparison, the Precor 923i ®, which 40% less energy efficient, is priced 49% less, at 4,700$ (3,450€)[34].

Stepmills in the US seem to have the same price range as treadmills, with about 3,000-7,000$ (2,200-5,100€).

4.5 Summary

Table 36 presents a summary of the product group Gym and athletics articles.

Table 18: Summary – Gym and athletics articles

	Year	Treadmill (fitness + home)	Stepmill	Total
Market data				
Sales	**2011**	0.1 Mio.	0 Mio.	-
Stock	**2011** **2020** **2030**	0.95 Mio. 1.05 Mio. 1.2 Mio.	0 Mio. 0.05 Mio. 0.13 Mio.	-
EU-27 Annual primary energy consumption				
Over the life cycle	**2011** **2020** **2030**	4.1 PJ 4.4 PJ 4.9 PJ	0 PJ 0.4 PJ 0.7 PJ	4.1 PJ 4.8 PJ 5.6 PJ
In use phase	**2011** **2020** **2030**	0.78 TWh 0.86 TWh 0.99 TWh	0 TWh 0.06 TWh 0.14 TWh	0.78 TWh 0.92 TWh 1.13 TWh
EU-27 Annual primary energy savings				
In use phase	**2020** **2030**	0.30 TWh / 1.09 PJ 0.35 TWh / 1.25 PJ	0.02 TWh / 0.07 PJ 0.05 TWh / 0.18 PJ	0.32 TWh / 1.26 PJ 0.40 TWh / 1.43 PJ
Additional information				
		-	-	-

[32] http://www.fitnesssuperstore.com/Life-Fitness-95T-Inspire-Treadmill-p/95tinspire.htm

[33] http://www.fitnessunlimitedcommercial.com/treadmills.asp

[34] http://www.precor.com/en-us/home/products/treadmills

4.6 Topics for discussion

- Stock and above all sales data are subject to rough estimates.
- The energy consumption and improvement potential not being significant, it would be interesting to have a deeper look to resources consumption (where data is today barely available).

5. Garden houses

5.1 Product group description

The Prodcom data includes pre-fabricated houses and garden huts in one category. However for possible Ecodesign measures only garden huts and small pre-fabricated houses *for temporary living* seem suitable as pre-fabricated houses for permanent living are already covered by the Energy Performance of Building Directive.[35]

In particular, the Energy Performance of Buildings Directive allows Member States to exempt from setting energy performance criteria for:

- Residential buildings which are used or intended to be used for either less than four months of the year or, alternatively, for a limited annual time of use and with an expected energy consumption of less than 25 % of what would be the result of all-year use; and
- Stand-alone buildings with a total useful floor area of less than 50 m^2.

Based on a quick check with experts familiar with the Energy Performance of Buildings Directive most if not all member states make use of this possibility.

A large share of these buildings is presumably not equipped with heating, lighting, etc. An initial internet research, however, reveals that many customers install heating and lighting on their own later on. Lighting energy consumption is regulated in existing Ecodesign Lots and not very dependent on the building design itself. Heating energy consumption is, however, very dependent upon building design and insulation.

Very small garden houses/sheds below about 4 m^2 usable space are likely not used for spending extended time and hence also not prone to be heated.

Garden houses are often self-or individually-build structures. Hence a wide variety of designs exist. Such individually designed and built garden huts are not suitable for Ecodesign measures on the level of the full building structure.

However, also pre-fabricated self-assembly garden houses are sold in Europe. These similarly come in a variety of pre-defined shapes and sizes and for different purposes. They are usually made of simple materials such as wood, aluminium, sheet metal, plastic or a combination of these.

For the purpose of possible Ecodesign measures hence all pre-fabricated buildings that are sold in Europe, fulfil one of the two above criteria of the Energy Performance of Buildings Directive, are above 4 m² usable space and are (potentially heated) are within scope. These are marketed under a number of different names, depending on local customs and suggested use, e.g. log cabins, summerhouses, playhouses, garden houses, garden huts, dachas, sommarstugas,

Retailers include DIY/ home improvement stores, garden centres and individual manufacturers.

They are small-scale building structures used in gardens/ allotments for temporary personal use (finding shade, spending leisure time, garden parties, temporary living), for purposes such as storing

[35] Directive 2010/31/EU.

garden equipment, tools, bicycles and other things and are usually not or must not be designed for permanent living.

Figure 8: Wooden garden house[36]

5.2 Market and stock data

Though the product in itself is fairly simple and common, it was not possible to obtain data indicating the size of the garden house market. Hence, an estimate based on own assumptions is given:

- Assumed number of (small domestic or allotment) gardens in Europe and other lots not used for permanent residence: 60 million[37];
- Assumed share of gardens with garden houses/huts: 25%;
- Assumed average life time: 10 years;
- Assumed initial share of pre-manufactured garden huts in installed base: 20%;
- Assumed share of sold pre-manufactured vs. self-build garden huts in 2014: 50%; and
- Assumed share of pre-manufactured garden huts that are later equipped with heating: 5%.

Based on these assumptions the

Table 19: Estimation of stock of heated pre-fab garden houses

	2014	2015	2020	2025	2030
Gardens (in millions)	60	60	60	60	60
Share of gardens with garden houses	25%	25%	25%	25%	25%
Installed garden houses (in millions)	15	15	15	15	15

[36] de.wikipedia.org, licensed under Creative Commons Attribution-Share Alike 3.0 Unported by Alfred Lehr, unmodified

[37] Germany has 17-22 million gardens alone , averaging 400 m², so actual figures for Europe may be much higher: BMELV, Zukunft Garten – Bedeutung für Politik, Wirtschaft und Gesellschaft, Conference report, 2011 and http://www.bmub.bund.de/fileadmin/Daten_BMU/Download_PDF/Bildungsservice/zahl_woche_2012_bf.pdf.

	2014	2015	2020	2025	2030
Average life time (in years)	10	10	10	10	10
Number of garden houses sold/re-build (millions per year)	1.5	1.5	1.5	1.5	1.5
Share of pre-fab sold vs custom built garden houses (each year)	50%	51%	56%	61%	66%
Sold pre-fab garden houses (in millions)	0.75	0.77	0.84	0.92	0.99
Share of pre-fab garden houses	20%	26%	37%	46%	54%
Total installed stock of pre-fab garden houses (in millions)	3.45	3.87	5.62	6.95	8.05
Share of installed pre-fab garden houses heated	5%	5%	5%	5%	5%
Sold pre-fab garden houses, eventually heated (in thousands)	37.5	38.25	42	45.75	49.5
Stock of heated pre-fab garden houses (in thousands)	173	194	281	348	402

Relevant for energy consumption, this gives an overall stock of heated garden houses of 173 thousand in 2014 growing to over 400 thousand in 2030.

Relevant for resource consumption, sold pre-fab garden houses amount to 38 thousand in 2014, growing to 50 thousand in 2030.

5.3 Resource consumption

5.3.1 Energy consumption

As energy consumption of building structures is very dependent upon the specific design, material, heating systems, climate etc. and no data on average consumption of garden houses was available the following assumptions were made to estimate overall energy consumption and lost savings, based on average heating degree days in Europe and U-values for non-insulated and insulated garden houses.

Table 20: Average heating degree days in EU-27 from 2007-2009[38]

	2007	2008	2009	Assumed 2014-2030
Heating degree days EU-27	2.943	3.008	3.076	3.000

As garden houses are only used temporarily, it is assumed that only 5% of average heating degree days in Europe are applicable to garden houses. As they are usually very simple structures of wood, metal or plastic, a high U-value of 3 W/m²K is assumed for the non-insulated version. For an insulated garden house 1,5 W/m²K are assumed as reasonable. An average garden house envelope (total surface area) of 60 m² is assumed which would represent ca a 4 m x 4 m footprint.

As heaters are not pre-installed, consumers may choose a number of heating systems. Popular seem to be easily installed convectors that run on electricity. An efficiency of 95 % is assumed for these. For calculating primary energy consumption from electricity consumption a conversion coefficient of 2,5 is used. (see Table 21)

[38] Data from Eurostat.

Table 21: Assumptions for energy requirements of average heated pre-fab garden house

Average heating degree days EU-27	3.000
Heating degree days garden house (5%)	150
U-value non-insulated garden house (W/m²K)	3
U-value insulated garden house (W/m²K)	1,50
Average garden house envelope (m²)	60
Convector/heater efficiency	95%

Based on these assumptions, primary energy consumption of non-insulated heated garden house amounts to about 6 GJ/year and energy consumption of the improved garden house is at about 3 GJ/year and house.

Table 22: Energy consumption individual product level

Electricity consumption for heating non-insulated garden house (kWh/year)	648
Electricity consumption for heating garden house (kWh/year)	324
Heating energy requirement non-insulated garden house (MJ/year)	2333
Heating energy requirement insulated garden house (MJ/year)	1166
Primary energy consumption non-insulated garden house (MJ/year)	6139
Primary energy consumption insulated garden house (MJ/year)	3069
Lost savings per heated garden house (MJ/year) if not improved	3069

Due to the diversity in possible housing designs and materials no data on life cycle energy consumption was available. Also only heating energy required was assessed as explained above.

Total energy consumption for installed stock of heated pre-fab garden houses is shown in Figure 9.

Figure 9: Primary energy consumption of stock of non-insulated garden houses (only heating)

	2014	2015	2020	2025	2030
Stock of heated pre-fab garden houses (in thousands)	173	194	281	348	402
Primary energy consumption stock non-insulated garden houses (PJ)	1.1	1.2	1.7	2.1	2.5

Primary energy consumption in 2014 amounts to about 1.1 PJ, rising to about 2.5 PJ in 2030.

5.3.2 Other resource consumption

Resource impacts of garden houses are mostly related to the use of basic bulk/building materials.

A phone interview with a manager at a local DIY-store in Germany revealed that pre-fabricated garden houses that may be used for spending recreational time in/ temporary living are generally made from wood. Sheet metal, aluminium, plastic is mostly used for smaller sheds. This is confirmed by a quick internet search of available garden houses on the website of the third largest European DIY-store (www.obi.de) (see Table 23). Of all available garden houses above 4 m² (231), 182 are made from wood, 18 from plastic and 31 from metal.

Table 23: Net turnover of largest European DIY retailers[39]

DIY retailer	Net turnover (in billion Euro)
Kingfisher	12.4
Groupe ADEO	12.2
OBI	5.7
Bauhaus	4.1

Hence, for heated garden houses the most relevant bulk material seems to be wood. Total yearly quantities have not been assessed.

5.4 Improvement potential

5.4.1 Improvement potential – Energy consumption

The following improvement options are conceivable:

- Improved insulation and ventilation; and
- Designed to allow for easy fitting of insulation and ventilation later on.

Possible intervention based on these improvement options are assessed in Figure 10.

Figure 10: Possible interventions to improve energy consumption of garden houses

Intervention	Assessment
Require improved insulation and ventilation	Due to the various designs available on the market and especially the various purposes garden houses are used for, requiring universal insulation seems unviable and would result in high costs and additional resource use.
Inform about energy performance of garden house	Informing potential customers about the energy performance of the building. Customers that consider heating their garden house could more easily evaluate possible options and compare costs (higher insulation vs. higher energy expenses)
Inform about design for insulation/ ventilation	Already now garden house designs are on the market which allow for later instalment of insulation/ ventilation. Informing customers about this option may allow for easier insulation at a later time.

Based on the above calculations for the stock of non-insulated and insulated garden houses an estimate of possible energy savings for the future stock of garden houses in Europe has been done (see Table 24).

Assuming that through appropriate communication measures 20 % of sold heated garden houses after 2015 are insulated, potential primary energy savings of 0.1 PJ per year are possible in 2020 and 0.3 in 2030.

[39] http://www.edra-online.com/english/diy_sales/index.html, last accessed 13 June 2014.

Table 24: Estimate of potential future energy savings achievable for garden houses

	2014	2015	2020	2025	2030
Stock of heated pre-fab garden houses (in thousands)	173	194	281	348	402
Primary energy consumption stock non-insulated garden houses (PJ)	1.1	1.2	1.7	2.1	2.5
Savings 100% of sold garden houses insulated (PJ per year)			0.6	1.3	1.4
Savings 50% of sold garden houses insulated (PJ per year)			0.3	0.7	0.7
Savings 20% of sold garden houses insulated (PJ per year)			0.1	0.3	0.3

5.4.2 Improvement potential – Other resource consumption

Improvement options for resource consumption have not been assessed.

5.4.3 Cost calculation

A cost calculation has not been done. Intervention could/should focus on insulation options that are cost-neutral or financially beneficial to consumer.

5.5 Summary

Table 25 presents a summary of the product group garden houses.

Table 25: Summary – Garden houses

	Year	Pre-fab Garden houses
	Market data	
Sales pre fab garden houses (thousands)	**2014**	750
Sales pre-fab garden houses eventually heated (thousands)	**2014**	375
Stock heated pre-fab garden houses (in thousands)	**2014** **2020** **2030**	173 281 402
	EU-27 Annual Primary Energy COnsumption	
Over the life cycle	**na**	na
In use phase (in PJ)	**2014** **2020** **2030**	1.1 1.7 2.5

	Year	Pre-fab Garden houses
EU-27 Savings in primary energy per year		
Savings 100% of sold to be heated garden houses insulated (PJ per year)	**2020**	0.6
	2030	1.4
Savings 50% of sold to be heated garden houses insulated (PJ per year)	**2020**	0.3
	2030	0.7
Savings 20% of sold to be heated garden houses insulated (PJ per year)	**2020**	0.1
	2030	0.3

5.6 Topics for discussion

- The stock model builds on many very rough assumptions that may alter the conclusions of the analysis. Stakeholder input would be helpful to gain a better understanding of basic parameters of the stock model.
- If basic assumptions of the model can be confirmed it may make sense to further differentiate pre-fab housing sizes and possibly installed heating systems.
- Are there related building types (small or used only seasonally) that are not covered by the Energy Performance of Buildings Directive and which should be considered when exploring possible Ecodesign criteria for garden houses?

6. Blowers for personal care (hand- and hairdryers)

6.1 Product group description

Blowers for personal care include both hair dryers and hand dryers.

A hair dryer is an electric blower that can blow warm air onto the hair; it is usually hand-held but it can also be some fixed device (like a drying hood). Different types of hair dryers may be distinguished, however the core technology does not vary from one item to the other.

Professional hair dryers are generally more powerful than household hair dryers: the power input of professional hair dryers ranges between 1600 and 2150 Watt, while household hair dryers stand somewhere below (starting at 900-1000 Watt). Professional devices often run with AC motors, whereas household hair dryers are usually equipped with DC motors[40]. Additional differences between professional and household hair dryers are different air flow rates, as well as air temperature options (professional hair dryers often include at least two hot air stages and one cold air stage).

Still, many reports underline that differences between household and professional hair dryers are blurring, since more and more professional devices are used by individuals.

Figure 11: Typical hand-held hair dryers[41]

A hand dryer is again an electric blower, used to blow air onto the hands; it may either operate with a button or automatically using an infrared sensor. Different technologies are available for hand dryers:

- Conventional hand dryers (warm air dryers): they use a fan to draw ambient air from the room, and a heating element to raise the temperature of the air. The fan exhausts the air, through a nozzle, over the user's hands[42];
- Jet air dryers: Dyson, Mitsubishi and Veltia have introduced new types of electric hand dryer, based on technology without hot hair.

Most, but not all hand dryers are installed in commercial places. From this point of view, it does not make sense to make a difference between professional and household hand dryers.

---

[40] Oeko-Institut (2012), PROSA Haarpflegegeräte – Entwicklung der Vergabekriterien für ein klimaschutzbezogenes Umweltzeichen.

[41] http://www.whenwasitinvented.org/when-was-the-hair-dryer-invented/

[42] Definition from Comac Croporation (http://www.comaccorporation.com/us/faq.html).

Figure 12: Typical warm air hand dryer[43]

Figure 13: Typical jet air hand dryer[44]

6.2 Market and stock data

Prodcom data is available both for hair and hand dryers. For hair dryers, Prodcom code 27.51.23.10 has been newly introduced and in use since 2011. It replaces former Prodcom code 27.51.23.15. Data are presented in Table 26 for EU-27.

Table 26: Market data for hair and hand dryers

Prodcom name	Prodcom codes	Year	Production	Import	Export	Apparent Consumption
Electric hair dryers	27.51.23.10	2006				
		2007				
		2008				
		2009				
		2010				
		2011	1,800,000	28,794,280	4,390,441	26,203,839
		2012	2,316,884	27,641,178	3,457,038	26,501,024
Electric hair dryers (excluding drying hoods)	27.51.23.15	2006	5,000,000	30,415,607	3,336,954	32,078,653
		2007	1,800,000	33,430,611	3,753,350	31,477,261
		2008	1,840,000	33,656,392	2,376,391	33,120,001
		2009	1,286,418	27,811,682	2,930,534	26,167,566
		2010	1,781,151	31,850,031	3,339,884	30,291,298
		2011				
		2012				
Electric hand-drying apparatus	27.51.23.50	2006	450,000	407,299	119,292	738,007
		2007	600,000	510,945	147,560	963,385
		2008	360,000	573,220	124,681	808,539
		2009	212,883	438,728	179,034	472,577

[43] http://www.mrgadget.com.au/gadget/2009/dyson-airblade-in-action-at-melbourne-airport/

[44] http://www.dhgate.com/product/jet-hand-dryer-airblade-design-duel-jet-not/161723374.html

Prodcom name	Prodcom codes	Year	Production	Import	Export	Apparent Consumption
		2010	208,534	556,993	100,375	665,152
		2011	199,492	707,070	77,898	828,664
		2012	219,777	884,103	104,435	999,445

Legend:

- Cells highlighted in red indicate that the Prodcom code is not valid in this year. In this case, it means that code 27.51.23.10 replaced code 27.51.23.15 in year 2011 – so that both codes are complementary.
- Cells highlighted in orange indicate that the total has been rounded to the base given in the BASE indicator of PRODCOM Stats.
- Cells highlighted in yellow indicate that at least one of the national figures in this EU aggregate is estimated.

A short analysis of sales data indicates that:

- For both hair and hand dryers, sales are far above the indicative 200,000 units threshold of the Ecodesign Directive; and
- The trend is rather flat in general. As Production data for hair dryers are not fully reliable from 2008 to 2009, it can be considered that a growing trend has developed since 2009 onwards. This could be a following of the introduction of jet air dryers, although no causal relationship has been demonstrated so far.

The stock, or installed base, is more difficult to assess. Hypotheses have to be made, which make the figures below more uncertain than sales data.

For hair dryers, an estimate is possible through the number of EU-27 households. According to Eurostat, there were about 501 million inhabitants in EU in 2011, with an average of 2.3 persons per household – and therefore, approximately 218 million households. The ownership rate of hair dryers is not available at EU level. However, the French federation of electric domestic appliances (GIFAM) indicates that 69.3% of French households actually have a hair dryer[45]. Going from this number, there would be about 151 million hair dryers in EU-27, perhaps a bit less given the possible higher ownership rate in France than in new Member States. All in all, the figure of 150 million as installed base seems to be a reasonable estimate.

For hand dryers, ownership rates are not available and would make little sense anyway (as they are commercial appliances). According to VHK (in the Working Plan 2 study), "initial estimates indicate a market for hand dryers of some 2 million units (assuming a stock of 20 million units and average product life of 10 years)". This could be somehow overrated, attending sales are barely one million units and lifetime could be shorter as well. As for sales, the Prodcom data above is largely confirmed by a recent study[46], according to which 676.3 thousand hand dryers have been sold within the six main EU markets (France, UK, Germany, Italy, Belgium and the Netherlands) in 2013 – meaning about a million is the EU-27. As for lifetime, in the Life Cycle Assessment of hand drying systems done by the MIT[47], the baseline scenario assumes a lifetime usage of 350,000 pairs of hands dried over a 5-year time frame. Depending on washroom traffic, the actual number of uses and therefore the lifetime could be higher or lower. An average lifetime of 8 years seems a fair estimate. Now, as sales are

[45] Figure from 2010: http://www.gifam.fr/images/stories/fiches-produits/2013/fiche%20appareils%20de%20coiffure%20gifam%202013.pdf

[46] Interconnection Consulting (2013), Blade Hand Dryers set to "Blow" away the Competition. Available at: http://www.interconnectionconsulting.com/index.php?lang=en&presse=58.

[47] MIT (2011), Life Cycle Assessment of Hand Drying Systems, Commissioned by Dyson.

rather flat (780,000 on average for the period 2006-2012), it is possible to have this approximation as the installed base: 8x780,000 = 6,24 million.

However, no data of the share in stock of warm air and jet air hand dryers have been found. Therefore, it has been assumed that the respective shares in EU stock of warm air and jet air hand dryers was 95/5 in 2011, 80/20 in 2020 and 60/40 in 2030, considering the recent presence of jet hair technology and its rapid growth.

Stock forecasts are trickier to estimate, both for hair and hand dryers. As sales are pretty flat for both, the installed base should not change much by 2020 or 2030. Both are rather replacement markets than developing or booming markets.

Reasons for higher sales and stock would be a return of economic growth and an increase of ownership rates in new Member States. Still economic growth is not at all certain; also reuse and repair, if increasingly popular, tend to make products' lifetime shorter. Perhaps for hand dryers, the release of new technological devices without hot air would support a growth in sales[48].

The graphic below summarises stock forecasts for hair and hand dryers.

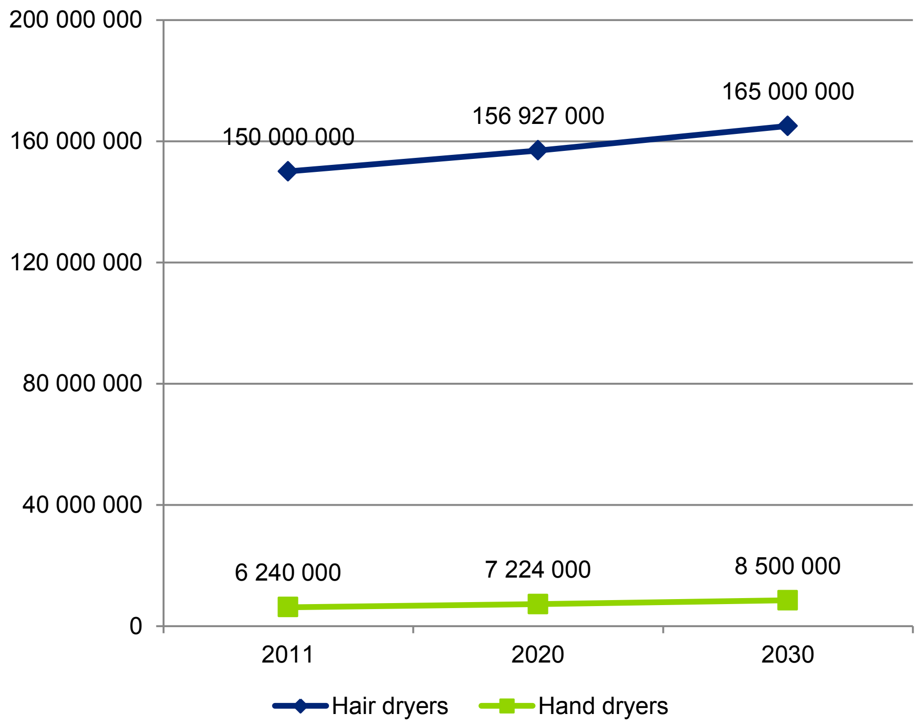


Figure 14: Estimates for current and future stock of hair and hand dryers

6.3 Resource consumption

6.3.1 Energy consumption

Hair dryers

A recent study performed by Oeko-Institut calculated the energy consumption of hair dryers on the basis of 46 models observed, with an input power between 960 and 2,300 Watt (1,937 Watt on

---

[48] Possibly detrimental to paper towel. Jet air hand driers could earn market shares to paper towel.

average). No explicit difference between household and professional hair dryers is made there, although the energy power makes it possible to split all hair dryers observed into two categories. Moreover, two hair dryers were taken as base-cases:

- One with DC motor and maximum power of 1800 Watt; and
- One with AC motor and maximum power of 2000 Watt.

