Ecodesign and Energy Labelling Preparatory Study on Hand Dryers (GROW Lot 12)

Final Report

Written by ICF Consulting Ltd
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GLOSSARY

A list of terms and abbreviations used in this report are described below.

Term	Description
AC	Alternating Current
BAT	Best Available Technology
BaU	Business as Usual
BC	Base Case
BNAT	Best Not yet Available Technology
BoM	Bill of Materials
DC	Direct Current
DG GROW	Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
DO	Design Option
EEI	Energy Efficiency Index
eHA	electric Hand Dryers Association
EN	European Standard
EPA	Environmental Protection Agency
EPD	Environmental Product Declaration
EoL	End of Life
ErP	Energy related Product
ETL	Energy Technology List
EU	European Union
HEPA	High Efficiency Particulate Air
LCC	Life Cycle Cost
LLCC	Least Life Cycle Cost
MEErP	Methodology for the Ecodesign of Energy related Products
MEPS	Minimum Energy Performance Standard
NSF	National Sanitation Foundation
PCB	Printed Circuit Board

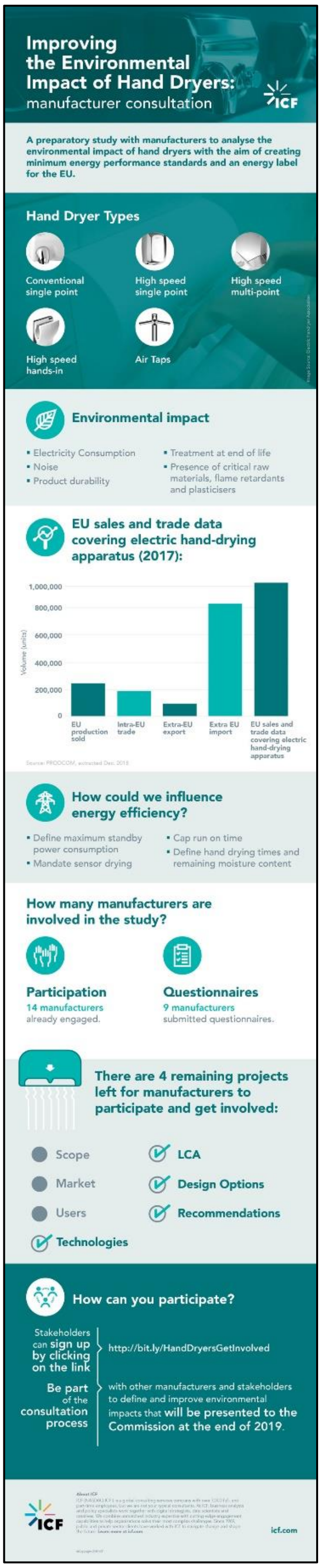
PEF	Primary Energy Factor
PCR	Product Category Rule
VSD	Variable Speed Drive

EXECUTIVE SUMMARY

Introduction

The Ecodesign preparatory study on hand dryers was delivered by ICF Consulting Ltd on behalf of DG GROW.

ICF has a track record in the testing and verification of hand dryer energy consumption and drying performance. ICF is a delivery partner for UK Government and performs technical conformity assessments on hand dryers seeking to be listed on the "Energy Technology List" (ETL). A UK Government backed list of energy efficient technologies, the ETL provides users/procurers with the top 25% performing, independently verified, energy efficient products on the market. The ETL's testing method for high-speed hand dryers is one of a small number of standards that exist globally.



The ICF Study Team were complemented by two experts, one from UL (U.S.), who led the creation of Product Category Rules (PCR) for the Environmental Product Declarations (EPD) for hand dryers, and a circular economy electronics expert from QSA Partners (UK).

The study kicked off in September 2018, together with representatives of the electric Hand Dryers Association (eHA). The preparatory study followed the *Methodology for the Ecodesign of Energy related Products* (MEErP), and as such comprised the delivery of the following seven task reports:

- Task 1 Product Scope
- Task 2 Markets
- Task 3 Users
- Task 4 Technologies
- Task 5 Environment & Economics
- Task 6 Design Options
- Task 7 Scenarios

Building from the kick-off, consultation with stakeholders was intrinsic throughout the study. This included with representatives of the eHA, and other manufacturers (e.g. Dyson), civil society (e.g. ECOS) and Member State representatives. Two key formal stakeholder consultation meetings were delivered at DG GROW in January 2019 (after publishing the draft Task 1-3 reports) and November 2019 (after publishing the draft Task 6 and 7 reports). However, the study team sought to consult regularly with the industry beyond these milestones. Examples include, during project inception, when ICF liaised with eHA to identify manufacturer contacts who would be interested in the study, and at the study mid-point, when ICF delivered an additional stakeholder teleconference call after publishing the draft Task 4, 5 Reports.

ICF undertook stakeholder communication activity to raise awareness of the study and build involvement. This included the production of infographics for use in social media (opposite). However, despite these activities, some manufacturers chose not to engage.

All draft and final versions of reports, the consultation feedback log, and minutes, actions and presentations from stakeholder consultation meetings, were published via the study website www.ecohanddryers.eu. This was also a vehicle for stakeholders to formally register their interest in the study – a route which 37 stakeholders used.

Due consideration was given in this preparatory study to the outputs from the Ecodesign Package, 2019. Specifically, in terms of two aspects. Firstly, regarding the precedent set from the introduction of measures designed for a Circular Economy. The measures to improve the availability of spare parts, access to repair and maintenance information, requirements for dismantling for material recovery and recycling and marking of plastic components have all been recommended as measures for the hand dryers product category. Secondly, regarding the revision to the previous Ecodesign electric motors regulation and the newly published Commission Regulation (EU) 2019/1781[1] and how the scope of this regulation aligns (or otherwise) with the types of motors found in electric hand dryers.