The two base case hair dryers were tested on six use options (three temperature levels and two blower stages), which led to an energy consumption of 78 kWh per year. The average use time was 12 minutes per day, on a basis of an everyday-use.

Other studies have different assumptions and results, but they are generally less detailed than the study by Oeko-Institut.

Table 27: Various assumptions made by previous studies

Study	Average power	Use time	Energy consumption
Oeko-Institut	1,937 W	12 minutes	78 kWh / year
Blue Angel[49]	-	-	65 kWh / year
VHK	1,000 W[50]	10 minutes	50 kWh / year
Energy Saving Trust[51]	-	-	20 kWh / year

Based on the various sources previously mentioned, an average energy consumption of 70 kWh per hair dryer and per year seems a reasonable estimate.

The Gross Energy Requirement (GER) presented in Table 28 is based on calculation with the EcoReport tool over the whole life cycle of the product, considering the production phase based on the bill of materials included in Table 32. Lifetime estimates indicate an average 200 hours, equivalent to 3-4 years, if the hair dryer is used 10 minutes every day. The study by Oeko-Institut takes a lifetime of 4 years as a basis for calculation[52].

Table 28: Energy consumption of a hair dryer

Product group	Average GER (over life cycle)	Average energy consumption in use phase
Hair dryer	2 543 MJ	70 kWh/year

Hand dryers

Various assumptions have been made by the MIT to carry out the hand-drying systems life cycle analysis[53]. Energy consumption per year can be approached through use intensity, and is presented in Table 29.

[49] Blue Angel (2012), Hair Dryers RAL-UZ 175.

[50] This could indicate that consumers are always more eager or encouraged to buy more powerful, nearly professional models.

[51] Energy Saving Trust (2012), Powering the Nation – Household electricity-using habits revealed.

[52] Oeko-Institut (2012), PROSA Haarpflegegeräte – Entwicklung der Vergabekriterien für ein klimaschutzbezogenes Umweltzeichen.

[53] MIT (2011), Life Cycle Assessment of Hand Drying Systems, Commissioned by Dyson.

Table 29: Energy consumption for various hand dryers

Drying system	Airblade®	XLERATOR®	Standard warm air dryer
Lifetime usage	350,000 pairs of dry hands over 5 years = 70,000 pairs a year		
Use intensity	12 sec @ 1,400 W	20 sec @ 1,500 W	31 sec @ 2,300 W
Energy consumption / year (in kWh)	70000*12*1400/360/1000 = 327 kWh	70000*20*1500/360/1000 = 583 kWh	70000*31*2300/360/1000 = 1 386 kWh

Rounding these figures to keep only two categories of hand dryers, one can assume that the average energy consumption per year of:

- A warm air dryer is around 1,400 kWh; and
- A jet air hand dryer is around 450 kWh (gross average of Airblade® and XLERATOR® hand dryers).

Another study conducted by the University of Westminster suggests that the gap between the two types of hand dryers could be even larger, since the mean times to achieve a minimum of 90% dryness of the hands would be 10 seconds for jet air hand dryers and 47 seconds for warn air hand dryers[54].

The figures above are consistent with the claim of manufacturers that jet air hand dryers reduce energy consumption up to 80%[55].

Table 30: Annual energy consumption of hand dryers

Product group	Average GER (over life cycle)	Average (final) energy consumption in use phase
Warm air hand dryer	19.6 GJ	1,400 kWh/year
Jet air hand dryer	6.3 GJ	450 kWh/year

The GER equals to the Cumulative Energy Demand (CED), which has been calculated by the MIT for the functional unit of a single pair of dry hands. They have been multiplied by the assumption of 70,000 pairs of dry hands over one year.

At aggregate level

All figures above can be compiled to get the energy consumption of EU-27 stock for hair and hand dryers, today and in 2020 / 2030.

[54] University of Westminster (2008), A comparative study of three different hand drying methods: paper towel, warm air dryer, jet air dryer. European Tissue Symposium (ETS).

[55] Dyson for instance, with the help of Carbon Trust: http://www.carbontrust.com/our-clients/d/dyson.

Table 31: Aggregate annual EU (primary) energy consumption – Blowers for personal care

Product group	Energy indicator	2011	2020	2030
Hair dryer	EU-27 GER	95 PJ	100 PJ	105 PJ
	EU-27 Energy consumption in use phase	26.3 TWh	27.5 TWh	28.8 TWh
Warm air hand dryer	EU-27 GER	116 PJ	113 PJ	100 PJ
	EU-27 Energy consumption in use phase	20.8 TWh	18.3 TWh	17.8 TWh
Jet air hand dryer	EU-27 GER	2 PJ	9 PJ	21 PJ
	EU-27 Energy consumption in use phase	0.3 TWh	1.8 TWh	3.8 TWh

6.3.2 Other resource consumption

A remark by Oeko-Institut for hair dryers is also applicable to hand dryers: in both cases, the use phase by far the most critical one, and energy consumption should be a major focus. Yet other resource consumption would occur during:

- Production phase (materials use); and
- Use phase, excluding energy consumption (health concerns).

Production phase

Manufacturers of hair dryers use different types of materials, which are summarised in the table below[56].

Table 32: Materials used in average hair dryer

Material	Weight [g]	Share [%]
Polypropylene	103.5	12.9%
Polyamide	78.0	9.7%
Polycarbonate	2.0	0.2%
Acrylonitrile butadiene styrene (ABS)	1.0	0.1%
Nylon	3.0	0.4%
Polyvinyl chloride (PVC)	11.0	1.4%
Aluminium	1.0	0.1%
Copper	156.9	19.5%
Iron-nickel-chrome alloy	14.0	1.7%
Steel	145.0	18.0%
Inductor	6.0	0.7%
Condensators	3.0	0.4%
Resistance	1.0	0.1%

56 Oeko-Institut (2012), PROSA Haarpflegegeräte – Entwicklung der Vergabekriterien für ein klimaschutzbezogenes Umweltzeichen (Tabelle 14: Materialzusammensetzung eines durchschnittlichen Handhaartrockners).

Material	Weight [g]	Share [%]
Ferrite	2.0	0.2%
Diode	1.4	0.2%
Copper-PVC-Cable	16.5	2.1%
Coated paper	23.0	2.9%
Graphite	1.0	0.1%
Cable	205.0	25.5%
Plug	30.0	3.7%
Total	**804.3**	**100.0%**

A simplified bill of materials of standard (warm air) hand dryer is available below. More detailed bills of materials for different types of jet air hand dryers may be found in the MIT study[57].

Table 33: Materials used in average standard hand dryer

Material	Weight [g]	Share [%]
Acrylonitrile butadiene styrene (ABS)	141.8	2.0%
Aluminium (primary)	979.0	14.0%
Aluminium (secondary)	979.0	14.0%
Ceramic tiles	105.7	1.5%
Copper	268.5	3.9%
Electronic component	234.2	3.4%
Galvanized steel	2,184.0	31.3%
Nylon 6	119.7	1.7%
Polyethylene	62.7	0.9%
Steel	1,330.0	19.1%
Zinc	563.5	8.1%
Total	**6,967.8**	**100.0%**

Use phase, excluding energy consumption

Two different health impacts could occur in use phase:

- Noise (both for hair and hand dryers); and
- Hygiene (for hand dryers mostly).

The noise volume of a hair dryer can negatively impact the health of the user, since it used quite close to the ear. Some hair dryers can have a noise level of above 85 or 90 decibels, which classify them in the "very loud" noise category (according to the American Speech-Language-Hearing Association)[58].

Hand dryers too can have a high noise volume. NSF Protocol P335 for Hygienic Commercial Hand Dryers includes requirements related to noise levels: "Any continuous noise, measured at a distance

[57] MIT (2011), Life Cycle Assessment of Hand Drying Systems, Commissioned by Dyson. Table 19 Bill of activities data representing one functional unit of hand dryer systems.

[58] http://www.asha.org/public/hearing/noise/

of one meter directly in front of the system, shall not exceed 90 dBA. Any periodic noise associated with unit operations shall not exceed 100 dBA."[59]

Even if the Dyson Airblade was the first to receive NSF Certification to P335, numerous people have noted that new hand dryers are significantly louder than the older, less energy efficient models[60]. Yet quieter sound levels are available, even in new models including: the Clean Dry by Toto (58-62 dBA), Jet Towel by Mitsubishi (65 dBA), Airforce and AirMax by World Dryer (83 dBA), and SpeedFlow by Saniflow[61].

Also the hygiene of hand driers has been challenged, since they blow hot air with bacteria onto the hand and the face[62]. According to the study from the University of Westminster, "the performance of both the warm air dryer and the jet air dryer was inferior to paper towels in all respects (drying efficiency, bacterial numbers on the hands, bacterial contamination of the air flow and surfaces of the devices, and transmission of bacteria in the washroom) with the one exception that the jet air dryer is equal in drying efficiency. The jet air dryer was shown to be superior to the warm air dryer in all respects except for similar bacterial contamination and greater transmission potential"[63].

6.4 Improvement potential

6.4.1 Improvement potential – Energy consumption

Hair dryers have been manufactured and sold for a longer time now, with no major technological change so far; from this point of view, it seems unlikely that a brand new technology emerges in the next coming years. Still, norms and label pave out the way towards better energy efficiency of hair dryers.

The German Blue Angel label developed the RAL-UZ 175 standard for hand-held hair dryers. According to Blue Angel, "eco-labelled hair care appliances achieve power savings of at least 30 % compared to standard appliances. In addition, Blue Angel eco-labelled hair care appliances meet requirements for noise emission, the plastics and materials used as well as for product safety and durability."[64]

The applicant to this label shall indicate the ratio of power consumption (in Wh) to drying rate of a hand-held hair dryer (DR in g/min). The power consumption to drying rate ratio of a hand-held hair dryer shall not exceed 5.2 Wh/g/min.

For hand driers, the NSF Protocol P335 indicates that certified products must dry the users' hands within 15 seconds, which studies have shown is the typical amount of time a person will spend drying their hands.

In terms of energy consumption, the standard "Low-Energy Hand Driers RAL-UZ 87", by the German Blue Angel, states that the maximum energy consumption in a drying period of 30 seconds shall be

---

[59] NSF International (2007), NSF Protocol P335 for Hygienic Commercial Hand Dryers.

[60] NSF International (2007), Questions & Answers about the new NSF Protocol P335: Hygienic Commercial Hand Dryers.

[61] J. Fullerton (2010), Noise from Energy Efficient Hand Dryers: Is This Progress?, Acoustical Society of America 159th Meeting Lay Language Papers.

[62] See for instance: http://www.dailymail.co.uk/health/article-2335811/Ditch-hand-dryer-Paper-towels-MORE-hygienic-remove-germs.html

[63] University of Westminster (2008), A comparative study of three different hand drying methods: paper towel, warm air dryer, jet air dryer. European Tissue Symposium (ETS).

[64] Blue Angel (2012), Hair Dryers RAL-UZ 175.

0.017 kWh[65]. This corresponds to a yearly energy consumption of 1,190 kWh (with the assumption of 70,000 dry hands a year); i.e. an improvement of 15% compared to the standard warm air hand dryer.

In addition, if we compare the jet hair with the warm air technology, the energy savings would represent 68% (1400 kWh/yr vs. 450 kWh/yr).

Table 34: Improvement potential at individual product level – Blowers for personal care

Product group	Improvement potential (primary energy use) with respect to GER	Improvement potential (primary energy use) with respect to energy consumption in use phase
Hair dryers	-	30%
Hand dryers	-	15% for warm air technology 68% when changing technology

Table 35 presents the estimated savings at EU level for both hair dryers and hand dryers (primary energy).

Table 35: Improvement potential at EU-27 aggregate level – Blowers for personal care

Product group		EU-27 improvement potential (PJ/year)	
		2020	2030
Hair dryers	with respect to GER	-	-
	with respect to consumption in use phase	8.3 TWh = 29.7 PJ	8.6 TWh = 31.1 PJ
Hand dryers	with respect to GER	-	-
	with respect to consumption in use phase	12.4 TWh = 44.8 PJ	12.1 TWh = 43.6 PJ

6.4.2 Improvement potential – Other resource consumption

Beyond noise progress that can be made both for hair and hand driers (see above), a better material efficiency could also be achieved. Especially the German Blue Angel provides qualitative options leading this way. Indeed requirements include:

For hair dryers[66]:

- Plastic parts over 25 grams may not consist of more than two separable polymers or polymer blends;
- Plastic components weighing more than 25 grams shall be marked according to ISO 11469;
- Maximum noise level of 80 dB with the dryer set at the highest speed (fan) and heat settings; and

[65] Blue Angel (2013), Elektrische Händetrockner RAL-UZ 87.

[66] Blue Angel (2012), Hair Dryers RAL-UZ 175.

- In terms of durability, the product shall be subjected to a 400 hour endurance test in 15-minute cycles of operation and pause adding up to a pure operating time of 200 hours. This shall go alongside with a minimum 2-year warranty on the entire product.

For hand driers[67]:

- The plastics used for the Hand Driers shall be marked in accordance with DIN 54840 or ISO 11469, respectively;
- No brominated flame retardants of the plastic parts shall be used; and
- No cadmium-plated parts may be used.

6.4.3 Cost calculation (where possible)

For hair dryers, an average price is provided in the Oeko-Institut study[68]. Depending on models and manufacturers, the average sale price for hair dryers ranges between 15€ and 80€, with most models not exceeding 50€. Hence the study takes on an average price of 41€.

Yet it seems difficult to get reliable prices for BAT hair dryers: the two hair dryers mentioned on the Blue Angel webpage are the "Silvercrest Haartrockner SHTR 2200 A1" by Lidl, which costs 9.99€[69], and the "Relax comfort Haartrockner" by Savoir Vivre International, which costs 89€[70]. It turns out that improvement options for hair dryers, in terms of energy efficiency, do not present excessive cost.

As for hand dryers, the range price is also quite broad, from below 100€ to above 800€[71]. Yet the new air jet hand driers are significantly more expensive than average, with a buying price of around 600€ usually – but as they consume less energy during use phase, the LCC calculation is balanced.

6.5 Summary

Table 36 presents a summary of the product group Blowers for personal care.

Table 36: Summary – Blowers for personal care

	Year	Hair dryers	Hand dryers (warm air + jet air)	Total
Market data				
Sales	**2011**	26 Mio.	1 Mio.	-
Stock	**2011** **2020** **2030**	150 Mio. 157 Mio. 165 Mio.	6.2 Mio. 7.2 Mio. 8.5 Mio.	-
EU-27 Annual primary energy consumption				
Over the life	**2011** **2020**	95 PJ	118 PJ	213 PJ

---

[67] Blue Angel (2013), Elektrische Händetrockner RAL-UZ 87.

[68] Oeko-Institut (2012), PROSA Haarpflegegeräte – Entwicklung der Vergabekriterien für ein Klimaschutzbezogenes Umweltzeichen.

[69] http://www.lidl.de/de/silvercrest-ionen-haartrockner-shtr-2200-a1/p24127

[70] https://shop.relax-comfort.com/relax-comfort-white.html

[71] A large sample of models and prices can be found at: http://www.hygienesuppliesdirect.com/sub/hand_dryers.

	Year	Hair dryers	Hand dryers (warm air + jet air)	Total
cycle	**2030**	100 PJ 105 PJ	122 PJ 121 PJ	222 PJ 226 PJ
In use phase	**2011** **2020** **2030**	26.3 TWh 27.5 TWh 28.8 TWh	21.1 TWh 20.1 TWh 21.6 TWh	47.4 TWh 47.6 TWh 50.4 TWh
EU-27 Annual primary energy savings				
In use phase	**2020** **2030**	8.3 TWh / 29.7 PJ 8.6 TWh / 31.1 PJ	12.4 TWh / 44.8 PJ 12.1 TWh / 43.6 PJ	20.7 TWh / 74.5 PJ 20.7 TWh / 74.7 PJ
Additional information				
		Concerns in terms of noise	Concerns in terms of noise and hygiene	-

6.6 Topics for discussion

Stock data for hand dryers had to be estimated, especially the share in stock of warm air and jet air hand dryers.

The improvement potential in manufacturing phase is difficult to know.

7. Humidifiers and dehumidifiers

7.1 Product group description

Humidifiers and dehumidifiers seem to be included under Prodcom category 28.25.1270: “air conditioning machines not containing a refrigeration unit; central station air handling units; vav boxes and terminals, constant volume units and fan coil units.” However there is no specific category for these devices.

The VHK study defines humidifiers as follows: “Humidifiers means equipment that generates a water mist or steam and releases it into the space where the unit is located or through duct work for transportation to separate rooms/ areas in order to increase the relative humidity of the conditioned air.”

In contrary to that, dehumidifiers are devices that reduce the level of humidity in the air by extracting water from the conditioned air. The collected water, that is called condensate, can be in a liquid or vapour form.

Out of scope

Air purifiers, room conditioning appliances, heating products and air conditioning and ventilation systems are not included, as they are to some extent already covered by other lots. Furthermore their main purpose is not to increase or reduce the humidity in the air.

7.1.1 Humidifiers

As mentioned before, the main purpose of humidifiers is to increase the humidity in the air. Depending on the working principle for generating the mist/steam, humidifiers can be classified by different technologies as:

- Steam humidifier (Vaporizer): a steam humidifier boils water and releases the warm steam into the room;
- Impeller humidifier: In this humidifier, a rotating disc flings water at a comb-like diffuser. The diffuser breaks the water into fine droplets that float into the air;
- Ultrasonic humidifier: An ultrasonic humidifier uses a metal diaphragm vibrating at an ultrasonic frequency to create water droplets. This type of humidifier is usually silent, and also produces a cool fog; and
- Evaporative system: This system uses a paper, cloth or foam wick or sheet to draw water out of the reservoir. A fan blowing over the wick let the air absorb moisture. The higher the relative humidity, the harder it is to evaporate water from the filter, which is why this type of humidifier is self-regulating - as humidity increases, the humidifier's water-vapour output naturally decreases.

Some of these systems include a reservoir/storage tank for water. Humidifiers can be installed as small portable room units, or they can be integrated into your furnace for full-house humidity control. The whole house systems are usually connected directly to a water source.

7.1.2 Dehumidifiers

The main purpose of dehumidifiers is to remove moisture from the air. They operate using one of the following physical methods:

- Thermal condensation: the air is drawn over cold coils, condensing out its moisture, before passing the air over warm coils and back into the room. The air becomes both warmer and dryer. The condensed water drips into a container in the unit that has to be emptied. Water is either drained away or collected in a container in the base of the unit. This type of dehumidifier is also called refrigerant dehumidifier.
- Adsorption / desiccant: the air passes over a desiccant material such as silica gel. The desiccant is often mounted on rotors, belts or other means of transporting it during a cycle of operation. The moisture is then absorbed or retained by the desiccant. The air is then dry and is blown into the room or building. The humidity-saturated desiccant material is heated to drive off the humidity and the vaporised water is blown outside.
- Ionic membrane dehumidifier: water vapour is removed through electrolysis. These devices work with electrochemical dehumidification using a proton conducting ceramic as a solid electrolyte. They are especially used in industrial areas such as fuel cell technology, chemical engineering, and for water improvement.

7.2 Market and stock data

As there is no specific Prodcom category for humidifying und dehumidifying equipment the total stock could not yet be assessed. It can be assumed that these devices are included in data related to air conditioning equipment with Prodcom code 28.25.12.70. Data is presented in Table 37 for EU-27.

Table 37: Market data of Prodcom code 28.25.12.70

Prodcom name	Prodcom codes	Year	Production	Import	Export	Apparent Consumption
Air conditioning machines not containing a refrigeration unit; central station air handling units; vav boxes and terminals, constant volume units and fan coil units	28.25.12.70	2006	2.581.530	124.000	766.000	1.939.530
		2007	1.844.999	259.000	1.565.000	538.999
		2008	1.717.969	400.000	1.405.000	712.969
		2009	1.145.863	533.000	1.200.000	478.863
		2010	1.268.618			
		2011	1.443.966			
		2012	1.466.326			

Legend:

- Cells highlighted in blue are VHK estimates (based on Eurostat data).
- Cells highlighted in purple originate from DG ENTR Lot 6, Task 2 (based on Eurostat data).
- Cells highlighted in yellow indicate that at least one of the national figures in this EU aggregate is estimated.

Regarding the existing stock of humidifiers and dehumidifiers, Energy Star provides data of installed humidifiers in the US (see Figure 15 and Figure 16).

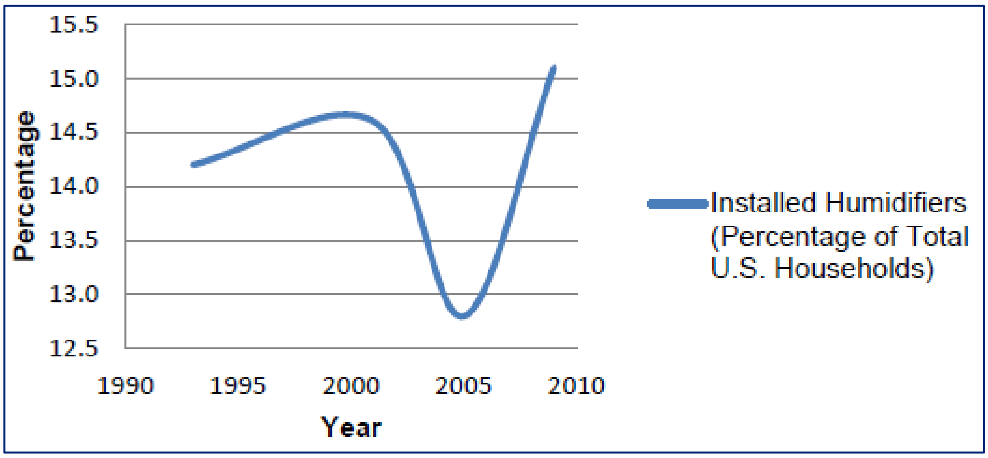


Figure 15: Humidifier usage in the US[72]

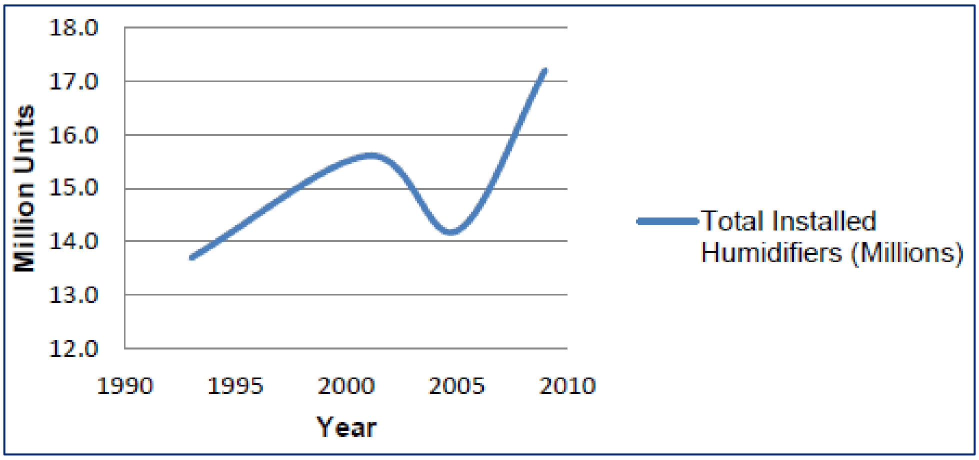


Figure 16: Humidifier market size in the US[72]

A short analysis of the data is added to this chapter at a later point in time.

7.3 Resource consumption

7.3.1 Energy consumption

Depending on the technology the energy consumption of humidifying and dehumidifying systems can vary considerably.

Table 38: Energy consumption individual product level

Product group	Average energy consumption	Source / Study
Steam humidifier	48,720 kWh/a	VHK study
Humidifier using recycled water	473 kWh/a	VHK study
Ultrasonic humidifier	350 kWh/a	VHK study
Dehumidifier	525 kWh/a	UK EST

[72] ENERGY STAR (2012), Market & Industry Scoping Report: Humidifiers.

As shown in the table, devices with steam production need the highest energy input.

The VHK study estimates that the energy consumption of humidification in the tertiary building sector is around 11 PJ primary energy for the EU-27.

Representative data of the stock of humidifying and dehumidifying systems are not available at present. We try to get some data to calculate the energy consumption of the EU-27 stock.

7.3.2 Other resource consumption

As the use phase by far is the most critical one, energy consumption should be a major focus. Yet other resource consumption would occur during:

- Production phase (materials use); and
- Use phase, excluding energy consumption (health concerns).

Production phase

Table 39 shows the main product components of humidifiers and dehumidifiers

Table 39: Components of humidifiers and dehumidifiers[73]

Component	Description
Portable humidifier	
Distribution tray	A reservoir-like container that holds a reservoir of water that is needed to be dispersed into conditioned space.
Evaporative wick	The evaporative wick is soaked with water and moisture is added to the conditioned space.
Electric motor	A small motor is used to vaporize, boil or disperse water mechanically.
Fan	The fan is used to propel moisture from the wick or distribution tray into the conditioned space.
Whole-house humidifier	
Drain	In most models, unused water in a distribution tray will be slushed down a drain to impede mold growth.
Distribution tray	An open container of water which allows the water contained therein to evaporate as air passes through.
Fan	Non-bypass models can use an internal fan to increase airflow over an evaporative wick or a distributive tray to aid in evaporation.
Evaporative wick	In models with a fan, a wick is soaked with water and moisture is added to the conditioned space.
Steam generator	In steam-producing models, electrodes are placed into a cylinder of water that increases its temperature to produce steam.

[73] Holber, N.: How dehumidifiers works (http://home.howstuffworks.com/dehumidifier1.htm)

Component	Description
Dehumidifier	
Fan compressor	This compresses and expands a refrigerant gas to cool the dehumidifier's coils.
Reheater	This captures and collects heat that the cooling process generates.
Compressor cooling coils	These coils use condensation to pull moisture from the air.
Reservoir	Removable plastic bucket.

Most of the bulk material is plastic. Total quantities have not been assessed.

Use phase, excluding energy consumption

The following health impacts could occur in the use phase:

- Noise; and
- Increasing number of bacteria in the room air.

The noise depends on the fan setting of the device. A high setting will produce more noise than a low setting. Besides that, the compressor also makes some noise, slightly more than the fan.

The increasing number of bacteria in the room air is relevant especially for humidifiers. It can be caused by air humidification. On the one side, bacteria like house dust mites, feel more comfortable in increasing humid air and will spread heavily. On the other hand if the device is not cleaned regularly carefully, bacteria and mould will multiply easily inside the device and can be set free during the cleaning of the humidifier.

7.4 Improvement potential

7.4.1 Improvement potential – Energy consumption

Humidifiers

The main improvement potential lies in the technology applied for creating the steam. Instead of heating up to boiling point the more energy efficient technologies rely on creating a mist of fine particles (droplets) of cold water. According to the VHK study, a cold water spray system requires roughly one tenth of the energy demand of a steam production humidifier.

The Energy Star Market and Industry Scoping Report made assumptions regarding the savings potential of domestic humidifier. The report compares hypothetical humidifiers that consume energy at 75^{th} quartile of the market to comparable hypothetical humidifiers that consume energy at 25^{th} quartile of the market. The results are illustrated in the following tables.

Table 40: Improvement potential individual product level

Product group	Improvement potential (kWh)	Annual operating hours	Annual improvement potential (kWh/a)
Portable humidifiers according to Energy Star			
Ultrasonic humidifier	0.014	843.25	11.81
Cool mist humidifier	0.043	843.25	36.26
Warm mist humidifier	0.095	843.25	80.12
Whole-house humidifier			
Fan powered humidifier	0.018	843.25	15.18
Steam humidifier	0.506	843.25	426.68

An extrapolation of the stock in EU-27 will be done, if reliable data is available.

Dehumidifiers

Kabeel and Bassuoni[74] compared two kinds of dehumidifying systems: a desiccant system and a traditional vapour compression system. Regarding the improvement potential of the energy consumption they came to the conclusion that around 35 % of the energy could be saved by using the desiccant system instead of the vapour compressing system.

Also within the same technology energy savings can be achieved. Energy Star for example points out that an energy efficient dehumidifier removes the same amount of moisture as a similarly-sized conventional unit, but uses 15% less energy.

An extrapolation of the stock in EU-27 will be done, if reliable data is available.

7.4.2 Improvement potential – Other resource consumption

Improvement options for resource consumption have not been assessed.

7.4.3 Cost calculation (where possible)

A cost calculation has not been done, as the VHK study assumes that the improvement can be achieved without excessive costs to manufacturers or end-users.

7.5 Summary

Table 41 presents a summary of the product group humidifiers and dehumidifiers.

Table 41: Summary – humidifiers and dehumidifiers

	Year	Steam humidifier	Humidifier using recycled	Ultrasonic humidifier	Dehumidifier	Total

[74] Kabeel, A. E.; Bassuoni, M. M.: Feasibility Study and Life Cycle Assessment of Two Air Dehumidification Systems, Global Advanced Research Journal of Engineering, Technology and Innovation (ISSN: 2315-5124) Vol. 2(9) pp. 250-258, October, 2013.

		water				
Market data						
Sales	**2011**	n.a.	n.a.			n.a.
Stock	**2006** **2007** **2008** **2009**	n.a.	n.a.			1.94 Mio. 0.54 Mio. 0.71 Mio. 0.48 Mio.
EU-27 Annual primary energy consumption						
Over the life cycle	**2011** **2020** **2030**	n.a.	n.a.	n.a.	n.a.	n.a.
In use phase	**2009**	23.33 TWh	0.23 TWh	0.17 TWh	0.25 TWh	23.98 TWh
EU-27 Annual primary energy savings						
In use phase	**2020** **2030**	n.a.	n.a.	n.a.	n.a.	n.a.
Additional information						
		-	-			-

7.6 Topics for discussion

- The market data relies on the Prodcom category that covers many more products than humidifiers and dehumidifiers.
- Reliable data of the stock in the EU is needed.
- The assumption of the VHK study, that improvements can be achieved without excessive costs to manufactures or end-users needs to be confirmed or amended by further analysis.

8. Imaging equipment

8.1 Product group description

This product group consists of equipment used for copying, printing and scanning documents. The group also includes equipment for transmitting facsimiles (fax machines). Variations in functions include:

- Colour or black and white printing;
- Single function (SF) or multifunction devices (MFD); and
- Printing method – electrophotography (EP), inkjet (IJ) and solid ink (SI) are included in scope, as these include most of the market.

This group includes designs made for home and office use and so industrial printers, dot matrix printers and high speed printers designed for printing books, magazines, etc. are excluded. The scope of this product group could be the same as the current imaging equipment voluntary agreement that was established after the DG ENER Lot 4 Imaging Preparatory Study carried out by Fraunhofer IZM and completed in 2007.

8.2 Market and stock data

Fraunhofer IZM included sales and stocks data in its preparatory study report, but this is now out of date. Prodcom Eurostat data is however available for EU production, imports and exports which can be used to calculate EU consumption for photocopiers, printers and fax machines. However, the categories have changed between 2004 and 2007 so current data are not directly comparable with the data published by Fraunhofer.

Table 42: Market data from ENER Lot 4 Preparatory Study for 2004 and from Prodcom for 2012, (EU25 totals, millions)

Product group / Prodcom code	EU production sold		EU imports		EU exports		Apparent EU consumption	
	2004	2012	2004	2012	2004	2012	2004	2012
Photocopiers	-		3.9		2.1		2.07	
Printers	0.9		37.4		27.5		27.1	
Fax machines	3.6		4.1		3.6		7.2	
Total – photocopiers, printers & fax	4.5		45.4		33.2		30.4	
26.20.16.40		3.16		10.87		4.36		9.67
26.20.18.00		6.0		21.9		3.76		24.1

Product group / Prodcom code	EU production sold		EU imports		EU exports		Apparent EU consumption	
	2004	2012	2004	2012	2004	2012	2004	2012
Total of 26.20.16.40 and 26.20.18.00		9.16		32.8		8.12		33.8

The two Prodcom categories with large numbers of sales in the EU are:

26.20.16.40 - "Printers, copying machines and facsimile machines, capable of connecting to an automatic data processing machine or to a network (excluding printing machinery used for printing by means of plates, cylinders and other components, and machines performing two or more of the functions of printing, copying or facsimile transmission)"

26.20.18.00 - "Machines which perform two or more of the functions of printing, copying or facsimile transmission, capable of connecting to an automatic data processing machine or to a network (multifunctional devices)"

Products in other categories have much smaller or negative consumption totals, so are not considered here.

It may be possible to estimate future sales from past sales using Prodcom data between 2008 and 2012 for EU consumption:

Table 43: Past EU Prodcom consumption data

Product group	EU Consumption				
	2008	2009	2010	2011	2012
26.20.16.40	17.1	9.8	9.6	16.9	9.7
26.20.18.00	20.7	18.3	21.4	10.3	24.1
Total of 26.20.16.40 and 26.20.18.00	37.8	28.1	31	27.2	33.8

Apart from the unusually high value in 2008, despite the fluctuations, there does not appear to be a significant increase or decrease in annual consumption. Consumption in 2004 was 30.4 million which is similar to the average of the 2009 to 2012 (30.0 million) consumption figures. Therefore, it would be reasonable to assume no significant increase or decrease in the future are likely, but manufacturers would be able to make more informed predictions.

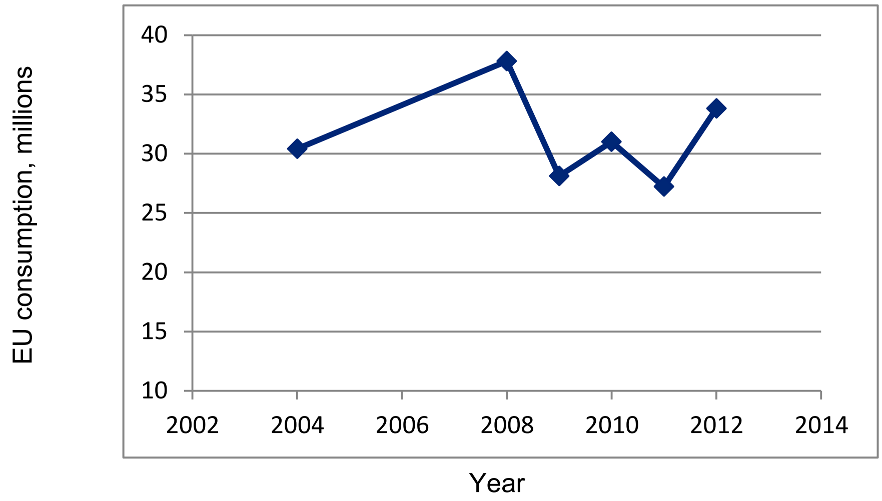


Figure 17: Consumption of imaging equipment in the EU (millions)

Estimates of stocks in the EU for 2005 and 2012 are given below.

Table 44: EU Stock for 2005 from ENER Lot 4 Preparatory Study and an estimate for 2012 based on 2012 consumption and a 5 year lifetime (millions)

	EU Stock	
Product group	**2005**	**2012**
Photocopiers	6.35	
Printers	106.8	
Fax machines	20.1	
Total	133.25	
Total of 26.20.16.40 and 26.20.18.00		169

The most common type of printers that were sold in 2007 today is ink jet type. The market share of multifunctional devices that copy, print, scan and sometimes also fax has been increasing since before the Fraunhofer study (predicted by Fraunhofer and confirmed by Prodcom data, see Table 43), so that in 2012, they were the most common type sold in the EU.

8.3 Resource consumption

8.3.1 Energy consumption

Data from the ENER Lot 4 Preparatory Study is provided here. This study found that ink jet multifunctional devices (IJ MFD) were the most commonly sold and this trend was expected to continue and so the base cases for this type of device are considered here. Resource consumption and environmental impacts were calculated by Fraunhofer using printer composition data from five colour multifunction ink jet printers. The average composition is given in table 26 of the Lot 4 task 4 report and this data has been used to recalculate the environmental and health impacts using the MEErP EcoReport Tool. Lifetime was assumed at 4 years (as did Fraunhofer) and annual energy consumption of the midpoint of the range of base case V5 energy consumption given in the

Fraunhofer report of 22.3kWh (Fraunhofer used a slightly smaller figure for base case V5, but the slightly larger figure used here is to reflect all imagine products as only one EcoReport calculation is included here).

The results from the EcoReport Tool are shown below.

Table 45: Lifetime energy consumption and other lifetime impacts at individual product level and EU-27 level from all products sold in one year from EcoReport

Selected impact	Individual product impact	EU-27 impact
Total primary energy (GER)	2,308 MJ	73.8 PJ
Electricity (primary energy)	1,257 MJ	40.2 PJ
Waste, non-hazardous	5.43 kg	173,846 tonnes
Waste hazardous	213 g	6,819 tonnes
Heavy metals emissions to air	84 mg Ni eq.	2.7 ton Ni eq.
Heavy metals emissions to water	67 mg Hg/20	2.1 ton Ni eq.
PAH	238 mg Ni eq.	7.6 ton Ni eq.
Particulate matter	193 g	6,185 tonnes
Eutrophication (water)	3 g PO4	67.8 tonnes PO4

8.3.2 Other resource consumption

The main resources used in a colour multifunctional printer from the Fraunhofer Lot 4 Preparatory Study are as follows:

- Bulk materials: the main materials used are various types of plastics and galvanized steel sheet. Each device typically also includes several printed circuit boards
- Precious or rare resources: Scarce raw materials are used on printed circuit boards within electronic components, such as gold and palladium. Chromium is present in stainless steel parts and most products have a liquid crystal display which will include indium as a thin indium tin oxide coating
- Process water is used in the production process and at end of life. The amount of water used was calculated as106 litres per unit from the EcoReport Tool, plus 873 litres for cooling
- Hazardous substances are regulated by RoHS and REACH so should not be present unless permitted by exemptions. However there are heavy metals emissions calculated by EcoReport, mainly during the production phase.

Imaging equipment is sold in large numbers and according to Fraunhofer had a relatively short lifetime. The current lifetime may not be the same as during the Fraunhofer study and printer BOMs may also be different.

Printers sold to consumers may be disposed of via municipal waste sites or returned to retailers. Business equipment is more likely to be returned to suppliers for disposal. Business photocopiers are often leased to users and returned after several years to be recycled by the original manufacturers who reuse many of the parts in new machines. This business model is highly beneficial to the environment as this avoids making new parts and so significantly reduces the environmental impacts from the production phase. Some printers and copiers are refurbished for second users.

Parts from low-priced printers are not however refurbished or their parts reused as these parts are less robust. Most low end printers will be mixed with other consumer waste after disposal at end of life, and sorting the millions of tonnes collected without damage would be very difficult.

8.4 Improvement potential

The performance of printers, copiers, fax and multifunctional device is defined by an Energy Star standard. During the ENER Lot 4 Preparatory Study, v1.2 was available whereas an updated v2.0 is now also available. However, the Imaging VA is based on v1.1, although the energy consumption maximum values are essentially the same in v1.1 and 1.2. Energy Star assesses performance in one of two ways depending on the type of device:

TEC = “Typical Electricity Consumption” is a measure of weekly energy consumption of a device used in a standard way. This method is used for most electrophotographic (EP) copiers and printers – often known as laser printers or copiers.

OM = “Operational Mode”, is used to compare products but does not give a single value for total energy consumption. This method is used for most types of ink jet printers and multifunctional devices with ink jet printing.

The differences between v1.2 and v2.0 of the Imaging Energy Star standard are summarized below:

Table 46: Energy Star Imaging standard, maximum TEC values

Standard version	Maximum TEC per week for multifunctional colour printer at 20 images per minute
V1.1 and 1.2	5.5 kWh/week
V2.0	2.65 kWh/week

This decrease is a 48% reduction in energy consumption decrease, which is very significant in relative terms.

Table 47: Energy Star Imaging standard specifications for Operational Mode (OM)

Characteristic	V1.1 and 1.2	V2.0
Sleep mode energy consumption (20 images per minute multifunctional device (colour)	1.4 W	0.6W
Standby energy consumption*	1.0 W	0.5W
Internal power supply efficiency	Regulated	No longer regulated

* As per the EU standby regulation.

The Energy Star imaging standard also specifies maximum energy consumption for various functions which are added to the sleep mode maximum values and some of these decreased between v1.1 / 1.2 and v2.

8.4.1 Improvement potential – Energy consumption

The Fraunhofer IZM preparatory study calculated annual energy consumption as "Typical Electricity Consumption" (TEC)[75]. They concluded that average electricity consumption was a factor of 0.8 of TEC (based on v1.1 / 1.2) and was achieved in 2005. They predicted that under the base case scenario (i.e. business as usual), this would decrease to 0.7 of TEC by 2015. This is equivalent to a decrease in energy consumption of 12.5%. However, due to increasing levels of stocks in the EU, a switch from black and white to colour and an increase in the proportion of multifunctional devices, the total EU-27 energy consumption was predicted to increase, despite this lower energy consumption under business as usual.

Fraunhofer also however predicted a "best case scenario" where BAT (best available technology) would be adopted and past improvements would continue and this would result in a decrease in average energy consumption from 0.7 TEC in 2005 to 0.6 TEC by 2015 and to 0.5 TEC by 2020. Fraunhofer stated that this should be achievable and that total EU-27 energy consumption would decrease despite the trends mentioned above. Under the BAT scenario, annual average energy consumption would decrease by over 28% between 2005 and 2020. As the base case total sector use phase energy consumption was 7.8TWh in 2005, a 28% decrease would give a potential primary energy saving of 2.2TWh per year.

Fraunhofer also considered the production phase energy consumption as this is significant in comparison with the use phase. They estimated that total EU-27 use phase energy consumption in 2005 was 7.8 TWh whereas production phase energy consumption in 2005 was 55.7 PJ (15.5 TWh), which is significantly larger. Fraunhofer determined that this would increase due to the trends discussed earlier, although imaging equipment designs will have changed since 2007 so there is some uncertainty over the size of the actual production phase energy consumption. The relatively short lifetimes of these types of equipment (3 – 5 years) may give an opportunity to reduce production phase energy consumption if this can be lengthened. Doubling lifetime, for example would save 28PJ (7.75 TWh) primary energy per year.

In this assessment, the impacts of colour inkjet MFD were calculated using the MEErP EcoReport Tool to represent this product group. This used a use-phase energy consumption of 22.3kWh per year (the mid-point of range of values in 2007 prep study report for this type of device), to calculate the EU energy consumption of stocks of 169 million to be 3.77 TWh/year. If the energy saving potential is 28%, as assumed by Fraunhofer, the **potential EU saving will be 1.06 TWh per year**. However, actual energy savings will depend on two factors – i) energy savings that have been made since 2007, so reducing the potential savings, and ii) photocopiers and EP printers have higher energy consumption than inkjet MFD and although these are understood to be a smaller proportion of the total market, this could increase the total figure. Due to the lack of current market and energy consumption data, the true savings potential is uncertain, but it is clearly not very large.

There may also be lifecycle savings available if average product lifetimes could be increased. There would also be savings if the approach used for business photocopiers (reuse of parts) could be extended to printers, but this would require significant effort in managing end of life so that printers can be collected separately. The EU would also need to ensure that other legislation such as RoHS and REACH do not inhibit the reuse of parts from older equipment or the repair of older equipment. These policy options would also benefit other environmental impacts as emissions and energy consumption in the production phase are both relatively large.

---

[75] TEC is measured using the method defined by Energy Star. During the ENER Lot 4 Preparatory Study, this was v1.0 for imaging equipment.

8.5 Summary

Table 48 presents a summary for the product group “Imaging equipment”.

Table 48: Summary – Imaging equipment

	Year	based on Fraunhofer IZM				based on Prodcom		
		Photocopiers	Printers	Fax	Total	26.20.16.40	26.20.18.00	Total
Market data								
Sales (EU 25, millions)	**2004**	2.07	27.1	7.2	30.4			
	2008					17.1	20.7	37.8
	2009					9.8	18.3	28.1
	2010					9.6	21.4	31
	2011					16.9	10.3	27.2
	2012					9.7	24.1	33.8
Stock (estimate, millions)	**2005**	6.35	106.8	20.1	133.25			
	2012							169
EU-27 Annual primary energy consumption								
Over the life cycle								73.8 PJ
In use phase								40.2 PJ
EU-27 Annual primary energy savings								
In use phase								1.06 TWh/year

8.6 Topics for discussion

As a result of the Lot 4 imaging preparatory study, the industry set up a voluntary agreement (VA) to achieve energy savings in the use phase and this has been in operation since 2011. The aim of the VA is for a minimum number of printers, copiers, scanners and multifunction devices placed on the market to achieve compliance with the Energy Star standard v1.1. More than 95% of units sold in the EU are manufactured by manufacturers who are members of the VA and >97% of imaging equipment that was in scope of the VA was in full compliance in 2013. The next phase, currently being discussed is to comply with Energy Star standard v2.0 from January 2015 with 70% being required to meet the v2.0 TEC requirement in 2015 rising to 80% in 2016 and 88% meeting the OM requirement in 2015 and 90% in 2016.

It is important to understand the difference between the aims of Energy Star and the most common eco-design option used in the EU for consumer products, i.e. the energy label:

- **Energy Star**: In general, for electrical appliances, this aims to set a minimum performance standard that includes 80 – 90% of products currently on the market. This has the effect of removing the least energy efficient models from the market. Although Energy Star is voluntary, consumers will often avoid models that do not meet the Energy Star standard so it is effective at reducing energy consumption. One limitation of Energy Star is that there is little incentive for improvement (apart from the prospects of revised versions with lower maximum energy consumption requirements) as there is no differentiation of models on the market. Appliances either comply or not. In the USA, measurement of performance by independent test houses is mandatory and spot checks are also carried out, but in the EU, this is totally voluntary. Mandatory testing of imaging equipment sold in the EU is in effect carried out in the USA, as long as the models sold in the EU and the USA are the same. The difference between v1.1 /1.2 and v2 of the imaging standard is quite large when TEC is the method of assessment, but the improvement when OM is used is less clear, although there is believed to be a significant energy saving between v1.1 and v2 for ink jet printers that use the OM method..

- **EU Energy Label**: This approach uses seven energy ratings, e.g. A to G to inform users of energy performance based on standard energy consumption measurement methods. Any appliances that cannot meet the lowest energy rating cannot be sold in the EU so the worst performing products are removed from the market and this is mandatory, unlike Energy Star. Consumers are able to determine which products will use the least energy and so this approach is a powerful incentive for continuous improvement by manufacturers. The difference in energy consumption of a G-rated appliance and an A-rated appliance can be very significant. In practice, this approach has to be mandatory so that market surveillance can check the accuracy of energy labels and prevent manufacturers from providing misleading information.

Fraunhofer estimated in their report that a reduction in TEC of 28% was achievable and 0.5 TEC (based on Energy Star v1.0) was possible by 2020. The proposed next phase for the imaging VA is to adopt Energy Star v2.0. The difference in TEC of equipment that uses the TEC method between the current v1.1 and v2.0 of the standard is quite a large decrease in maximum TEC (e.g. 48% for colour MFD). However, the most common type of imaging product sold in the EU are ink jet MFDs where the OM method is used. Although standby and sleep modes are regulated by Energy Star and both have decreased significantly from v1.1/1.2 to v2.0, the energy consumption when in the operating mode (i.e. when printing) is not specified in the Energy Star standard.

Market trends since the Lot 4 imaging preparatory study have seen significant changes in the distribution of types of new sales. Black and white printers are now primarily sold to businesses with colour ink jet printers being predominant with consumers. Most printers are also copiers and can also scan so the majority of equipment would be classified as multi-functional devices. Fax machines sales have all but disappeared with the switch to email and scanner sales are now very few as most printer/copiers also scan documents. Ink jet is the dominant print medium although EP products are still sold in large numbers.

Some current sales data is available (from Prodcom) but actual energy consumption data for each print medium is not published so the variation between models cannot be determined. Moreover, although manufacturers will measure the energy consumption of their own imaging products, the results will be company confidential and not publically available. Fraunhofer determined in 2007, however that there are ways in which energy consumption can be minimised and so if mandatory Energy Labels were to be adopted, there should be opportunities for manufacturers to reduce energy consumption to achieve the best energy ratings.

The Task 4 report of the Lot 4 imaging prep study states that for most base cases, there was a large variation in the energy consumption of products on the market. The product type with largest sales was base case V5; “ink jet multifunctional devices (colour)”, which had a use phase energy consumption range from 6kWh/year to 38.6 kWh/year at the time of the reparatory study. Although this range is at least in part due to variations in product characteristics, such as print speed (images per minute) and functions, this does suggest that there was improvement potential.

Energy Star also has requirements for several other aspects of imaging equipment, for example to minimise the amount of paper used, etc. and these obligations are met by the imaging VA.

The Energy Star standard for imaging equipment uses a standard energy consumption method to so this could be used as the basis for EU energy labelling, if this were to be considered.

8.7 Conclusions

Data used for the Fraunhofer study is now almost ten years old. If a mandatory implementing measure were to be considered, then the changes in the imaging equipment market, equipment design and reductions in energy consumption that have occurred since the study was completed will first need to be reassessed. The Fraunhofer study found that the base case sector energy consumption was 7.8TWh per year. A potential energy saving of 28% was predicted by Fraunhofer that was equivalent to **a saving of 2.2 TWh.** Clearly, there have been reductions in energy consumption since 2007 and so the current improvement potential for the use phase is probably less than 2TWh per year.

Since, 2007, the proportion of ink jet printers has increased and these use less energy than EP devices and despite the trends discussed earlier, the sector's total energy consumption may have decreased, irrespective of the impact of compliance with Energy Star. This assessment has carried out one simple MEErP EcoReport calculation using colour ink jet MFD and with the potential use phase primary energy saving of 28%. This concluded that use phase primary energy savings are likely to be of the order of only about 1TWh.

The EcoReport calculation made by Fraunhofer and in this assessment suggests that the production phase energy consumption is quite large (Fraunhofer's estimate was 15.5TWh/year) and so if lifetimes could be lengthened, significant savings would be achieved:

- 25% lifetime increase (4 years to 5 years) will result in four printers used in a 20 year period instead of five, so production phase impacts are 20% lower = 3.1 TWh/year

However, this assumes no design changes since the Lot 4 imaging prep study was carried out, which is unlikely, so saving may be smaller if modern products are smaller and lighter with smaller and fewer PCBs, so this needs to be reassessed using an up-to-date BOM.

A binding implementing measure instead of the current Voluntary Agreement would have both advantages and disadvantage.

Advantages of mandatory eco-design requirements:

- Possibly, greater transparency of the process, particularly for equipment that uses the OM Energy Star method
- All manufacturers would have to comply
- The reassurance from market surveillance that data should be accurate
- If energy labelling is adopted, users would be able to select the most energy efficient designs. This in turn would give an added incentive beyond that already achieved by Energy Star
- Implementing measures could include obligations that encourage longer lifetimes which will reduce lifetime energy consumption as well as reducing the amounts of emissions and waste

Disadvantages:

- Over 90% of the market is already covered by the VA
- Greater costs to Member States and the Commission for market surveillance

- Any additional use phase energy saving is likely to be relatively small (< 2TWh per year)
- Additional measures on lifetimes could in principle be implemented in a revision of the VA
- Increased compliance costs for industry, which are likely to be passed on to users.

It is worth noting that standby power consumption of printers and external power supplies for printers are already regulated by eco-design implementing measures. Many ink jet printers are supplied with external power supplies.

9. In-house networking equipment

9.1 Product group description

9.1.1 Internet at home

As a reminder, and to introduce the subject, there are several ways to have high-speed (broadband) Internet at home. Indeed, different channels are used to pass on data from the Internet to the home, including:

- **Telephone network (ADSL)**: The telephone cable can carry different frequencies, up to 1.1 Mhz. The lowest frequency range, between 0 and 140 KHz, is used to carry voices; the frequency range between 20 and 140 KHz is used to upload data; the frequency range between 150 and 1,100 kHz is dedicated to download data[76];
- **Cable**: The cable is an old technology that was originally destined for television broadcasting and which can also be used for Internet transmission, at similar speeds to ADSL; and
- **Optical Fibre:** Optical fibre is a more recent technology that allows data to circulate at a much higher speed. Unlike the (coaxial) cable and telephone cable, made out of copper, optical fibre is a cable made out of glass or very thin plastic that can conduct light. A great advantage with this material is that signal over long distances is only slightly mitigated, but it still has to be installed in many European homes: whilst almost all homes have transitioned to the telephone cable, only 5% possess optical fibre[77].

9.1.2 Home network equipment

While three different means are most commonly use to “bring” Internet to the households, only one device exists to “receive” it, the **modem**. The function of a modem is to connect the household to its (broadband) Internet service provider. A **router** is often directly linked to the modem and used to connect various terminals (computers, printers, tablets, etc.) within a household. “Hub” may be employed as a synonym of router. The modem processes the Internet signal and manages connectivity; the router identifies connected devices and establishes a bridge between them.

While modems and routers may be used as standalone devices, they are more and more combined together in one **gateway**, or Integrated Access Device (IAD), or “Internet box”. Sky Box in the UK, Freebox in France, Fritz!Box in Germany are examples of gateways.

Energy Star defines “network equipment” as a device whose primary function is to pass Internet Protocol (IP) traffic among various network interfaces / ports. Energy Star divides network devices into two main categories[78]:

- Broadband Access Equipment:

[76] The frequency range between 5 and 20 kHz is left empty to separate telephone data from Internet data.

[77] FTTH Council Europe (2013), Winners and losers emerge in Europe’s race to a fibre future. 5% is a gross average, since Germany, France, Spain, Italy and the UK are below this mark. Yet Lithuania and Sweden are above 20%.

[78] Energy Star (2013), Product Specification for Small Network Equipment – Eligibility Criteria, Version 1.0.

- Broadband Modem: receives a broadband signal from a cable or telephone service provider via a coaxial, telephone or fibre-optic cable; and
- Gateway or Integrated Access Device (IAD): includes a modem and one or more of the following functions: wired network routing, multi-port Ethernet switching and/or access point functionality. A gateway that receives a broadband signal over a fibre-optic cable is called an Optical Network Termination Device (ONT);

- Local Network Equipment:
  - Access Point: provides wireless network connectivity to multiple clients as its primary function;
  - Router: determines the optimal path along which Internet traffic should be forwarded as its primary function; and
  - Switch: filters, forwards, and floods frames based on the destination address of each frame as its primary function.

On top of that, the European Joint Research Center (JRC) has been working since ten years on a "Code of Conduct" on Energy Consumption of Broadband Equipment. The version 5.0 was published in December 2013[79], which covers equipment for broadband services both on the customer side (Customer Premises Equipment or CPE), and on the network side. The network side is further studied by ENTR Lot 9 on "Enterprises' servers, data storage and ancillary equipment", and it is out of scope of the present analysis.

9.1.3 Scoping

Following the definitions above, Figure 18 gives an overview of in-house networking equipment. Italic writings on the left and right sides indicate ordering by the JRC and by Energy Star. Devices marked in green are those in scope.

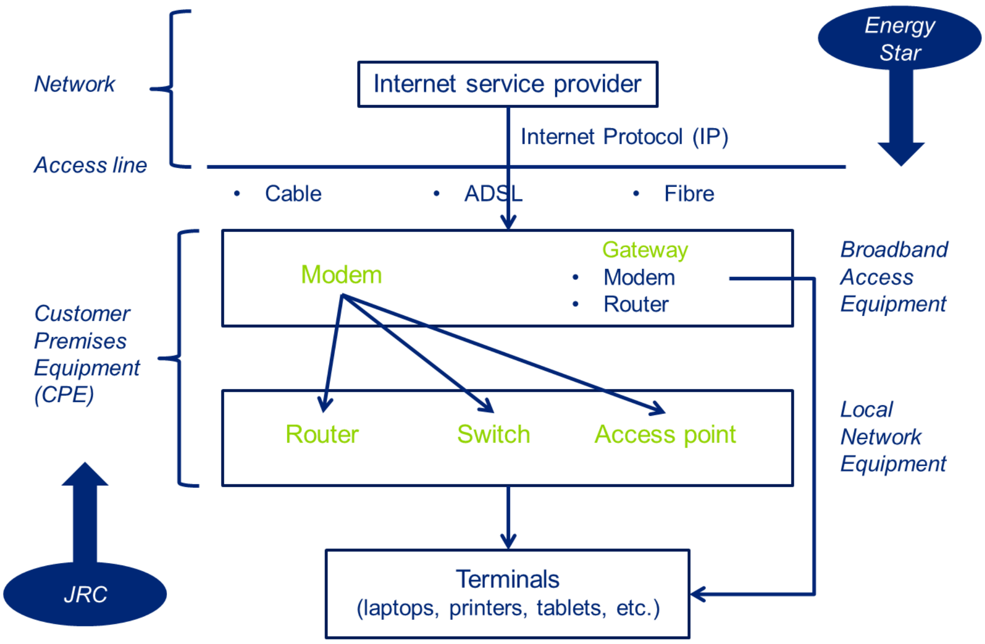


Figure 18: Simplified diagram of equipment to provide Internet access to final customer

[79] European Commission – Joint Research Center (2013), Code of Conduct on Energy Consumption of Broadband Equipment, Version 5.0.

Pictures of network devices in scope are available in Figure 19 below.

Modem[80]

Gateway[81]

Router[82]

Switch[83]

Access point[84]

Figure 19: Examples of products in the scope of the product group "In-house networking equipment"

To study this "in-house networking equipment" product group, we will extensively rely on a recent paper from the Natural Resources Defense Council (NRDC), which carried out a very similar exercise in the United States[85].

[80] http://computer.howstuffworks.com/dsl.htm

[81] http://www.voipmonitor.net/2007/02/14/Comtrend+Debuts+CT6382T+Integrated+Access+Device.aspx

[82] http://en.wikipedia.org/wiki/Wireless_router

[83] http://www.dlink.com/uk/en/business-solutions/switching/unmanaged-switches

[84] http://www.amazon.com/Cisco-Aironet-1602i-Standalone-Access/dp/B00BB3FTVA

9.2 Market and stock data

Partial data is available from Prodcom, with two relevant codes:

- 26.30.23.20: "Machines for the reception, conversion and transmission or regeneration of voice, images or other data, including switching and routing apparatus"; and
- 26.12.20.00: "Network communications equipment (e.g. hubs, routers, gateways) for LANs and WANs and sound, video, network and similar cards for automatic data processing machines".

While the second category could cover gateways (Internet boxes), the first is perhaps more appropriate for standalone devices, although this is not explicit. The two names are somehow confusing anyway, since the router function for instance is present in both categories.

Table 49: Prodcom data - In-house networking equipment

Prodcom name	Prodcom codes	Year	Production	Import	Export	Apparent Consumption
Machines for the reception, conversion and transmission […]	**26.30.23.20**	2006				
		2007	195,766,201			
		2008	44,947,841			
		2009	36,707,477			
		2010	52,168,184			
		2011	59,119,491			
		2012	38,873,915			
Network communications equipment […]	**26.12.20.00**	2006				
		2007				
		2008	9,146,131			
		2009	2,904,537			
		2010	769,731			
		2011	7,811,299			
		2012	5,228,484	1,296,856	175,211	6,350,129

Legend: Cells highlighted in yellow indicate that at least one of the national figures in this EU aggregate is estimated.

Average sales of about 50 million units a year in EU-27 may be considered a correct estimate for in-house networking equipment as defined above, including modems, gateways, routers, switches and access points. However, Eurostat data show important variations what does not provide a high level of confidence in the their reliability.

The installed base of home network devices can be derived from the number of users in Europe. According to Eurostat, in the EU-27, 79% of households had access to the Internet in 2013 and 76% had a broadband Internet connection[86]. With about 218 million households in Europe, this would lead to a total of 172 million broadband access equipment installed. Yet, we would have to guess the share of the different types of devices, assuming a significant share of gateways probably (typically 50%).

[85] Natural Resources Defense Council (2013), Small Network Equipment Energy Consumption in U.S. Homes – Using Less Energy to Connect Electronic Devices.

[86] Eurostat News Release (2013), Internet access and use in 2013.

Building on data from NRDC (2013), we may come up with following estimates for stock in 2013.

Table 50: Estimates of 2013 stock data - In-house networking equipment (in million units)

	US Total	US per household[87]	Broadband / Local	EU-27 Total	EU-27 per household	Broadband / Local
Modems	40	0.35	0.77 Broadband	42	0.20	0.76 Broadband
Gateways	42	0.37		112	0.49	
Gateways (ONTs)	6	0.05		12	0.06	
Routers	53	0.46	0.49 Local	56	0.26	0.29 Local
Switches	1	0.01		3	0.01	
Access points	2	0.02		4	0.02	
Total	144	1.25	1.25	229	1.05	1.05

The table is consistent in that it shows higher rates in the US, and a different repartition of devices between the US and the EU – assuming more gateways in the EU, since this is really the standard offer in at least Germany, France and the UK. The 6% mark of ONTs in Europe is consistent with the 5% rate given by FTTH Council Europe (stated above).

Stock forecasts can be modelled as follows, considering the market is an undoubtedly growing one. Especially ONTs are promised to rise in the very coming years.

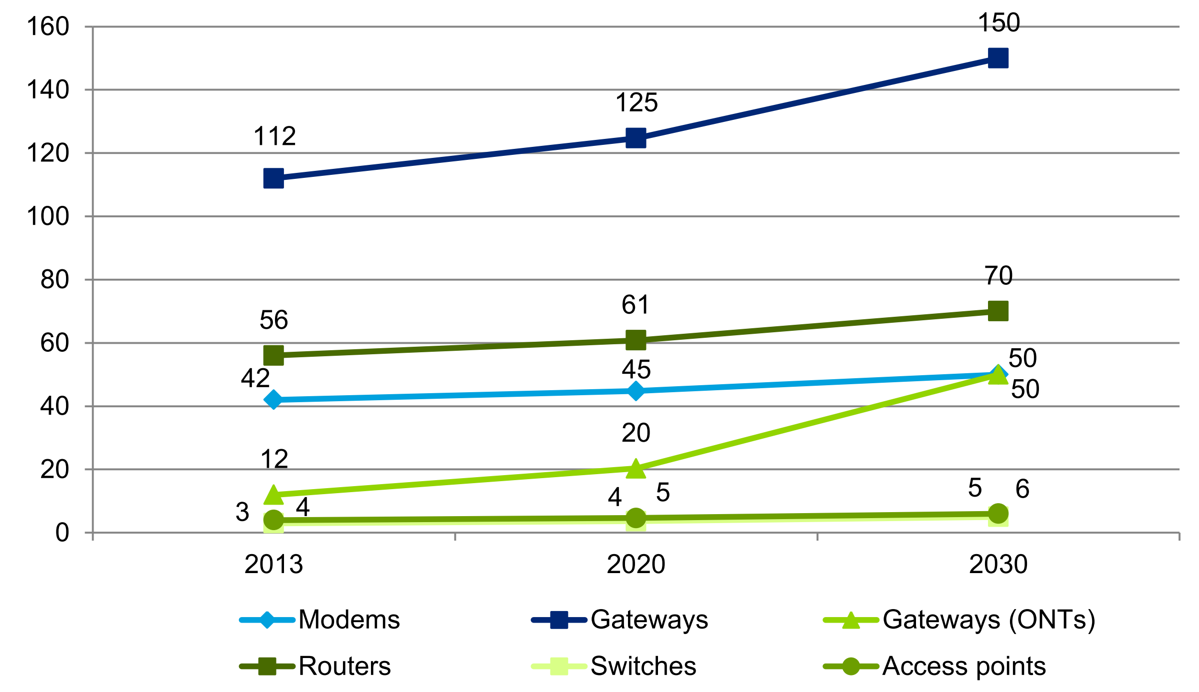


Figure 20: Estimates for current and future stock – In-house networking equipment

---

[87] With 115 million households in the US (http://www.census.gov/prod/2013pubs/p20-570.pdf).

9.3 Resource consumption

9.3.1 Energy consumption

Based on a total of 60 models tested, the Natural Resources Defence Council (NRDC) comes up with precise estimates of average energy consumption.

Table 51: Estimated (final) energy consumption of residential small network equipment

Product type	Average power (W)	Average unit energy consumption (kWh / year)
Modems	5.7	50
Gateways	7.9	69
Gateways (ONTs)	16.2	142
Routers	5.7	50
Switches	1.9	17
Access points	2.6	23

The NRDC notes that "in most but not all cases, it is more efficient to use a gateway with combined modem and routing functionality than to use separate modem and router devices".

The figures above are consistent with other independent studies (although slightly superior):

- For (standalone) modems and routers, the UK Energy Saving Trust[88] estimated the annual energy consumption at 62 kWh for a modem (+24%) and 58 kWh for a router (+16%); and
- For gateways, the French consumers' association "60 millions de consommateurs" had an average power consumption for various Internet boxes of 9 W[89], which is 78.8 kWh a year if never switched off (+14% as compared to NRDC).

Yet, as the NRDC study is both more robust and more recent, figures of the table above will be kept as a basis for further calculation.

At aggregate level, using stock forecasts above, the total (primary) energy consumption of in-house networking equipment rises from 36 TWh in 2013 to 42 TWh in 2020 and 59 TWh 2030 (+64%). The shift to the faster data transfer rates (like in the ONTs category) results into a rapid increase of energy consumption.

The Gross Energy Requirement (GER) of gateways has been calculated through the EcoReport tool, with the (assumed) bill of materials presented in the next section and with an average lifetime of 3 years.

---

88 Energy Saving Trust (2012), Powering the Nation – Household electricity-using habits revealed.

89 http://greenwatchers.org/2009/04/05/la-consommation-electrique-des-box-adsl/

Table 52: Aggregate annual EU (primary) energy consumption – In-house networking equipment

Product group	Energy indicator	2013	2020	2030
Modems	EU-27 Energy consumption in use phase	5.3 TWh	5.6 TWh	6.3 TWh
Gateways	EU-27 GER	80 PJ	88 PJ	104 PJ
	EU-27 Energy consumption in use phase	19.3 TWh	21.5 TWh	25.9 TWh
Gateways (ONTs)	EU-27 Energy consumption in use phase	4.3 TWh	7.2 TWh	17.8 TWh
Routers	EU-27 Energy consumption in use phase	7.0 TWh	7.6 TWh	8.8 TWh
Switches	EU-27 Energy consumption in use phase	0.1 TWh	0.2 TWh	0.2 TWh
Access points	EU-27 Energy consumption in use phase	0.2 TWh	0.3 TWh	0.3 TWh
Total	**EU-27 Energy consumption in use phase**	**36.2 TWh**	**42.3 TWh**	**59.2 TWh**

This order of magnitude is consistent with the one of the JRC, which estimated the European consumption of broadband equipment (in general) to be of up to 50 TWh per year in 2015.

9.3.2 Other resource consumption

Manufactured home network equipment are mostly made out of plastics, what raises issues in terms of recyclability, since in 2012, around 25.2 Mt of plastic waste was generated in Europe and only 6.3 Mt of it was collected for recycling[90].

Additional concerns show up in end-phase, as in-house networking devices are full of electronics. To this regard, they are covered by Regulation 2012/19, i.e. WEEE Directive, as "IT and telecommunications equipment".

In terms of reparability. although they look rather reliable, all network devices are probably not often repaired in case of breakdown. Gateways, for instance, get most usually replaced by the internet service provider (by newer and better devices).

A detailed bill of materials is available in preparatory study of ENER Lot 18 (on Complex Set Top Boxes or CSTB), for triple play box. A triple play box is what we called an Internet box or a gateway – yet it is not included in the Voluntary Agreement on CSTB, since the base functionality of a gateway is not to receive digital TV signals. Hence, gateways (integrated access devices) are not covered by the

[90] BIO Intelligence Service (2013), Study on an increased mechanical recycling target for plastics.

Voluntary Agreement. Yet the simplified bill of materials below is partially derived from ENER Lot 18, with an average weight of 1.3 kg[91].

Table 53: Assumption for materials used in an average integrated access device (gateway)

Component	Material	Weight [g]	Share [%]
Plastic case	Acrylonitrile butadiene styrene (ABS)	450	34.6%
Hard drive	Stainless coil	500	38.5%
Internal cables	Copper	25	1.9%
Printed circuits	Gold	0.1	0.0%
Printed circuits	Small integrated circuit	2	0.2%
Printed circuits	Large integrated circuit	6	0.5%
Printed circuits	Board	110	8.5%
Printed circuits	SMDs	3	0.2%
Printed circuits	Connectors	25	1.9%
Other electronics	Capacitor and coil	30	2.3%
Plug	Plug	30	2.3%
ADSL/Ethernet ports	Electronics	60	4.6%
Other	Electronics	48.9	3.8%
Screws	Ferro (St tube/profile)	10	0.8%
	Total	**1,300**	**100.0%**

No Polyvinyl chloride (PVC) has been put in the bill of materials, since more and more devices seem to be PVC-free[92]. Yet the analysis of critical raw materials and hazardous substances used in manufacturing phase would merit a deeper analysis for each category of in-house networking equipment in scope.

9.4 Improvement potential

9.4.1 Improvement potential – Energy consumption

At a very broad level, the JRC assumes that the energy consumption of broadband equipment could be halved thanks to the general principles and actions resulting from the implementation of the Code of Conduct (from 50 to 25 TWh per year) – and indeed the CoC designed maximum power consumption targets that Customer Premises Equipment (CPE) should meet.

Yet this 50% improvement potential mark is too general and cannot be taken as an estimate for the whole product group. The NRDC study indicates that "the top quartile of small network devices on the market today use one-third less energy than average models". Moreover, there is potential for even greater savings, thanks to the emerging Energy Efficient Ethernet (EEE) standard[93]. None of the

[91] The AVM FRITZ!Box 7390 is 499 grams (without hard drive), the Freebox Révolution is 1.5 kg and the Sky DRX890W Sky+ HD Digibox is 2.3 kg (with hard drive).

[92] Like Apple TVs (http://images.apple.com/environment/reports/docs/AppleTV_Product_Environmental_Report_2012.pdf)

[93] According to NRDC, "EEE enables Ethernet ports and system components to enter a sleep mode called Low Power Idle (LPI) in between data packets when transmitting at less than maximum data rate and when both ends of the network link have EEE enabled. EEE does this without impacting the performance of consumer computing applications".

modems or ONTs tested by NRDC supported EEE, and only two of the 23 routers and gateways. Hence "the opportunity to capture additional savings by increasing market penetration of these capabilities appears to be large". The first-generation EEE devices achieve 5-20% energy savings, while next-generation EEEs are expected to save up to 80% of system power[94].

Although no split-up by product category is available, we may build on a global 40% improvement potential in 2020 and 60% in 2030. This would result in the following savings (of primary energy).

Table 54: Improvement potential at EU-27 aggregate level – In-house networking equipment

Product group		EU-27 improvement potential (PJ/year)	
		2020	2030
In-house networking equipment	with respect to GER	-	-
	with respect to consumption in use phase	16.9 TWh = 61.0 PJ	35.5 TWh = 126.8 PJ

9.4.2 Cost calculation

Internet boxes (gateways) are often set to the consumers' disposal by the Internet service providers, either explicitly rent at a fixed price (3-5€ / month) or implicitly included in the subscription's price. Only standalone devices are sold in consumer electronics stores, the price ranges for them being:

- A modem (without router function) is about 20-40€[95];
- A router (without modem function) is about 30-50€[96];
- A switch has a most variable price from 20 to 120€[97], depending on speed and the number of ports; and
- An access point is more expensive, at 100-500€[98].

It is yet difficult how differently priced are the most energy efficient devices of the market.

9.5 Summary

Table 55 presents a summary of the product group "In-house networking equipment". As improvement potential is only available at broader level, only total figures are shown.

[94] Cisco/Intel (2011), IEEE 802.3az Energy Efficient Ethernet: Build Greener Networks.

[95] See for instance: http://www.amazon.fr/Netgear-DM111P-100ISS-ADSL2-Ethernet-Modem/dp/B000XHD3VI/ref=sr_1_9?ie=UTF8&qid=1402077920&sr=8-9&keywords=modem

[96] See for instance: http://www.darty.com/nav/achat/hifi_video/reseau/modem_routeur_wi-fi/belkin_routeur_n300.html

[97] See for instance: http://www.walmart.com/ip/D-Link-DGS-1008P-8-Port-Gigabit-Ethernet-PoE-Switch/16419372

[98] See for instance: http://www.amazon.co.uk/Cisco-AIR-CAP2602I-E-K9-Aironet-Controller-Access/dp/B009BY78LU/ref=sr_1_fkmr0_3?ie=UTF8&qid=1402078299&sr=8-3-fkmr0&keywords=Cisco+Aironet+3700+Series+Access+Point

Table 55: Summary – In-house networking equipment

	Year	Total
Market data		
Sales	**2013**	60-70 Mio.
Stock	**2013** **2020** **2030**	229 Mio. 259 Mio. 331 Mio.
EU-27 Annual primary energy consumption		
Over the life cycle	**2013** **2020** **2030**	-
In use phase	**2013** **2020** **2030**	36.2 TWh 42.3 TWh 59.2 TWh
EU-27 Annual primary energy savings		
In use phase	**2020** **2030**	16.9 TWh / 61.0 PJ 35.5 TWh / 126.8 PJ
Additional information		
As in-house networking equipment is quite complex and highly technical ICT device, they integrate precious metals and rare earth metals (gold, tantalum, copper, etc.). RoHS and WEEE Directives shall ensure that no major environmental impacts occur at the end-of-life.		

9.6 Topics for discussion

- No bill of materials for all product categories included in the product group “In-house networking equipment” have been gathered;
- Although estimates above look robust, more precise shares in stock data between the various home network equipment devices would be useful; and
- Energy savings are estimated at the broader product group level, yet without any split between sub-categories (due to a lack of data).

10.Lawn and riding mowers

10.1 Product group description

Directive 2000/14/EC on the noise emission in the environment by equipment for use outdoors provides the following definition for lawnmower:[99]

"A walk-behind or ride-on grass cutting machine or a machine with grass-cutting attachment(s) where the cutting device operates in a plane approximately parallel to the ground and which uses the ground to determine the height of cut by means of wheels, air cushion or skids, etc., and which utilises an engine or an electric motor for a power source. The cutting devices are either

- *rigid cutting elements, or*
- *non-metallic filament line(s) or freely pivoting non-metallic cutter(s) with a kinetic energy of more than 10 J each; the kinetic energy is determined using EN 786:1997, Annex B.*

Also a walk-behind or ride-on grass cutting machine or a machine with grass-cutting attachment(s) where the cutting device is rotating about a horizontal axis to provide a shearing action with a stationary cutter bar or knife (cylinder mower)

Lawn and riding mowers can be distinguished:

- By energy source: gasoline/internal combustion powered, electricity powered (corded and cordless/battery powered), manual/hand-pushed;
- By handling: push mower, riding mower, tractor-pulled mower, robotic mower, hovercraft (push) mower;
- By rotation type: cylinder/reel/flail mowers (horizontal axis), rotary mowers (vertical axis); and
- By user group: professional, domestic.

Figure 21: Gasoline-powered rotary push mower[100]

Figure 22: Riding mower[100]

[99] http://ec.europa.eu/enterprise/sectors/mechanical/documents/legislation/noise-emissions/index_en.htm, accessed 12 May 2014.

[100] Source: en.wikipedia.org, public domain

Figure 23: Robotic mower[101]

Figure 24: Corded electric rotary lawn mower[102]

Figure 25: Cordless and rechargeable rotary lawn mower[103]

Certain mowers provide additional functionality, such as mulching or clipping collection. These are not distinguished here.

Lawn and riding mowers have been previously investigated in the Study on Amended Working Plan under the Ecodesign Directive[104] for period 2012-2014. (VHK study) It identified savings potentials of 5 PJ/year in 2030 for lawn and riding mowers, mostly based on internal combustion mowers. Electric mowers were evaluated as insignificant, which could not be confirmed based on current market data and is also counter-intuitive as electric mowers have been around for a long time and are widely used.

To complement this initial assessment further information has been compiled on electric mowers and to a limited degree on robotic mowers (powered by batteries), constituting a seemingly exponentially growing market.[105]

In scope

All mowers as defined by Directive 2000/14/EC, excluding hand-pushed mowers and tractor pulled mowers, in particular:

- Gasoline/ internal combustion powered push mower;
- Gasoline/ internal combustion powered riding mower;
- Electricity (mains) powered corded push mower;

[101] Source: en.wikipedia.org, licensed under Creative Commons Attribution-Share Alike 3.0 Unported by Author Slaunger, unmodified.

[102] Source: en.wikipedia.org, licensed under Creative Common Attribution-Share Alike 2.5 Generic by Author Stan Shebs.

[103] Source: en.wikipedia.org, licensed for any purpose by Author Fancy-cats-are-happy-cats.

[104] VHK (2011), Study on Amended Working Plan under the Ecodesign Directive.

[105] Rise of the Lawn-Cutting Machines, Businessweek, 25 October 2012, http://www.businessweek.com/articles/2012-10-25/rise-of-the-lawn-cutting-machines, accessed 12 May 2014.

- Electricity powered cordless/ battery powered push mowers;
- Combined electricity powered corded and cordless push mowers;
- Robotic mowers; and
- Hovercraft mowers (expected to be a niche market).

Out of scope

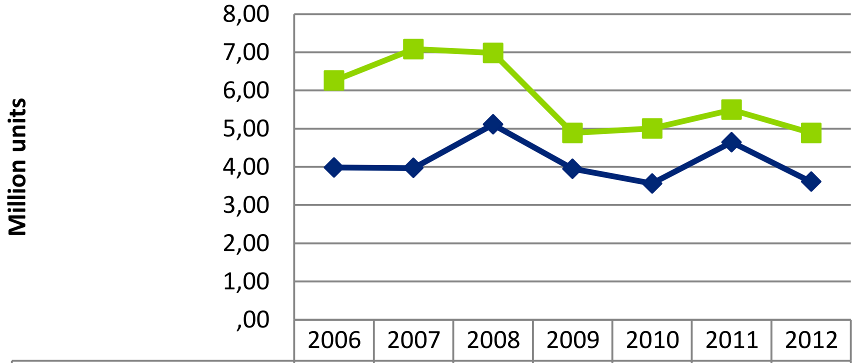
- Manual hand-pushed mowers (Prodcom code: 28.30.40.70);
- Tractor pulled mowers;
- Handheld power tools for garden care (hedge cutters, tillers, scarifiers, etc.);
- Mobile agricultural machinery; and
- Brushcutters.

There are a number of special purpose mowers on the market, especially for professional/ heavy duty use. A decision about in- or excluding them should be made in a possible preparatory study.

10.2 Market and stock data

Push mowers with all of the mentioned energy sources are on the market and common. Riding mowers are mostly equipped with combustion engines. Robotic mowers are all powered by batteries.

In Prodcom two major categories of motorised mowers can be identified (with apparent consumption above 200.000 units): Electric mowers (Code 28.30.40.10: Electric mowers for lawns, parks, golf) and Non-electrically powered mowers (Code 28.30.40.30: Mowers for lawns, parks or sports grounds, powered non-electrically, with the cutting device rotating in a horizontal plane). It is not clear how the newer lawn types, i.e. battery powered push and robotic mowers are represented in this data, but they should be included in the code for electric mowers.



	2006	2007	2008	2009	2010	2011	2012
Combustion engine mowers	6,2543	7,0805	6,9815	4,8849	5,0046	5,4927	4,8862
Electric mowers	3,9829	3,9690	5,1089	3,9464	3,5626	4,6451	3,6098

Figure 26: Apparent consumption lawn mowers (in million units)

Based on this Prodcom data the general market trend appears to be stable for electric mowers and slightly falling over time for motorised lawn mowers (see Figure 26). In Germany, electric mowers are the most popular by far.[106] This is partly due to the – on average – small garden sizes, for which

[106] http://www.gartentechnik.de/News/2012/02/14/rasenmaeher/, accessed 9 June 2014.

electric mowers are particularly well suited. It is very difficult to predict future sales of the different mower types. No information was available on market development and penetration levels in different European countries. The major markets (UK, Germany, France, Italy) seem to be very stable, with electric and battery powered motors gaining ground. However, it is unclear how dynamic other European markets grow. Hence, very basic assumptions are used to predict sales and stock of lawn mowers to 2030, taking into consideration the following observations of market trends:

Table 56: Main mower types, applications and trends[107]

	Main applications	General rends
Electric push mowers	Lawns <500 m² Mowing width 32-50 cm Light weight (easy to transport)	Cheapest on the market, gaining popularity Battery powered gaining popularity (greater manoeuvrability)
Combustion engine push mowers	Lawns 500-1,000 m² Off-grid	Not clear, appears to losing market share to electric mowers over time as they increase range
Riding mowers	Lawns 500-2,000 m²	Not clear, due to their distinct market and falling prices probably slowly growing sales Mostly combustion engines
Robotic mowers	Independent regular mowing All lawn sizes	Prices dropping fast, units sold increasing; Battery powered

Lawn and riding mowers are part of the garden equipment sector, in which Europe has a share of about 35 %, with UK, Germany, France and Italy being the biggest markets. The members of the European Garden Machinery Industry Federation alone sell more than 6 million lawn mowers per year [108], roughly confirming Prodcom data. There are more than 1,500 hand-pushed mower variants from 70 manufacturers and importers on the German market alone.[109] As no figures on riding mower quantities were available, they are not distinguished from the other mower types in the projected data.

Robotic mowers gain rapidly in popularity. Total market for Europe is apparently around 170 million dollars in 2012, with a 30 % growth rate per year. In 2012 they already had a share of 6 % in the German market.[110] Assuming average retail prices of 2.200 dollar in 2012, number of units sold amount to 68,000.

Altogether, it is assumed that the market for combustion engine mowers declines by about 2 % per year (being replaced by high range electric and robotic mowers). The market of electric mowers is divided into corded, cordless battery powered and robotic mowers, altogether assumed to be growing at 3 %, with battery powered having an initial share of 20 % in 2012 and sold units growing by 5 % per

---

[107] http://www.gartentechnik.de/News/2012/02/14/rasenmaeher/, accessed 9 June 2014.

[108] EGMF European Garden Machinery Industry Federation, Economic Information – http://www.egmf.org/en/economic-information/, last accessed: 7 June 2014.

[109] http://www.gartentechnik.de/News/2012/02/14/rasenmaeher/, last accessed 9 June 2014.

[110] http://www.businessweek.com/articles/2012-10-25/rise-of-the-lawn-cutting-machines, accessed 9 June 2014.

year. Robotic mowers are assumed to grow at 30 % until 2020 and at 20 % until 2030. Based on these assumption expected sales for 2020 and 2030 can be derived. The results are shown in

Table 57: Expected sales for different mower types (in million units)

	2012	2015	2020	2025	2030
Combustion engine mowers	4.9	4.60	4.17	3.78	3.42
Electric mowers	3.6	3.94	4.57	5.30	6.15
- corded	2.81	2.94	2.88	2.38	0.52
- cordless	0.72	0.84	1.07	1.36	1.74
- robotic mowers	0.08	0.17	0.63	1.56	3.89
TOTAL	8.5	8.5	8.7	9.1	9.6

Lifetime of mowers is often assumed to be at 8-10 years. No figures on lifetime of battery powered mowers was available, assumed to be mostly dependent on battery lifetime. Assuming average lifetimes of 6 years for battery powered mowers total stock of mowers can be estimated (see the following table).

Table 58: Stock forecast mowers EU-27 (in million units)

	2012	2015	2020	2025	2030
Combustion engine mowers	44.0	41.4	37.5	34.0	30.8
Electric mowers	30.1	32.5	36.1	38.9	38.4
- corded	25.3	26.5	25.9	21.4	4.7
- cordless	4.33	5.01	6.40	8.17	10.4
- robotic mowers	0.46	1.02	3.77	9.38	23.3
TOTAL	74.1	73.9	73.6	72.9	69.2

10.3 Resource consumption

For mowers the main issues with regard to resource consumption and environmental impacts are:

- Energy consumption in use phase;
- Noise;
- Particulate matter and local pollution;
- Substances in handles;
- Use and lifetime of batteries; and
- Reparability/ Recyclability.

10.3.1 Energy consumption

Energy consumption of corded electric mowers is estimated at 27 kWh per year, based on 1 h of mowing per week from April to September. This is the result of a comparative electric lawn mower test by German consumer organisation Stiftung Warentest.[111]

Stiftung Warentest also compared robotic mowers. Energy consumption was found to be between 3 and 14 kWh per months (for a lawn of 300 m²). This would result in an average of about 50 kWh per year (mowers running from April to September)

Combustion engine energy consumption is assessed based on figures used in the VHK study, i.e. 250 MJ/ year.

Cordless electric mower consumption is assumed to be a little higher than a corded electric mower at 300 MJ/ year.

Table 59: Energy consumption of lawn mowers – individual level

	Energy consumption use-phase per year	Primary energy consumption per year
Combustion engine lawn mower		250 MJ
Electric mower corded	27 kWh	243 MJ
Electric mower cordless		300 MJ
Robotic mower	50 kWh	450 MJ

Based on these figures overall energy consumption of the stock of these mower types can be estimated. Energy consumption of professional riding mowers was not assessed here. As their energy consumption is also significant as was shown in the VHK study their overall energy consumption is added based on the figures given in the VHK study.

Table 60: Primary energy consumption of lawn mower stock (in PJ/year)

	2015	2020	2025	2030
Combustion engine mowers	10.4	9.4	8.5	7.7
Electric mowers	8.4	9.9	11.9	14.8
Corded	6.4	6.3	5.2	1.1
Cordless	1.5	1.9	2.5	3.1
Robotic mowers	0.5	1.7	4.2	10.5
Riding mowers	4.6	4.7	4.7	4.8
TOTAL	23.3	24.0	25.1	27.3

One manufacturer claims that this battery powered lawnmower is more efficient than any other type of lawnmower with an energy consumption of only 7 kWh/months for an area of 400 m² (20 W power consumption) Price tag: 1,350 EUR.

[111] Rasenmäher: Viel Durchschnitt im Schnitt.

10.3.2 Other resource consumption

Resource consumption/ environmental impact issues with regard to lawn and riding mowers exist especially with regard to the energy conversion technologies used.

For combustion engine lawn mowers this includes noise and pollution levels of motors, the leakage and diffusion of hazardous substances (gasoline, oil). For battery powered lawn mowers this concerns the battery technology used and especially the achieved battery lifetime.

There is also some concern about hazardous substances in plastics used, especially in lawn mower handles.

Noise

- Especially prevalent in combustion engine mowers. There are reported cases of mowers that exist existing noise emission levels.[112] Combustion engine mowers tested by Stiftung Warentest had noise levels between 91 and 98 dB(A), exceeding required 96 dB(A).
- Electric lawn mowers produce only about on tenth of the noise level of gasoline powered mowers, at 84-88 db(A).
- Robotic mowers produce even less noise emission, so that some are supposedly silent enough to run at night.

Table 61: Weight and basic data of popular lawn mowers

	Weight and power	Noise (Sound power level, guaranteed (LWA)) and vibrations handlebar
Electric push mower Bosch Rotak 40[113][114]	12.3 kg 1,700 W	94 db(A) 2,5 m/s²
Electric push mower Bosch Rotak 32[115]	6.8 kg 1,200 W	94 db(A) 2,5 m/s²
Combustion engine push mower Hecht 40[116]	20 kg (steel deck) 3.5 hp	Not found on manufacturer website
Combustion engine push mower BMC Wolf BIG 20" Self Propelled Petrol Lawn Mower[117]	35 kg (steel deck) 5.5 hp	Not found on manufacturer website
Electric hover mower Flymo Easiglide 300[118][119]	8.5 kg	91 dB(A)

[112] Stiftung Warentest, Rasenmäher: Die Billigen mähen nicht gut, March 2013. http://www.test.de/Rasenmaeher-Die-Billigen-maehen-nicht-gut-4517665-0/

[113] Presumably regularly most popular model in UK. http://www.whichlawnmower.co.uk/bosch-rotak-40/, accessed 9 June 2014.

[114] http://www.bosch-do-it.de/media/media/garden/gardenmedia/manuals/775211_F016L70884_201401pdf..pdf, accessed 9 June 2014.

[115] Bestselling lawn mower on amazon.de in June 2014.

[116] Bestselling gasoline powered lawn mower on amazon.de in June 2014, accessed 9 June 2014.

[117] Bestselling gasoline powered lawn mower on amazon.co.uk in June 2014, accessed 9 June 2014.

	Weight and power	Noise (Sound power level, guaranteed (LWA)) and vibrations handlebar
	1.300 W	1.09 m/s²
Battery powered mower Bosch Rotak 43 LI[120]	13.8 kg 36 V/2.6 or 4.0 Ah Lithium-ion battery	90 dB(A) 2.5 m/s²
Bosch Indego robotic lawn mower[121122]	11,1 kg 32,4 V/ 3.0 Ah Lithium-ion battery	75 dB(A) NA
Robotic mower Flymo 1200r	18 V/ 1.6 Ah Lithium-ion Battery	58 db(A) NA

Lifetime

Not all gasoline powered mowers may tolerate E10, reducing lifetime of components[123]

Spareparts may not be offered for extended periods for some mower models on the market

Battery lifetime obviously crucial. Especially robotic lawn mower batteries quickly undergo many charging cycles. Not information was available on achieved lifetimes.

Emission from the combustion of gasoline

Combustion engine lawn mowers are a significant source of pollutants as they are not equipped with catalysts.

Leakage and diffusion of gasoline, oil, greases

Criteria addressed by the German Blue Angel that indicate possible resource/ environmental impact issues:

Systems for refilling gasoline/ oil must be included with machine to avoid leakage of hazardous substances

Permeation/ diffusion from tank must be below defined threshold level

Use of hazardous substances

Criteria addressed by the German Blue Angel that indicate possible resource/ environmental impact issues:

Types of plastics and additives used: Must not contain halogenated polymers and organic halogenated flame retardants or carcinogenic/mutagenic/toxic for reproduction according to Dangerous Substances Directive (67/548/EEC).

---

[118] Bestselling hover lawn mower on amazon.co.uk in June 2014, accessed 9 June 2014.

[119] http://www.flymo.com/uk/lawn-mowers/hover/easi-glide-300/, accessed 9 June 2014.

[120] Bestselling battery lawn mower on amazon.de and second best on amazon.co.uk, accessed 9 June 2014

[121] Bestselling robotic lawn mower on amazon.de, accessed 9 June 2014.

[122] http://www.bosch-indego.com/ch/de/product/der+indego.html, accessed 9 June 2014.

[123] http://www.test.de/Leserfrage-E10-Benzin-im-Rasenmaeher-4248826-0/, accessed 7 June 2014.

Handles must not contain DEHP (criterion required for gasoline powered mowers, recommended for electric mowers) or PAH (polycyclic aromatic hydrocarbon)

Design for recyclability

Besides motors and batteries, lawn mowers use mostly steel and plastic. To facilitate future recycling declaration of used types of plastics can be envisioned as demanded by Blue Angel criteria for lawn mowers.

In a comparative life cycle analysis of gasoline-, battery-, and electricity-powered lawn mowers Deepak Sivaraman and Angela Lindner came to the conclusion that corded electric mowers have the lowest environmental impact in all categories considered, followed by battery powered and gasoline powered.[124]

10.4 Improvement potential

10.4.1 Improvement potential – Energy consumption

For electric lawnmowers use of permanent magnet motors is supposed to reduce energy consumption by 50 % due to higher motor efficiency and better electronic control.[125]

4-stroke engine instead of 2-stroke engine is more energy efficient and produces fewer emissions.[126] According to one source 2-stroke engines lose as much as 25 % of their fuel unburned.[127] It is unclear how many 2-stroke engines are still found on the market.

For battery powered lawnmowers use of lithium-ion batteries increases efficiency. All models found use lithium-ion batteries already today. It is unclear if other batteries for mowers are still on the market.

No detailed assessment of individual improvement options has been done.

10.4.2 Improvement potential – Other resource consumption

Possible interventions to improve resource consumption/ reduce environmental impact:

- Noise emission levels are regulated but not enforced, also not displayed at point-of-sale;
- Require 4-stroke engines;
- For gasoline powered lawn mowers alkylate gasoline is available as a cleaner option and produces less harmful substances during mower operation;
- Require “clean” battery options (Lithium-ion batteries currently deemed best);[128]
- Use of catalysts for combustion mowers: A possibility, but only implemented in few (much higher costs).[129] Could drastically reduce emission levels.
- Marking of plastics to allow for better recycling;
- Require tolerance for E10 to increase lifetime; and

---

[124] Deepak Sivaraman and Angela S. Lindner. Environmental Engineering Science. November/December 2004, 21(6): 768-785. doi:10.1089/ees.2004.21.768.

[125] http://www.topten.ch/deutsch/ratgeber/elektro-rasenmaeher.html&fromid=, accessed 13 May 2014.

[126]

[127] http://home.howstuffworks.com/lawn-mower4.htm, accessed 9 June 2014.

[128] http://www.topten.ch/deutsch/ratgeber/elektro-rasenmaeher.html&fromid=, accessed 13 May 2014

[129] http://www.gartentechnik.de/News/2012/01/18/benzinrasenmaeher/, accessed 8 June 2014

- Ensure availability of spare parts to increase lifetime.

10.4.3 Cost calculation (where possible)

No cost calculations have been done so far.

10.5 Summary

Table 62 presents a summary of the product group lawn and riding mowers.

Table 62: Summary – Lawn and riding mowers

	Year	Combustion engine	Electric corded	Electric cordless	Robotic	Riding mower prof.[130]	Total
EU-27 Market data (in millions)							
Sales	**2012**	4.9	2.81	0.72	0.08	0,07	8.6
Stock	**2012** **2020** **2030**	44.0 37.5 30.8	25.3 25.9 4.7	4.3 6.4 10.4	0.5 3.8 23.3	0.6 0.6 0.6	74.7 74.2 69.8
EU-27 Annual primary energy consumption (PJ)							
Over the life cycle	**2012** **2020** **2030**	na	na	na	na	na	na
In use phase	**2012** **2020** **2030**	11 9.4 7.7	6.1 6.3 1.1	1.3 1.9 3.1	0.2 1.7 11	4.6 4.7 4.7	23.2 24.0 27.3
EU-27 Annual primary energy savings							
In use phase	**2020** **2030**	na	na	na	na	na	na
Resource consumption/ improvement							
Combustion mowers: noise, air pollution, leakage oil/gas Concerns in terms of noise			Lifetime (battery, spareparts)	Design for recyclability			-

10.6 Topics for discussion

- Accuracy of market and stock model;
- More information on significant types of lawn mowers, especially professional; and
- Most effective measures to reduce energy consumption and environmental impacts.

[130] Data from VHK study.

11.Mobile phones / smartphones

11.1 Product group description

In the VHK study for the 2nd Working Plan mobile phones were defined as follows:

A mobile phone is a portable telephone device that does not require the use of landlines. Mobile phones utilize frequencies transmitted by cellular towers to connect the calls between two devices. Mobile phones may also be referred to as wireless or cellular phones.[131]

A subgroup of mobile phones are "smartphones", providing additional functionality and connectivity (particularly internet) and generally larger display sizes than conventional mobile phones, usually several of the below:

Connectivity: GSM (2G), GPRS/EDGE (2.5G), UMTS (3G), increasingly LTE (4G), Wifi, Bluetooth, USB (or similar), GPS, increasingly NFC

Functionality: Touchscreen (in general), Internet Protocols (web browsing, email, "App store", Cloud services), "Apps", music player, camera/ video recorder, motion sensors, vibration, processing power, data storage

Sometimes the additional category of "feature phone" is used, being more functional than a mobile phone (with only basic telephony and messaging ability), yet less versatile than a smartphone. Here this further distinction is not used.

Smartphones are evolving rapidly in their functionality, defying an exact definition. Also much of the same functionality is found in other devices (such as tablets, music/media players and digital (video) cameras, navigation systems, gaming devices). Smartphones however still have core phone capabilities (connectivity to mobile networks/base stations, roaming). A new generation of devices are so-called "phablets", which put even more emphasis on uses other than conventional telephony, yet also allow for it. These are not explicitly covered here (though sales data is presumably not always clearly distinguished). Given their very similar technologies it may be worth including them in a possible preparatory study.

Though tablets have much of the same functionality and arguably underlying technology as smartphones they are currently covered in Regulation 617/2013. There they are named 'slate computer' and defined as follows:

- "Notebook computer" means a computer designed specifically for portability and to be operated for extended periods of time either with or without a direct connection to an AC power source. Notebook computers utilise an integrated display, with a viewable diagonal screen size of at least 22,86 cm (9 inches), and are capable of operation on an integrated battery or other portable power source.
- Notebook computers include: "Slate computer" means a type of notebook computer that includes an integrated touch-sensitive display but does not have a permanently attached physical keyboard.

[131] Based on definition at http://www.businessdictionary.com/definition/mobile-phone.html.

Hence, it is suggested that the category of mobile phones/ smartphones includes all devices with above functionality up to a diagonal screen size of 22,86 cm (9 inches).

Portable landline phones are not included as they are experiencing declining sales and generally have a much longer life time. Pagers and callers are not included as they also have low sales.

Mobile phones were ranked 25 in the VHK study with energy saving potentials of 13 PJ/year. Assumed energy savings potentials were however quite substantial (30 % over 25 years). In the conclusion, this was described as a low energy savings potential and a recommendation for more detailed analysis given. Here we will hence put a focus on the rapidly growing market of mobile phones/ smartphones and particularly possible resource issues, which were not explored in the VHK study and may be particularly prevalent for this subgroup of mobile phones.

11.2 Market and stock data

For energy consumption the **stock of actively used phones** is of interest. For resource consumption the **number of sold phones per year** is of interest as it determines total resources consumed (together with other criteria such as lifetime, use of recycled materials, etc discussed below). For recovery of materials **number of phones reaching end-of-life treatment facilities** and **stock of unused and not yet discarded phones** is of interest. The model hence focusses on estimating these four figures and their projection into the future.

The VHK study estimated overall 'stock' of mobile phones in Europe of 588 million in 2010, growing to around 700 million in 2030, with smartphones eventually constituting the largest share (> 95 %). With 'stock' of mobile phones presumably 'actively used' phones are meant. However, common statistics are not clear about this differentiation and an approximation is attempted here.

The study *Mobile Economy Europe 2013* by mobile operator association GSMA[132] points at higher penetration rates, with 629 million "actively used" SIM cards at the end of 2012, used by 400 million people. Smartphone penetration in particular is identified as close to 50 % in western European countries. GSMA also expects 700 million active SIM cards (which should rather directly translate into devices[133]) already by 2017, based on current growth rates and an increasingly saturated market. Likely not all SIM cards can be translated into smartphone or mobile phone devices (with tablets, internet USB-"sticks", some internet connected machines/"things" and others also using SIM-cards). They should however constitute the largest share, assumed here to be around 80% in 2012, which equals 503 'actively used' mobile phones/ smartphones or close to 100 % penetration rate. This is used to initialize the model.

Prodcom data (presented in Table 64) points to 209 million mobile phones/ smartphones consumed in the EU-27 in 2012. As some smartphones may be reported in the palm-top organisers category the numbers could be a little higher. However, compared to figures found in market/ industry reports actual mobile phone consumption rates could be much higher. Taking the above GSMA figures and assuming an 80 % share of mobile phones/ smartphones of all SIM-enabled devices (as no specific data was available) and an average use-time (before replacement) of 2 years, number of mobile phones/ smartphones sold in Europe in 2012 are as high as 256 million (relevant for resource consumption). This figure is used instead of the Prodcom data.

[132] GSMA (2013), Mobile Economy Europe: http://gsmamobileeconomyeurope.com/GSMA_Mobile%20Economy%20Europe_v9_WEB.pdf.

[133] GSMA points at a close to 1 to 1 relationship between the number of SIM cards and the number of devices in developed markets: https://gsmaintelligence.com/analysis/2014/5/measuring-mobile-penetration/430/.

The VHK study identified an average use time of 1.5 years, with most people supposedly replacing their actively used phone after 1 to 2 years. Based on a review of different studies Navazo et al. (2014) confirm this estimate, equating it with the average lifetime of mobile phones. In eco-profiles of mobile phones some manufacturers report longer use times of up to 3 years. Estimates in other studies range from 1.5 to 2.5 years. This has consequences for the relative relevance of use-phase energy consumption and for the number of new phones sold each year. Here an initial average active use-time of mobile phones of 2 years is taken as basis.

The use-time is not equal to the lifetime of a mobile phone/ smartphone. Several sources point to only around 2.5% (!) of phones reaching dedicated end-of-life treatment after active use. Oeko (2012) reports that worldwide only about 1 % of mobile phones reach material recovery facilities. In Germany around 5% of mobile phones are collected for recycling/ recovery.

Most phones are assumed to be stored at home unused or (a much smaller share) disposed of incorrectly. However only 1 in 20 phones reaching end-of-life treatment seems rather low. Comprehensive assessments for Germany estimate around 10% current recovery rates based on weight.[134] Hence, here an initial share of correctly disposed of mobile phones of 7% based on all phones reaching end of use-time in Europe is assumed. The rest (minus an assumed 20% loss/unknown) is assumed to be stored at home. Share of correctly disposed of phones is assumed to grow at 0.5 % per year to 16% in 2030 in a business-as-usual scenario.

As there is a continuous development in technology from mobile phones to smartphones, these two are not explicitly differentiated here. The model could be differentiated further, assuming 50% smartphone share in 2012, growing to 95% in 2030 as assumed in the VHK study and confirmed by other sources (such as the GSMA study mentioned above). However, such a detailed differentiation would probably not provide much additional insight.

Longer term projections are of course prone to a lot of uncertainties, given the fast paced technological development. Any current projection is hence likely highly inaccurate. Some technology trends that may significantly influence future smartphone sales (or that of core technologies):

- Advent of connected machines (“Internet of thing”, M2M), which may employ core mobile phone/ smartphone technologies; number of connections is expected to be multiple times that of mobile phones;
- Increased use of dual-SIM phones, possibly inverting the trend towards multiple devices;
- New interfaces/devices for core smartphone functionalities (“Google Glass”, “smart” watches);
- Magnitude of internet/Wifi coverage and possibility for IP-telephony;
- Functionality of related devices, such as tablets, media players and other internet-connected devices;
- Use of high-performance smartphones as alternative to laptops/ PCs (with external docking station, keyboard, harddrive, display); and
- For energy consumption also increased use of energy harvesting (using ambient temperature differences, body movements, heat sources, abundant Wifi, etc.) may hold a significant potential for reduced energy consumption.

---

[134] Chancerel, P. (2009). Gold in der Tonne. MÜLLMAGAZIN 1/2009. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Gold+in+der+Tonne#1 and Chancerel, P. (2010). Substance flow analysis of the recycling of small waste electrical and electronic equipment – An assessment of the recovery of gold and palladium. Ph.D. Thesis. Technische Universität Berlin. Retrieved from http://opus.kobv.de/tuberlin/volltexte/2010/2590/

For the purposes here, it is assumed that penetration with actively used mobile phone-/ smartphone-like devices (that may fall under a possible Ecodesign regulation) is reaching a plateau of 130 % in 2025. This would translate into on average 1.3 actively used smartphones per capita.

Table 63 provides the results of the stock model based on these assumptions.

Table 63: Stock model mobile phones

	2012	2013	2014	2015	2020	2025	2030
Population EU-28 (in millions)	505	506	507	508	512	516	518
Assumed mobile phone penetration, active use (in %)	100%	105%	109%	112%	122%	130%	130%
Mobile phones in active use (in millions)	503	531	553	569	625	670	674
Average use time (in years)	2	2	2	2	2	2	2
Mobile phones sold	256	279	287	293	318	338	337
Phones reaching end-of-life treatment after reaching end of use-time	7.0%	7.5%	8.0%	8.5%	11.0%	13.5%	16.0%
Phones reaching end-of-life treatment (in millions)	17.3	18.9	21.2	23	34	45	54
Stock unused mobile phones after end-of-use (in millions) (20% loss assumed)	1,601	1,784	1,975	2,173	3,206	4,297	5,388

Findings:

The **stock of actively used mobile phones** in Europe grows from 503 million in 2012 to 625 million in 2020.

Mobile phones sold in Europe every year grow from 256 million in 2012 to 318 million in 2020.

The **number of phones reaching end-of-life treatment** after active use-time are at 17.3 million in 2012, growing to 34 million in 2020.

The **stock of unused and not yet discarded** phones grows from 1.6 billion in 2012 to 3.2 billion in 2020. This is more than three phones per capita in 2012 and 6 phones per capita in 2020.

For comparison Prodcom data for the years 2010 and 2012 is provided in Table 64.

Table 64: Prodcom market data

Product group	Year	EU production (in million)	Import	Export	Apparent consumption
Telephones for cellular networks/wireless networks (Prodcom 26.30.22.00)	2010	112	213	71	255
Telephones for cellular networks/wireless networks (Prodcom 26.30.22.00)	2012	34	231	57	209
Laptop PCs and palm-top organisers (Prodcom 26.20.11.00)	2010	10	56	5,2	61
Laptop PCs and palm-top organisers (Prodcom 26.20.11.00)	2012	7,8	81	8,7	80

11.3 Resource consumption

11.3.1 Energy consumption

Given the small use-phase energy consumption of mobile phones, overall improvement potential may be limited, particularly after regulating (i.e. limiting) charger no-load power consumption and given the general ambition of phone manufacturers to increase time before recharging is required.

However, the large numbers of mobile phones may allow for significant reductions in energy consumptions even with small efficiency improvements.

Annual electricity consumption of a current high-end phone is estimated to be at around 4 kWh, assuming once-daily full charging.[135]

Assuming average yearly use-phase energy consumption of 4 kWh electricity (see Table 67 and below) total primary energy consumption (using a conversion coefficient of 2.5) is at about 16 PJ in 2012, growing to 20 PJ in 2020.

135 http://blog.opower.com/2012/09/how-much-does-it-cost-to-charge-an-iphone-5-a-thought-provokingly-modest-0-41year/#Methodology

Table 65: Aggregate EU energy consumption of mobile phones

	2012	2013	2014	2015	2020	2025	2030
Mobile phones in active use (in millions)	503	531	553	569	625	670	674
Average energy consumption per mobile phone (kWh/y)	4	4	4	4	4	4	4
Total electricity consumption (TWh/y)	2.0	2.1	2.2	2.3	2.5	2.7	2.7
Total electricity consumption (PJ/y)	7.2	7.6	8.0	8.2	9.0	9.7	9.7
Total primary energy consumption use phase (PJ/y)	15.9	16.8	17.5	18.0	19.8	21.2	21.4
Total primary energy consumption life cycle (PJ/y)	102	112	115	117	127	135	135

UK based organisation WRAP estimated that 29 % of lifecycle energy consumption of a mobile phone are in the use phase, 59 % in the resource extraction/manufacturing phase, 10 % in the distribution and the rest in the end-of-life stage. As this was before efficiency criteria for chargers were introduced, it can be assumed that use-phase energy consumption has become relatively less significant. An initial review of published Eco-Profiles by a mobile phone manufacturer confirms this. (see Table 67)

For the purposes here, i.e. estimating overall energy use of mobile phones in Europe, average GER is assumed to be at 400 MJ and use phase energy consumption at 72 MJ in 2 years or 36 MJ primary energy per year (~4 kWh electricity per year).

If overall energy consumption is deemed relevant, further differentiation in user scenarios may provide insights into improvement options.

The preparation study for the new German Blue Angel criteria for mobile phones/ smartphones, e.g. point to much higher energy consumption if charging is taking place through a laptop or computer, which is turned on for this purpose alone, and not through a normal phone charger.

Also (declining) battery performance may require different charging cycles. Recharging once a day is assumed to be a realistic use case, with many heavy (data/ display intensive) users charging several times a time and others only every other day or less.

Not taken into account here is the energy consumption of base station/ network energy consumption, which can be significant according to various sources. A report by A.T. Kearney for GSMA points to an electricity consumption of 19.1 kWh/ GB of data and 23.4 kWh “per connection” (connected device) in 2011.[136] Assuming European grid mix and a conversion coefficient of 2.5 this translates into 211 MJ of primary energy consumption per smartphone per year, which is in the order of life cycle energy

[136] GSMA (2013), The Mobile Economy 2013, p. 69: http://www.atkearney.com/documents/10192/760890/The_Mobile_Economy_2013.pdf/6ac11770-5a26-4fef-80bd-870ab83222f0.

consumption. Table 66 provides an overview of total primary energy consumption of network use based on these figures.

Table 66: Energy consumption mobile network

	2012	2013	2014	2015	2020	2025	2030
Mobile phones in active use (in millions)	503	531	553	569	625	670	674
Electricity consumption of network use (kWh/ connected device)	23	23	23	23	23	23	23
Total primary energy consumption network use (PJ/y)	42	44	46	47	52	56	56

The resources and manufacturing stages are generally found to be the most energy intensive and also most relevant with regard to a number of other environmental impacts.[137]

Certain components hereby presumably dominate primary energy consumption. WRAP for example estimates that "electronic components such as large integrated circuits can require 140 times more energy to produce than plastics such as PVC"[138]

Table 67: Energy consumption individual product level[139]

Product group	Average GER (MJ)	Average energy consumption in use phase (MJ)[140] (2 year use-time)	Share of energy consumption in use phase to GER
Mobile phone			
WRAP (2010) low	235	75	32 %
WRAP (2010) average	255	75	29 %
WRAP (2010) high	1498	587	39 %
Smartphone			
Nokia Lumia 920[141]	260	35	13 %
Nokia Lumia 1520[142]	504	80	16 %

137 Moberg et al. (2014), Simplifying a life cycle assessment of a mobile phone.

138 WRAP (2010), Environmental assessment of consumer electronic products (summary report)

139 Consumed electricity was converted into consumed primary energy using a conversion coefficient of 2.5, unless primary energy consumption was provided in source.

140 Assumed lifetime of 2 years in WRAP study.

141 Nokia Lumia 920 Eco-profile: http://nds1.nokia.com/eco_declaration/files/eco_declaration_phones/Lumia_920_Eco_profile.pdf, retrieved 26 May 2014. Recalculated for 2-year use time instead of reported 3-year use.

142 Nokia Lumia 1520 Eco-profile: http://download.fds-ncom.nokia.com/supportFiles/eco_declaration/files/eco_declaration_phones/Lumia_1520_Eco_profile.pdf, retrieved 2 June 2014. Recalculated for 2-year use time instead of reported 3-year use.

Product group	Average GER (MJ)	Average energy consumption in use phase (MJ)[140] (2 year use-time)	Share of energy consumption in use phase to GER
Assumed average energy consumption per mobile phone	400	72	18 %

Accessories and packaging

Energy consumption of chargers has been regulated and limited. However, their production makes up a significant part (around 57 %) of the life cycle energy consumption[143].

Other accessories and packaging have not been investigated.

11.3.2 Other resource consumption

Mobile phones vary in shapes and sizes. The general trend is towards higher performance smartphones, rapidly replacing conventional mobile phones. The average weight of mobile phones (as a proxy for overall resource use) has remained roughly constant over time, as increased performance/functionality and miniaturization of components are about balanced. The weighted[144] average of mobile phone weight is apparently around 100-120 g[145], though large differences exist between models: A quick search reveals that it is possible to find currently available phones weighing less than 70 g and more than 700 g[146].

WRAP argues that the environmental impact of smartphones is growing with its increasing functionality and hence electronic complexity[147]. This is mostly due to resource use. The resources and manufacturing stages are generally found to be the most relevant with regard to different environmental impacts[137].

Mobile phones/ smartphones are made from a range of materials and components, among these:

- Materials, in particular plastics, metal, glass;
- Components, in particular printed circuit boards (PCBs), integrated circuits (ICs), LCDs; and
- Specific metals, such as gold, silver, tin, aluminum, palladium, copper, nickel, lead, antimony, tantalum, niobium and indium.

Table 68 provides an estimate of materials used in phones. The data is taken from Navazo et al (2014), who compared content estimates from different studies, by averaging provided data (for each material excluding sources that did not provide data for that material) and adding missing materials from other sources, namely the study itself and Oeko-Institut (2012)[148].

---

[143] EuP Preparatory Study Lot 7: Battery chargers and external power supplies. BIO IS & Fraunhofer IZM, Brüssel 2007.

[144] Weighted by popularity, measured in “hits” on a particular website.

[145] Mobile phone evolution: Story of shapes and sizes, 15 July 2010, http://www.gsmarena.com/mobile_phone_evolution-review-493p6.php, accessed 26 May 2014

[146] See for example http://www.gsmarena.com/search.php3.

[147] WRAP (2010), Environmental assessment of consumer electronic products (summary report).

[148] Oeko-Institut (2012), PROSA Smartphones: Entwicklung der Vergabekriterien für ein klimaschutzbezogenes Umweltzeichen, Freiburg, 2012.

Table 68: Estimate of material contents of mobile phones

	Approximate average based on studies reviewed in Navazo et al. (2014)[149]		Presumed content in 120g phone (95g phone + 25g battery) (in g)
Organics	48.4	%	4.60E+01
Glass	12.3	%	1.17E+01
Iron	5.9	%	5.62E+00
Aluminum	4.5	%	4.24E+00
Copper	12.3	%	1.17E+01
Nickel	1.1	%	1.05E+00
Lead	0.5	%	4.94E-01
Tin	0.9	%	8.74E-01
Antimony	0.1	%	7.13E-02
Silver	2386.2	ppm	2.27E-01
Gold	374.0	ppm	3.55E-02
Palladium	116.3	ppm	1.10E-02
Platinum	5.0	ppm	4.75E-04
Beryllium	48.7	ppm	4.62E-03
Zinc	0.5	%	4.61E-01
Magnesium oxide	3.2	%	3.04E+00
Calcium oxide	1.9	%	1.81E+00
Silica	11.6	%	1.10E+01
Manganese	0.2	%	1.43E-01
Titanium	0.6	%	5.42E-01
Barium	0.5	%	5.07E-01
Zirconium oxide	0.1	%	1.05E-01
Cerium oxide	0.1	%	9.50E-02
Chromium	0.5	%	4.94E-01
Neodymium	1454.0	ppm	1.38E-01
Wolframium	7.0	ppm	6.65E-04
Bismuth	161.7	ppm	1.54E-02
Arsenic	23.0	ppm	2.19E-03
Cadmium	1.1	ppm	1.05E-04
Mercury	0.1	ppm	4.75E-06
Gallium	53.0	ppm	5.04E-03

[149] Navazo et al. (2014), Material flow analysis and energy requirements of mobile phone material recovery processes.

	Approximate average based on studies reviewed in Navazo et al. (2014)[149]		Presumed content in 120g phone (95g phone + 25g battery) (in g)
Strontium	163.0	ppm	1.55E-02
Tantalum	985.0	ppm	9.36E-02
Dysprosium	33.0	ppm	3.14E-03
Niobium	38.0	ppm	3.61E-03
Tungsten	3.0	%	2.85E+00
Praseodym			1.00E-02
Cobalt (in battery)			6.30E+00

Based on that composition, future material use has been calculated (Table 69). This is assuming static composition based on what has been found in mobile phone waste in the past. Current and especially future composition will likely be different. Especially rare metals are increasingly used in smartphones, so that their future consumption is likely highly underestimated. Lead was deleted from the list. As it is regulated by RoHS, it should not be found in new phones anymore (except in exempt forms).

Table 69: Material use (in t/year) (assuming past/ current composition of mobile phones)

	2012	2015	2020	2025	2030
Organics (Plastics)	11.754	13.461	14.631	15.551	15.512
Glass	2.987	3.421	3.718	3.952	3.942
Iron	1.438	1.647	1.790	1.902	1.897
Aluminum	1.083	1.240	1.348	1.433	1.429
Copper	2.992	3.427	3.724	3.958	3.949
Nickel	268	307	334	355	354
Tin	223	256	278	296	295
Antimony	18.2	20.9	22.7	24.1	24.0
Silver	57.9	66.4	72.1	76.7	76.5
Gold	9.1	10.4	11.3	12.0	12.0
Palladium	2.8	3.2	3.5	3.7	3.7
Platinum	0.1	0.1	0.2	0.2	0.2
Beryllium	1.2	1.4	1.5	1.6	1.6
Zinc	118	135	147	156	155
Magnesium oxide	777	890	967	1.028	1.026
Calcium oxide	461	528	574	610	609
Silica	2.817	3.226	3.507	3.727	3.718
Manganese	36.4	41.7	45.3	48.2	48.1
Titanium	138	159	172	183	183
Barium	130	148	161	171	171
Zirconium oxide	26.7	30.6	33.3	35.3	35.3
Cerium oxide	24.3	27.8	30.2	32.1	32.1
Chromium	126	145	157	167	167
Neodymium	35.3	40.4	44.0	46.7	46.6
Wolframium	0.2	0.2	0.2	0.2	0.2
Bismuth	3.9	4.5	4.9	5.2	5.2
Arsenic	0.6	0.6	0.7	0.7	0.7

	2012	2015	2020	2025	2030
Cadmium	0.0	0.0	0.0	0.0	0.0
Mercury	0.0	0.0	0.0	0.0	0.0
Gallium	1.3	1.5	1.6	1.7	1.7
Strontium	4.0	4.5	4.9	5.2	5.2
Tantalum	23.9	27.4	29.8	31.6	31.6
Dysprosium	0.8	0.9	1.0	1.1	1.1
Niobium	0.9	1.1	1.1	1.2	1.2
Tungsten	729	834	907	964	962
Praseodym	2.6	2.9	3.2	3.4	3.4
Cobalt (from batteries)	1,610	1,844	2,005	2,131	2,125

Table 70 provides a comparison of some available eco-profiles of smartphones, which provide product composition estimates on material group/ component level.

Table 70: Resource consumption (or environmental impact) individual product level (based on average of 120 g mobile phone)

Source	Nokia Lumia 920 Eco-profile[150]	iPhone 5s[151]	IPhone 5c[152]
Average total weight (incl. battery)	185 g	112 g	132 g
Display		11 g	11 g
Plastics	59.2 g	5 g	7 g
Polycarbonate			14 g
Glass/Ceramics	14,8 g	18 g	18 g
Circuit boards		12 g	13 g
Metals	81.4 g[153]		
Aluminum		21 g	
Steel, stainless		18 g	41 g
Battery	27,8	25 g	25 g

Critical materials used in smartphones: Antimony, beryllium, cobalt, gallium, indium, magnesium, niobium, platinum group metals, rare earths, tungsten[154]

Conflict used in smartphones: Tin, tantalum, wolframium and gold

---

[150] http://nds1.nokia.com/eco_declaration/files/eco_declaration_phones/Lumia_920_Eco_profile.pdf, retrieved 26 May 2014.

[151] http://images.apple.com/euro/environment/reports/a/generic/docs/iPhone5s_product_environmental_report_sept2013.pdf, retrieved 2 June 2014.

[152] http://images.apple.com/euro/environment/reports/a/generic/docs/iPhone5c_product_environmental_report_sept2013.pdf, retrieved 2 June 2014.

[153] Stainless steal, copper, zinc, aluminium. 0.1-0.2 % "precious metals".

[154] Report on Critical Raw Materials for the EU: Report of the Ad hoc Working Group on defining critical raw materials, May 2014. - http://ec.europa.eu/enterprise/policies/raw-materials/files/docs/crm-report-on-critical-raw-materials_en.pdf.

Hazardous substances in mobile phones: mercury, cadmium, lead, arsenic, dioxins, and furans, copper, chromium, flame retardants.

Hazardous substances pose a threat especially at end-of-life stage, if mobile phones are not treated correctly at end-of-life, particularly at low key recycling facilities: Substances and processes, used at recycling facilities, may leak into water or soil. Dioxins from burning flame retardants used in plastics.

Electromagnetic radiation: Safe levels are established, hence not taken into account here.

11.4 Improvement potential

Few clear improvement options for use-phase energy consumption exist. A general improvement potential however seems realistic. However, efforts should focus on resource and energy consumption outside the use phase, especially in the resource/manufacturing states and with regard to network energy consumption.

11.4.1 Improvement potential – Energy consumption

Manufacturers claim significant energy efficiency improvements in the past years. Apple for example claims to have achieved 57% reduction of energy consumption of (all of) its products by 57% in 5 years alone. No information was available on their improvement in mobile phones.

It seems reasonable to achieve further energy consumption improvements in the future. Much of these will likely happen without regulatory intervention as manufacturers have an interest in reducing the need for frequent recharging.

Not yet commercially available technology could allow mobile phones in the future to harvest energy from the environment, from e.g. body movements (as implemented in watches), temperature differences, PV. However this may also entail increased energy consumption in the production stage.

Specific options to reduce energy consumption in the use-phase:

- Reduce frequency of recharging on laptops/ computers (e.g. through consumer information). Using computers to recharge phones may also become more prevalent when chargers are not included in phone purchases anymore.
- Specific mobile phone functions require significant energy to run (Display brightness, Wifi, Bluetooth, GPS, etc.) though they may actually not be needed at the time by the consumer. Providing specific options to consumers such as automatically shutting off Wifi when on the move etc. could reduce energy consumption.

The Blue Angel criteria require mobile phones to signal finished charging and to recommend disconnecting from charger/computer

Table 71 provides an overview what savings potentials a reasonable 30% efficiency improvement would entail. For 2020 an energy savings potential of about 6 PJ/y would ensue.

Table 71: Improvement potential EU-28 aggregate level

	2012	2013	2014	2015	2020	2025	2030
Mobile phones in active use (in millions)	503	531	553	569	625	670	674
Total primary energy consumption (PJ/y)	15.9	16.8	17.5	18.0	19.8	21.2	21.4
Savings potential through ecodesign				30%	30%	30%	30%
% of stock with reduced consumption				0%	100%	100%	100%
Reduced total primary energy consumption (PJ/y)				18.0	13.9	14.9	14.9
Savings (PJ/y)				0	5.9	6.4	6.4

Given the high data-driven energy use of mobile phone networks, savings achieved here would quickly outweigh energy savings achieved on mobile phone level alone. This has not been explored here but provides further potential for mobile phone related energy improvements.

Improvement options not considered further

WRAP suggests that in the future self-charging mobile phones may provide improvement opportunities.[155] As it is currently unclear if and how such an innovation actually decreases energy consumption it is not considered here further.

11.4.2 Improvement potential – Other resource consumption

Improvement opportunities for reduced resource consumption and environmental impact exist on different levels and can be grouped into interventions addressing technical and economic lifetime, use of recycled materials, design for recyclability/ recoverability, repurposing of phones and key components, reduce amount of hazardous substances and use of mobile phones to replace other goods or services.

Lifetime extension

It can be assumed that technical lifetime of mobile phones/ smartphones is often higher than real use-time (economic lifetime), i.e. in many cases consumers will replace a mobile phone even though it is still technically functioning. This may be due to different reasons, e.g. lifestyle/aesthetic preferences for new phone models, interest in new features, contract bound replacement of phones after 1.5-2 years. But technical lifetime also plays an important role, e.g. deteriorating battery performance, expensive repairs.

A recent representative study conducted among 1,006 German consumers on behalf of the German business association BITKOM showed that for 54% of the interviewees, the reason for an exchange of a high-tech device such as computer, flat screen TV or mobile phone was that the old one was broken. With older consumers, this figure increased to 60%.

[155] WRAP (2010), Environmental assessment of consumer electronic products (summary report), p. 17.

Table 72: Reasons for the exchange of a high-tech device

	Consumers 14-29 years	Consumers 60 years and older	All consumers
Because the old one was broken	49%	60%	54%
Because there was a new model on the market	52%	28%	45%
Because there were no more accessories available for the old one	29%	21%	26%
Because the old one was outdated	30%	18%	26%
Because there were no more software updates for the old one	21%	9%	20%
Because there were no more spare parts for the old one	15%	8%	12%

Source: BITKOM 2014[156]

Possible use-time/life-extensions would reduce overall resource consumption as fewer new phones would be needed; each 3-months use-time extension would reduce resource consumption by more than 10 % per year based on the above model.

Different interventions are suggested to increase technical and economic lifetime of mobile phones:[157][158]

- Use of high quality batteries;
- Allow for easy replacement (without tools) of battery by end-user (will be regulated);
- Allow for increase of memory (e.g. through Micro-SD-Cards) and other performance critical components;
- Increase offered warranty times by manufacturers;
- Ensure availability of spare parts (batteries, displays, …);
- Increase attractiveness of SIM-only contracts;
- Allow for easy manual retrieval and erasure of personal data; this may also require the availability of replacements memory;
- Possibilities for updating/replacing the software/ operating system to ensure ongoing security, performance (also energy) and usability; availability of alternative operating systems if manufacturer support has ended (availability of specifications to alternative operating systems vendors/ communities); and

[156] BITKOM Presseinfo Austausch von Hightech-Geraeten [Press information Exchange of Hightech Appliances], 15.04.2014, http://www.bitkom.org/files/documents/BITKOM-Presseinfo_Austausch_von_Hightech-Geraeten_16_04_2014.pdf. BITKOM Graph Austausch Hightechgeraete [Exchange Hightech Appliances], 15.04.2014 , http://www.bitkom.org/files/documents/Hightechgeraete.jpg

[157] Oeko-Institut (2012), PROSA Smartphones: Entwicklung der Vergabekriterien für ein klimaschutzbezogenes Umweltzeichen, Freiburg, 2012.

[158] Blue Angel criteria for mobile phones and smartphones.

- Improved durability based on minimum average lifetime (as in the Eco-design Regulation on Fluorescent lamps).

Table 73: Assessment of interventions for lifetime extension of smartphones

Intervention	Assessment
Use of high-quality batteries	Low battery performance may stimulate consumers to buy new phones. Available technology.
Allow for easy replacement of battery by end-user (without special tools)	Battery is a component which has a low life time and highly determines usability of a phone. If transaction costs for consumers are low for installing a new battery, use-time can probably be increased significantly. This is already a requirement of the EU Battery directive and should be enforced in the future.
Allow for increase of memory (e.g. through Micro-SD-Cards) and other performance critical components	Some consumers consider buying new phones because of limited performance of current phone. Easy upgrades could ensure longer usability. Micro-SD cards are widely implemented in mobile phones; Easy exchange of other performance critical components not implemented in most phones. Replacability of performance critical components has likely interference with design of mobile phone.
Increase offered warranty times by manufacturers	May stimulate consumers to keep their phone in active use or to consider re-selling to 2nd user.
Ensure availability of spare parts (batteries, displays, …)	As many mobile phones are replaced due to technical failure, ensuring supply with critical spare parts for anticipated longer life-time (e.g. 5 years) could motivate extended repair.
Increase attractiveness of SIM-only contracts	Contracts that entail customers to a new phone every 1.5-2 years motivate consumers into early replacement. SIM only contracts exist and are increasing. Unclear, how this could relate to Ecodesign, though. Ban short contracts that require phone replacement??
Allow for easy manual retrieval and erasure of personal data	Many customers keep their phones because they cannot easily save/keep stored information elsewhere or are concerned that their data is not save (privacy/security). Can be implemented on software level, consumer information and perhaps small hardware adjustments. Due to reduced barrier for resale/pass-on, potentially one of the most effective options for prolonging use-time of phones. Also related to recycling/recoverability. This option may also include the availability of replacements memory (see above).
Possibilities for updating/replacing the software/ operating system	Many phones that have been sold in the past are not actively supported with software updates. Customers may not use them due to decreased usability, performance, privacy, security. Options: 1. Extend need for low-/no-cost manufacturer support over extended time period. 2. Ensure availability of alternative operating systems if manufacturer support has ended: This may require open availability of specifications to alternative operating systems vendors/communities. Blue Angel e.g. requires functionality for free-of-charge software updates
Repurposing	

Reduced resource consumption through use of recycled materials

Different components of mobile phones are already recycled today, such as aluminium (directly tied to primary aluminium market), glass and plastic. Most important is likely the use of other recycled metals and electronic components as they entail the biggest energy consumption and environmental impact over the life cycle. Hence, increased recycling rates of these (see below) could encourage further uptake of recycled material in phones.

Reduced resource consumption through repurposing of phones or key components

In their "Environmental assessment of consumer electronic products" WRAP suggests that key components such as processors and memory could be reused/repurposed.[159] Also repurposing of whole phones is proposed as a possibility for reduced resource consumption/increased lifetime.[160] It is difficult to assess the improvement potential of such interventions as these are very dependent upon the new application(s). These can naturally be very diverse. However, such possibilities can only be realised in practice if mobile phones are designed for easy and economic recoverability of key components/ materials.

Likely repurposing is economically inferior to resource recovery through metallurgical treatment, especially given the already existing reverse logistics systems.

Reduced resource consumption through design for recyclability/recoverability

Already today a large share of material contents of mobile phones can be economically recovered. One source gives the following share/potential of profitably recoverably contents in 1 ton of used mobile phones: 128 kg of copper, 0.347 kg of gold, 0.15 kg of palladium, 3.63 kg of silver, 15 kg of nickel, 6 kg of lead, 1 kg of antimony, and 10 kg of tin.[161]

Recycling and recovery of resources in mobile phones may require very different treatment methods. Hence, any future regulation should allow for all or make a decision for most viable (economic and ecologic) pathways for recycling/recovery:

1. Can mobile phones suitable for repurposing be easily identified?
2. Can mobile phones with components suitable for repurposing be easily identified?
3. Can mobile phones be easily separated and handled for recovery of materials?

Exploring these general options is far beyond the scope of this study. Yet, with regard to the enormous amount of components and materials present in discarded phones any interventions that can increase use of any of these options may provide enormous benefits.

Oeko (2012) reports in the PROSA product sustainability assessment of smartphones in preparation of new Blue Angel criteria that pyromettalurgic material recovery already today allows for the viable retrieval of certain metals. It also has the advantage that certain hazardous substances such as flame retardants are destroyed in the process.[162] To allow for pyrometalurgic recovery it is necessary:

[159] WRAP (2010), Environmental assessment of consumer electronic products (summary report): http://www.wrap.org.uk/sites/files/wrap/Environmental%20assessment%20of%20consumer%20electronic%20products.pdf.

[160] Zink et al. (2014), Comparative life cycle assessment of smartphone reuse: repurposing vs. refurbishment.

[161] Navazo et al. (2014), Material flow analysis and energy requirements of mobile phone material recovery processes.

[162] Oeko-Institut (2012), PROSA Smartphones: Entwicklung der Vergabekriterien für ein klimaschutzbezogenes Umweltzeichen, Freiburg, 2012.

- To collect discarded mobile phones for pre-treatment in dedicated recycling facilities
- To pretreat mobile phones

The pretreatment foremost includes the separation of the Li-Ion battery from the rest of the phone. The Li-Ion battery requires a separate recovery process for the contained cobalt and separation also reduces risk of short-circuits in the waste stream.

If this is ensured the following recovery rates can be achieved with currently operating pyrometalurgic facilities:

Table 74: Recovery rates of selected materials in pyromettalurgic recovery[161,162]

Material	Recovery rate in pyrometalurgic processes
Cobalt	95%
Silver	95%
Gold	95%
Palladium	95%
Copper	>80%
Nickel	>80%
Tin	>80%
Antimony	>80%
Neodymium	0%
Praseodymium	0%

Steel, aluminium, glass, neodymium, praseodymium are part of the residual slag and recovery from this material is uneconomic. Also, facilities for rare earth recovery do not exist in the EU

The possibility of recycling/recovery is enabled by high recovery rates and mobile phones designed for recycling/ easy recovery of resources. The following interventions are suggested to be of particular relevance:

- Allow for easy manual retrieval and erasure of personal data;
- Design for easy retractability of battery; and
- Marking of plastics and other components.

Table 75: Assessment of interventions for better recycling/recovery of resources

Intervention	Assessment
Allow for easy manual retrieval and erasure of personal data	See above. Stored sensitive or valuable data presumably keeps customers for giving their phone to other users and into formal recycling systems. Due to reduced barrier for resale/pass-on, potentially one of the most effective options for prolonging use-time of phones. Also related to use-time extension.
Design for easy retractability of battery (within seconds)	Viable and save pyrometalurgic recovery processes require very easy separation of battery from mobile phones[162]. For economic recovery and separation of waste streams this must be possible within seconds. This is different from the possible

	replaceability for end consumers. Possibly the most effective measure.
Marking of plastics and other components	Due to the diverse types of plastic, clear plastic marking can allow for better management of waste streams and retrieval of recycled plastic. (See Task 2: Supplementary Report "Identification of resource-relevant product groups and horizontal issues").

Potential for reduced resource consumption (economic perspective)

Smartphones may have the potential to replace other separate devices with distinct functionalities such as mp3 players and cameras and hence decrease overall resource use as argued by WRAP[159]. It is unclear if this effect is real or the market for these other devices is determined by other factors. Also influencing this development through Ecodesign seems unreasonable. This is hence not explored further here.

Avoidance of hazardous substances

Hazardous substances have not been explored here. Many manufactures claim avoidance of hazardous substances beyond legal requirements, such as arsenic and mercury free displays (not surprising as arsenic-free glass has been available for decades, GaAs chips are very expensive and display backlights for phones are now always LEDs so mercury lamps are not needed). Smartphones are in scope of the RoHS directive. However, most hazardous substance emissions will occur during the mining, extraction and production phases.

11.4.3 Cost calculation

No detailed cost assessment was done due to the diverse nature of improvement options. It can be assumed that some of the possibly most effective improvement options can be implemented with little or no cost or even economic benefits (e.g. through economic resource recovery):

- Allow for easy replacement (without tools) of battery by end-user;
- Allow for easy manual retrieval and erasure of personal data; this may also require the availability of replacements memory;
- Possibilities for updating/replacing the software/ operating system to ensure ongoing security, performance (also energy) and usability; availability of alternative operating systems if manufacturer support has ended (availability of specifications to alternative operating systems vendors/communities);
- Design for easy retractability of battery; and
- Marking of plastics and other components.

Many of these options are implemented in existing mobile phones.

11.5Summary

Table 76 presents a summary of the product group mobile phones, smartphones.

Table 76: Summary - Mobile phones, smartphones

	Year	Mobile phones, smartphones
EU-28 Market data (in millions)		
Sales	2012 2020 2030	256 318 337
Stock (active use)	2012 2020 2030	503 625 674
Stock (unused, broken, …)	2012 2020 2030	1,601 3,206 5,388
EU-28 Primary energy consumption (PJ)		
Over the life cycle	2012 2020 2030	102 127 135
In use phase	2012 2020 2030	15.9 19.8 21.4
EU-28 Resource consumption (t/y)		
Bulk materials		
Organics/ plastics	2012 2020 2030	11,754 14,631 15,512
Glass	2012 2020 2030	2,987 3,718 3,942
Iron	2012 2020 2030	1,438 1,790 1,897
Copper	2012 2020 2030	2,992 3,724 3,949
Aluminium	2012 2020 2030	1,083 1,348 1,429
Critical materials		
Antimony	2012 2020 2030	18.2 22.7 24.0

	Year	Mobile phones, smartphones
Beryllium	**2012** **2020** **2030**	1.2 1.5 1.6
Cobalt	**2012** **2020** **2030**	1,610 2,005 2,125
Gallium	**2012** **2020** **2030**	1.3 1.6 1.7
Magnesium oxide	**2012** **2020** **2030**	777 967 1,026
Niobium	**2012** **2020** **2030**	0.9 1.1 1.2
Platinum group metals	**2012** **2020** **2030**	tbc
Rare earths	**2012** **2020** **2030**	tbc
Tungsten	**2012** **2020** **2030**	729 907 962
Conflict materials		
Tin	**2012** **2020** **2030**	223 278 295
Tantalum	**2012** **2020** **2030**	23.9 29.8 31.6
Wolframium	**2012** **2020** **2030**	0.2 0.2 0.2
Gold	**2012** **2020** **2030**	9.1 11.3 12.0
EU-27 Annual Savings		
30% energy efficiency improvement after 2015 (primary	**2020** **2030**	5.9 6.4

	Year	Mobile phones, smartphones
Energy savings (in PJ))		
3 months lifetime extension	2020 2030	10% reduced resource consumption
Selected improvement options		
Easy retractability of battery at end-of-life	Possibilities for safely archiving/ erasing personal data	

11.6 Topics for discussion

- Overall stock model builds on a number of assumptions and should be further verified based on stakeholder input
- Slate computer (commonly named tablet computers) have likely very similar resource issues as smartphones. The current Commission Regulation 617/2013 on Computers and Computer Servers currently defines basic energy performance requirements for slate computers but no resource efficiency requirements. Given the similar nature and to avoid incentivising conflicting end-of-life treatment systems future revisions of 617/2013 and a possible preparatory study for mobile phones/ smartphones should establish this link.

12. Swimming pool heaters

12.1 Product group description

Swimming pool heaters are equipment used to warm the pool water to an acceptable level of comfort (usually between 27°C and 30°C) as the water circulates through a circuit which includes the heater, filter, central pump unit, and generally under the following two circumstances:[163]

- During the initial heat up, for filling the swimming pool; or
- When due to the ambient temperature and relative humidity in the air surrounding the pool, the pool is losing heat as a result of evaporation, radiation, convection and/or conduction.

Swimming pool heaters may use as energy input: gas, oil, electricity; renewable energy: heat pump/solar thermal systems; other heat source in combination with heat exchangers. Therefore, they can be classified into the following types (see Figure 27):

- Gas Heaters: Burn either natural gas or propane to create heat and can have either a direct (where pool water flows through the boiler) or indirect (central heating boilers which are connected to the pool water via a secondary heat exchanger) configuration.
- Oil Heaters: Oil fired heaters are usually designed identically to gas heaters and available in either direct or indirect configuration. However, these heaters are not very common nowadays.
- Electrical Resistance Heaters: These heaters are normally of the direct type encompassing a heater element, which is compatible with swimming pool water.
- Heat Pumps: Usually electrically driven but differ from other dynamic heating devices by providing most of their heat output from energy they have recovered from a low-grade source. Depending on geographical condition, heat pumps are either air-to-water or water/soil-to-water type.
- Solar Heaters: These heating systems include solar collectors that capture the sun's heat and transfer it to the swimming pool water, as the water circulates through the system.

[163] EUSA (2010), Heating of domestic outdoor swimming pools, Draft guidelines, 8th March 2010.

Figure 27: Typical types of swimming pool heaters classified per energy source

12.2 Market and stock data

Retrieval of market data from Prodcom, specifically for swimming pool heaters, was not possible. However, an analysis based on the overall number of swimming pools in Europe can provide an indication of the market and stock of swimming pool heaters.

12.2.1 Private swimming pools

The European Union of Swimming pool and Spa Associations (EUSA) has compiled market data on swimming pools up to the year 2011. This information is presented in Table 77.

Table 77: Sales of private swimming pools[164]

Country	Private Pool Sales (units)				
	2007	2008	2009	2010	2011
France	96,000	61,000	59,000	63,000	57,000
Germany	21,000	21,000	20,000	20,000	20,000
UK	6,000	5,000	2,500	2,500	2,300
Italy	21,000	24,000	22,000	20,700	19,000
Spain	38,000	35,000	15,000	16,000	14,000
Sweden	2,000	2,000	2,000	2,000	2,000

[164] EUSA estimated data (2012), Market Data 2011.

Country	Private Pool Sales (units)				
	2007	2008	2009	2010	2011
Portugal	5,000	5,000	4,000	4,000	3,000
Hungary	3,000	3,500	3,000	3,000	2,500
Switzerland	2,000	2,000	2,000	2,000	1,900
Total EUSA[165]	**194,000**	**158,500**	**129,500**	**133,200**	**121,700**

Sales trends indicate that France has the biggest share of sales, although it largely decreased after 2007, which was also the case in UK and Spain after 2008.

EUSA also estimated the number of installed swimming pools (stock) in the years 2006, 2009 and 2011. The average lifetime of private swimming pools is between 10 and 15 years.

Table 78: Stock of private swimming pools164

Country	Installed swimming pools (units)			Installed Pool/Population (%) (in 2011)
	2006	2009	2011	
France	1,270,000	1,466,000	1,606,200	2.49
Germany	998,000	-	1,100,000	1.34
UK	200,000	213,500	218,300	0.35
Italy	200,000	267,000	306,700	0.5
Spain	1,112,000	1,200,00	1,230,000	2.64
Sweden	40,000	-	50,000	0.53
Portugal	75,000	89,000	96,000	0.88
Hungary	59,000	68,500	74,000	0.74
Switzerland	72,000	-	81,900	1.04
Greece	NA	NA	75,000	0.68
Total EUSA165	**4,026,200**	**4,367,500**	**4,813,810**	**1.32**

More than 4.8 million units of private swimming pools were installed by 2011 in the main EU countries, and we can assume that it is close to the EU-27 total. In order to estimate the stock of swimming pool heaters, as no data specific for the EU market was retrieved, a market penetration rate of 21% was assumed, similar to the one in North America[166]. Therefore, the number of installed private pools including a heating system can be estimated at approximately 1,000,000 units in EU in 2011**.**

Figure 2 illustrates the current and future stock of swimming pool heaters for private use. The stock forecast takes into account the evolution in the installed base of swimming pools from 2006 to 2011, estimating a stock growth rate of 3.6%, and assuming a stable (i.e. 21%) penetration rate for heated pools until 2030.

---

[165] Total value is representative of EUSA members. Members include national associations of Greece, Portugal, Italy, UK, Germany, Spain, France, Hungary, Austria, Sweden, and Switzerland.

[166] Consortium for Energy Efficiency (2012), CEE High Efficiency Residential Swimming Pool Initiative: http://library.cee1.org/sites/default/files/library/9986/cee_res_swimmingpoolinitiative_07dec2012_pdf_10557.pdf

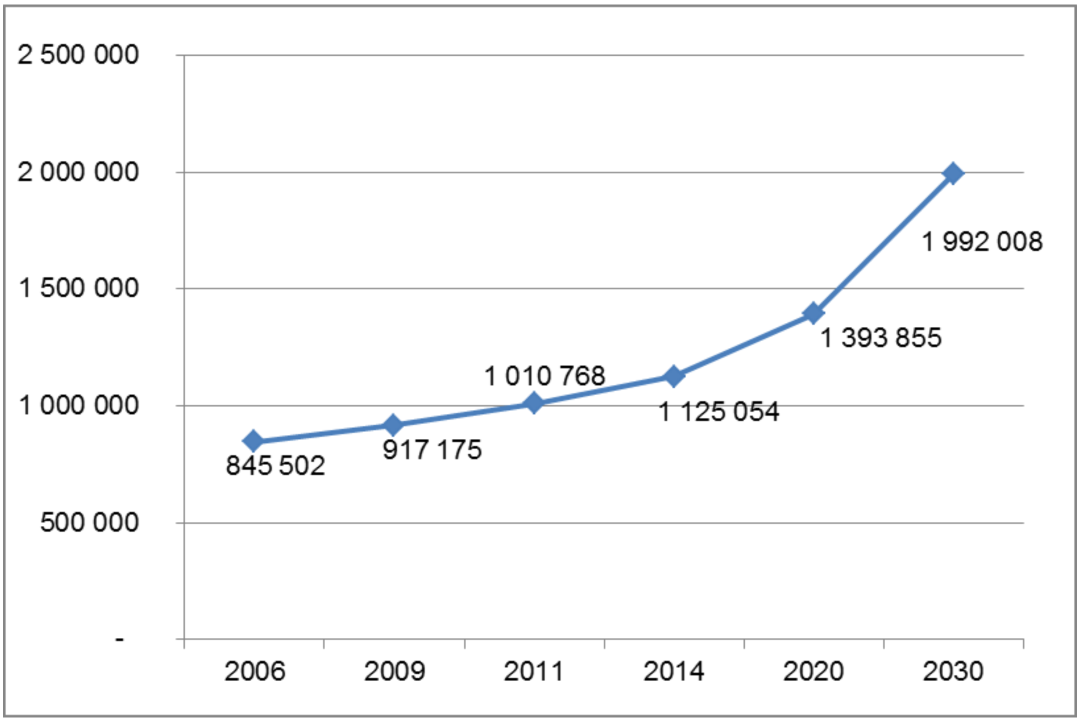


Figure 28: Stock of swimming pools heaters for private pools (2006 – 2030)

12.2.2 Public swimming pools

EUSA has estimated the number of installed public swimming pools (stock) in 2009, presented in Table 79.

Table 79: Stock of public swimming pools164

Country	Installed public pools (units) 2009
France	25,630
Germany	25,800
UK	7,100
Italy	14,930
Spain	16,900
Sweden	4,030
Portugal	2,700
Hungary	2,055
Switzerland	2,560
Greece	200
Total EUSA165	**101,905**

More than 100,000 public swimming pools were installed within the main EU countries by 2009. It is thought that the majority of these public pools utilise swimming pool heaters.

Forecast of the future stock of public swimming pool heaters considers the ratio of installed public pools to installed private pools in 2009. This ratio is approximately 2%, and assumed that it will remain stable between 2009 and 2030.

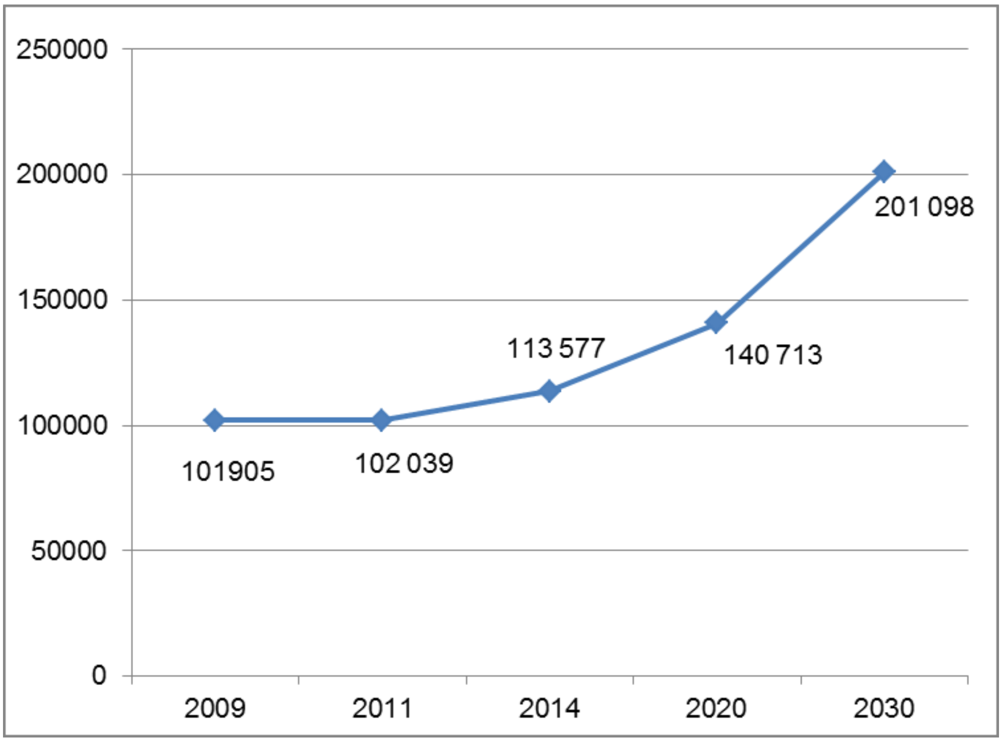


Figure 29: Stock of swimming pool heaters for public pools (2009 – 2030)

12.3 Resource consumption

12.3.1 Energy consumption

The energy range for swimming pool heaters is wide with operation depending on the size of the swimming pools, desired pool temperature, and conditions such ambient temperature, wind, shade, etc. Certain assumptions have to be considered in order to obtain indicative average energy consumption values.

Private swimming pools

A universal assumption considered is the duration of swimming pool season. The length of the pool season ranges from about 4 months in cooler climates to year-round in hot climates. Taking this into account, the operational time for swimming pool heaters in Europe is estimated as 6 months.

General characteristics of each type of swimming pool heater have been compiled and presented in Table 80. To provide a better comparative analysis, average daily energy consumption values for gas heaters, heat pumps, and solar heaters have been retrieved from a study conducted by Ausgrid[167]. The average Gross Energy Requirement (GER) has been calculated through the EcoReport tool, based on (assumed) bill of materials (BoM) and average lifetime, presented in section 12.3.3.

[167] Ausgrid (2012), Swimming pool efficiency. Available at: http://www.ausgrid.com.au/~/media/Files/Ways%20to%20save/Energy%20efficiency%20brochures/Ausgrid_Pool_Spa_201213.pdf

Table 80: Energy consumption of private swimming pool heaters

Heater type	Input range (kW)	Efficiency range (%)	Daily final energy consumption (kWh)	Average GER (over life cycle)	Average energy consumption in use phase (kWh/yr)
Gas	29-119	60-95	218[168]	2.7 TJ	39,785
Oil	41-103	75-85	-	NA	-
Electrical resistance	1.5-40	100	166[169]	1.2 TJ	30,295
Heat pump	2.6-4.5	300-600	43168	0.5 TJ	7,848
Solar	NA	NA	6[170]	0.1 TJ	1,095

Public swimming pools

Leisure centres incorporating public swimming pools and pool halls are large energy consumers. A study performed by The Smart Energy Design Assistance Centre (SEDAC)[171] devised a breakdown of energy consumption by equipment, illustrated in Figure 31 and Figure 31. These centres annually consume between 510 and 745 kWh/m^2.[172]

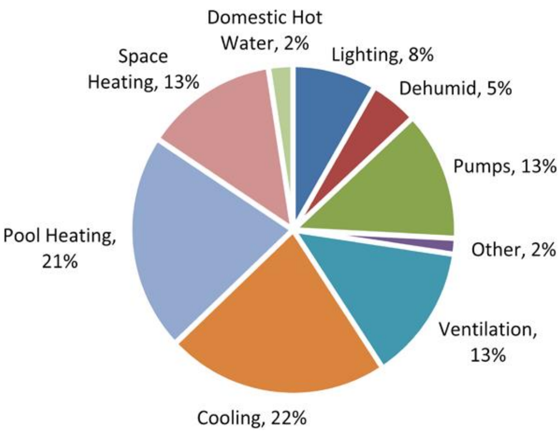


Figure 31: Energy breakdown for indoor public pools

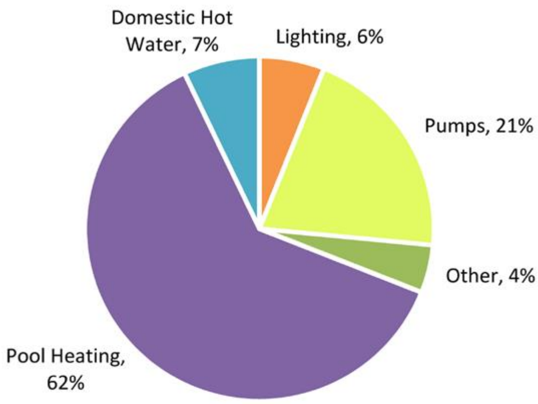


Figure 31: Energy breakdown for outdoor public pools

The average of the mentioned consumption values is 628 kWh/m^2. A leisure centre of 500 m^2 area would have an average annual energy consumption of 314 MWh. If an indoor pool is considered, pool heating would consume 65 MWh/yr; while for an outdoor pool, consumption would be 194 MWh/yr.

[168] Estimates of daily energy usage for gas and heat pump heating systems are based on providing enough heat to raise the temperature of a 50,000 litre pool by 3 degrees per day (assumed to be the average temperature loss per day for a standard sized outdoor pool).

[169] This daily consumption is calculated assuming 8 hours of use per day and that the electric heater is operating at full capacity.

[170] Solar pool heating daily energy use is based on running a 500 W (0.75hp) pump for 8 hours a day on average to circulate water through the solar collector.

[171] SEDCAC (2011), Energy smart tips for swimming pools.

[172] Good practice guide 219, Energy efficiency in swimming pools – for centre managers and operators.

12.3.2 At aggregate level

Private swimming pools

The available stock data does not indicate the share of each swimming pool heater type; therefore estimations have been performed, comparative with a related study[173] which estimated that solar heaters have 20% while gas and electric heaters have an 80% share in US stock of residential swimming pools.

A similar ratio is applied to the current and predicted stock presented in Figure 28 (2011 – 2030), with the exception that solar heaters are thought to have increased their share to 30%, as the obtained comparative data is from 1997. The remaining 70% is divided equally between heat pumps, gas and electrical resistance heaters. As mentioned earlier, swimming pool oil heaters are following a declining trend, therefore their share is assumed to be negligible.

The above assumptions complemented with energy consumption calculations from the previous section have been compiled to obtain the energy consumption of EU-27 stock for 2011 and 2014 as well as 2020 and 2030.

Table 81: Aggregate EU energy consumption of private swimming pool heaters

Heater type	Energy indicator	2011	2014	2020	2030
Gas	EU-27 GER	85 PJ	94 PJ	117 PJ	167 PJ
	EU-27 Primary energy consumption in use phase	23.1 TWh	26.5 TWh	32.3 TWh	46.2 TWh
Electrical resistance	EU-27 GER	64 PJ	72 PJ	89 PJ	127 PJ
	EU-27 Primary energy consumption in use phase	17.9 TWh	19.9 TWh	24.6 TWh	35.2 TWh
Heat pump	EU-27 GER	17 PJ	19 PJ	23 PJ	33 PJ
	EU-27 Primary energy consumption in use phase	3.1 TWh	3.5 TWh	4.3 TWh	6.1 TWh
Solar	EU-27 GER	3 PJ	3.3 PJ	4 PJ	6 PJ
	EU-27 Primary energy consumption in use phase	0.8 TWh	0.9 TWh	1.1 TWh	1.6 TWh
Total	EU-27 GER	169 PJ	188.3 PJ	233 PJ	333 PJ
	EU-27 Primary energy consumption in use phase	45.3 TWh	50.4 TWh	62.4 TWh	89.2 TWh

Public swimming pools

Retrieval of information about the proportion of indoor/outdoor pools and other characteristics (i.e. hall area) of public swimming pools was not possible. Consequently, an area of 500m^2 and a 50% split between indoor and outdoor pools was assumed. Utilising public pools stock data in 2009 (Table 3)

[173] Bill Quam (1997), A Marketing Analysis of SolarAttic Inc.

and stock forecasts (Figure 29), the aggregate energy consumption of public swimming pool heaters was calculated at EU level. This is presented in Table 82.

Table 82: Aggregate EU energy consumption of public swimming pool heaters

	Energy indicator	2009	2014	2020	2030
Public swimming pool heaters	EU-27 GER	-	-	-	-
	EU-27 Primary energy consumption in use phase	33.2 TWh	37 TWh	45.8 TWh	65.5 TWh

12.3.3 Other resource consumption

Identification of other resources consumed has been based on Internet research of product factsheets from swimming pool heaters manufacturers, and retrieval of bill of materials (BoM) for similar products. Initial observations indicate that numerous resources consumed by swimming pool heaters are common to all types of heaters, although certain materials are specific to the type (i.e. solar) and manufacturer of heater.

Swimming pool gas heaters weight between 36 kg and 113 kg (average 75 kg). Their lifetime is between 5 and 10 years (average 7.5 years). The BoM for this type of heater, presented in Table 7, is based on the BoM of gas-fired instantaneous water heaters acquired by a study performed by VHK[174]. It has been assumed that the materials used as well as their corresponding composition (%) are similar to VHK's study. The weights of materials have been corrected to the average weight of swimming pool gas heaters.

Table 83: Assumed BoM of swimming pool gas heater

Material	Share [%]	Weight [kg]
Plastics	8.0%	6.0
Steel - galvanised	62.1%	46.6
Cast iron	2.6%	2.0
Ins. Ceramic	1.8%	1.4
Stainless steel	5.9%	4.4
Aluminium die cast	4.3%	3.2
Copper	9.4%	7.1
Brass	3.6%	2.7
Electronics	1.5%	1.1
Others	0.8%	0.6
Total	100.0%	75.0

For electrical resistance heaters, the BoM is also based on the BoM of electric instantaneous water heaters acquired by the study performed by VHK174. A similar material composition has been assumed, corrected to the average weight of swimming pool electrical resistance heaters. The weight

[174] VHK (2007), Ecodesign Preparatory Study on water heaters - Task 5 final report.

ranges between 4 kg and 12 kg (average 8 kg); and lifetime is between 3 and 6 years (average 4.5 years).

Table 84: Assumed BoM of swimming pool electric heater

Material	Share [%]	Weight [kg]
Plastics	24.2%	1.9
PA6	24.8%	2.0
Steel - galvanised	3.8%	0.3
Stainless steel	3.6%	0.3
Copper	14.0%	1.1
Brass	10.5%	0.8
Electronics	9.1%	0.7
Others	10.0%	0.8
Total	100%	8.0

Swimming pool heat pumps weight between 55 kg to 145 kg (average 100 kg), and have a lifetime of 5 to 10 years (average 7.5). A simplified BoM is presented in Table 85, inspired by a study conducted by EPTA[175] which presents a simplified BoM for heat pumps. The weights have been corrected to the average weight of 100 kg.

Table 85: Assumed BoM of swimming pool heat pump

Material	Share [%]	Weight [kg]
Steel	85%	85
Plastics	14%	14
R410a refrigerant	1%	1
Total	100%	100

The BoM of a typical solar water heating system[176] has been assumed for swimming pool solar heaters. They have an average lifetime of 10 to 15 years.

Table 86: Assumed BoM of swimming pool solar heater176

Material	Weight [kg]
Heated glass	12
Copper	5
Aluminium	11
Steel	40
Polyurethane	7

[175] EPTA (2007), Study for preparing the first Working Plan of the Eco-Design Directive.

[176] C Koroneos, E Nanaki (2012), Life cycle environmental impact assessment of a solar water heater.

Material	Weight [kg]
Fibre glass	5
EPDM	2
Total	82

12.4 Improvement potential

12.4.1 Improvement potential – Energy consumption

Private swimming pools

Swimming pool heat pump and solar heaters are often discussed as the energy efficient alternatives to traditional swimming pool heating systems, i.e. based on gas and electrical resistance. However, realising the improvement potential within the product group swimming pool solar heaters was a difficult task. This may be partly due to the energy efficient alternative view. A similar conundrum was faced in realising the improvement potential of electrical resistance heaters. Consequently, an improvement potential of 20% was assumed for each of the two types, solar and electrical resistance heaters.

Best Available Technology (BAT) gas heaters possess thermal efficiencies between 90 – 95%. Recent studies performed by Consortium for Energy Efficiency166 and California Statewide Utility Codes and Standards Program[177] indicate that a 95% efficient gas heater can provide estimated savings of 17% compared to products within the 70-80% efficiency rate.

Heat pumps have an efficiency range of COP 3 to COP 6. Switching from an average COP of 4.5 to heat pumps possessing the highest efficiency of COP 6 would result in 25% energy savings.

Table 87: Improvement potential individual product level – private swimming pool heaters

Heater type	Improvement potential (primary energy use) with respect to GER	Improvement potential with respect to energy consumption in use phase
Gas	-	17%
Electrical resistance	-	20%
Heat pump	-	25%
Solar	-	20%

Another way to reduce the energy consumption for swimming pool heating is to use pool covers. A transparent bubble cover may reduce pool solar energy absorption by 5%–15%. A completely opaque cover will reduce it by 20%–40%[178].

[177] Codes and Standards Enhancement (CASE) Initiative (2013), Pool Heaters, Analysis of Standards Proposal for Residential Gas Fired Pool Heaters.

[178] Source: U.S. Department of Energy.

Table 88: Improvement potential aggregate level – private swimming pool heaters

Heater type		EU-27 improvement potential	
		2020	2030
Gas	with respect to GER	-	-
	with respect to primary energy consumption in use phase	5.5 TWh = 19.8 PJ	7.9 TWh = 28.4 PJ
Electrical resistance	with respect to GER	-	-
	with respect to primary energy consumption in use phase	4.9 TWh = 17.7 PJ	7 TWh = 25.3 PJ
Heat pump	with respect to GER	-	-
	with respect to primary energy consumption in use phase	1.1 TWh = 3.9 PJ	1.5 TWh = 5.4 PJ
Solar	with respect to GER	-	-
	with respect to primary energy consumption in use phase	0.2 TWh = 0.8 PJ	0.3 TWh = 1.2 PJ

Public swimming pools

The improvement potential of public swimming pool heaters is estimated at 18%. This calculation considered annual energy consumption difference between the most efficient pool hall/leisure centre and a pool hall/leisure centre having an average performance. The range of energy consumption for pool halls/leisure centres was defined as 510 – 745 kWh/m^2.

Table 89: Improvement potential of public swimming pool heaters

	Improvement potential (primary energy use) with respect to GER	Improvement potential (final energy use) with respect to energy consumption in use phase
Public swimming pool heaters	-	18%

The improvement potential at an aggregate level is presented in Table 90.

Table 90: Improvement potential aggregate level - public swimming pool heaters

		EU-27 improvement potential	
		2020	2030
Public swimming pool heaters	with respect to GER	-	-
	with respect to primary energy consumption in use phase	8.3 TWh = 30 PJ	11.8 TWh = 42.5 PJ

12.4.2 Cost calculation

The unit price of swimming pool heaters varies greatly depending on the manufacturer, model, and required performance. The following sale price ranges and averages are based on internet research.

Sale price of gas heaters ranges between 1,000€ and 4,000€, resulting in average price of 2,500€. Electrical resistance heaters cost between 900€ and 2,000€, giving an average of 1,450€. Heat pumps are the costliest type of swimming pool heater with a range from 2,000€ to 9,850€ and an average price of 5,925€. Solar heaters have a large cost variation as well mainly dependent on swimming pool size, ranging between 600€ and 9,000€ resulting in an average of 4,800€.

12.5 Summary

Table 91 presents a summary of the product group "Swimming pool heaters".

Table 91: Summary – Swimming pool heaters

	Year	Gas	Electrical resistance	Heat pump	Solar	Public pool heater	Total
Market data							
Sales	**2011**	121,700				-	-
Stock	**2011**	235,000	235,000	235,000	300,000	102,000	1,107,000
	2020	325,000	325,000	325,000	418,000	140,000	1,533,000
	2030	465,000	465,000	465,000	597,000	200,000	2,192,000
EU-27 Annual primary energy consumption							
Over the life cycle	**2011**	85 PJ	64 PJ	17 PJ	3 PJ	-	169 PJ
	2020	117 PJ	89 PJ	23 PJ	4 PJ		233 PJ
	2030	167 PJ	127 PJ	33 PJ	6 PJ		333 PJ
In use phase	**2011**	23.1 TWh	17.9 TWh	3.1 TWh	0.8 TWh	33.2 TWh	78.1 TWh
	2020	32.3 TWh	24.6 TWh	4.3 TWh	1.1 TWh	45.8 TWh	108.1 TWh
	2030	46.2 TWh	35.2 TWh	6.1 TWh	1.6 TWh	65.5 TWh	154.6 TWh
EU-27 Annual primary energy savings							
In use phase	**2020**	5.5 TWh = 19.8 PJ	4.9 TWh = 17.7 PJ	1.1 TWh = 3.9 PJ	0.2 TWh = 0.8 PJ	8.3 TWh = 30 PJ	20 TWh = 72.2 PJ
	2030	7.9 TWh = 28.4 PJ	7 TWh = 25.3 PJ	1.5 TWh = 5.4 PJ	0.3 TWh = 1.2 PJ	11.8 TWh = 42.5 PJ	28.5 TWh = 102.8 PJ

Legend: Cell highlighted in grey indicates the total value of sales including all types of heaters (excluding public pool heaters) as individual market data was unavailable.

12.6 Topics for discussion

The main limitation of the above approach concern the lack of market data on swimming pool heaters (sales, stock, market share), resulting in the use of swimming pools' stock in Europe as a proxy, but it must be noted that the number of heated pools in Europe is not known.

Another concern relates to improvement potential of electrical resistance heaters and solar heaters. Electrical resistance heaters placed on the market are 100% efficient and in solar heaters, the comprised equipment (i.e. water pump) is the main source of energy consumption.

Finally, very little data for public swimming pools are available.