Scope

Hand dryers are classified under PRODCOM as *electric hand drying apparatus*. There are no EN or ISO standards from which to draw hand dryer definitions but based upon existing third-party standards, hand dryers can be classified into one of five categories. The names and descriptions cited below in Table 1 are drawn from UL's PCR for preparing an EPD for hand dryers, which are accepted by the eHA. Although presently having a very low EU market share, air taps have been added to the categorisation.

- Category 1 Conventional single point (hands under) dryer
- Category 2 High speed single point (hands under) dryer
- Category 3 High speed multi point (hands under) dryer
- Category 4 High speed trough style (hands in) dryer
- Category 5 Air tap

Table 1 Types of hand dryers

Category 1	**Category 2**	**Category 3**	**Category 4**	**Category 5**
				

The preparatory study focused on hand dryers and did not consider other forms of hand drying systems (e.g. paper towels or cloth roll towels). These other hand drying systems are not consistent with the definition for an *Energy-related Product*[2] as per article 2 *definitions*, paragraph 1 of the Ecodesign Framework Directive 2009/125/EC[3].

Furthermore, the MEErP defines "direct" Energy-related Products (ErPs) as products that use energy during the use phase of the product's life cycle. Electric hand dryers are thus considered a direct ErP. The method also defines "indirect" ErPs, where the product does not use energy in the use phase but has a significant impact on the energy consumption of products that are using energy within its system (e.g. insulation and glazing). Such

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2019.272.01.0074.01.ENG

[2] *'Energy-related product', (a 'product'), means any good that has an impact on energy consumption during use which is placed on the market and/or put into service, and includes parts intended to be incorporated into energy-related products covered by this Directive [2009/125/EC] which are placed on the market and/or put into service as individual parts for end-users and of which the environmental performance can be assessed independently*

[3] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0125&from=EN

indirect ErPs affect the energy consumption of heating systems, which operate within its wider system context. Paper and cotton towels would not be considered an indirect ErP because they do not affect the energy consumption of products in their system.

Manufacturers have advised that an unintended consequence of potential "over" regulation of electric hand dryers could be a sideways behavioural shift to other forms of hand drying, such as paper towels – dubbed a "substitution effect" by manufacturers.

Product Performance Parameters

The primary product performance parameter or functional unit is the quantified performance of the product. In this study, that was one use or drying cycle. To standardise this unit, a secondary performance parameter was introduced, namely remaining moisture content. Thus, a drying cycle would be complete when the user's hands are dried to a certain remaining moisture content (e.g. 0.10g to 0.25g). A third performance parameter of time was included, to measure how long it takes to achieve the required remaining moisture content for a drying cycle (e.g. 10 to 15 seconds).

Measurement & Test Standards

There are no harmonised measurement or test standards for hand dryers covering the product performance parameters. However, there are four non-harmonised measurement and test standards covering the product performance parameters. These are owned by either testing and certification bodies (e.g. UL or the National Sanitation Foundation, NSF) or by national EU Member State Governments or delivery bodies:

- UK's Energy Technology List Test Method for High Speed Hand Air Dryers
- NSF's Protocol P335 for Hygienic Commercial Hand Dryers
- Germany's Blue Angel Criteria for Electric Hand Dryers
- UL's Product Category Rule for Hand Dryer Environmental Product Declarations

Manufacturers have advised that the existence of harmonised test standards for the measurement and declaration of the product performance parameters should be a prerequisite for the introduction of any regulatory measures for the product group.

EN standards exist elsewhere for the measurement of electrical standby power consumption, noise emissions and material efficiency.

Technology Description

Hand dryers are essentially fan systems. As such, all hand dryers perform their function through the same basic steps:

- Activation from standby – either manually, by means of a push button, or automatically, by means of a sensor.
- Draw air in – by means of a fan motor via one or more inlets and ducting. Incoming air may be cleaned by means of a filter and, once inside, may be warmed by means of a heating element, the motor or through compression in order to encourage evaporation of water from the user's hands.
- Blow air out – by means of the same fan motor via ducting and one or more outlets onto the user's wet hands. Water removed by the scraping effect of the moving air, rather than by evaporation, may be collected in a tank or drained directly to a wastewater pipe.
- Return to standby – automatically, by means of either a sensor or a timer.

Category 1 hand dryers primarily use heat and achieve dryness through evaporation whereas categories 2-4 use airspeed that blows the water off the hands, sometimes in combination with heat. Generally speaking, the former consumes more power for longer but is quieter whereas the latter is more efficient and faster but louder.

Hand dryers can be activated through one of four activation methods: push button on/off, push button and timer, sensor and timer or sensor only. Note that "run-on time" can result when the user withdraws their hands but the sensor has not instructed the dryer to stop immediately. This results in the hand dryer continuing to operate and consume energy.

Hand dryers can use a conventional thermoelectric heating element, with a potentially adjustable heat output or use no heat at all. Where heat is used, some models can recover waste heat from the motor and thus avoid the need for a heating element. Heating can represent a very significant proportion of the overall energy consumption of the hand dryer. In general terms, for category 1 dryers, the warmer the air flow, the faster the drying time, but the greater the energy consumed by the heating element. For high-speed hand dryers, suppliers note that warm air flow does not have a significant effect on drying efficiency with its prime benefit being the addition of comfort.

The fan consists of a bladed impeller housed in a casing. In hand dryers, a fan motor consists of a fan connected directly to the shaft of an electric motor. Although hand dryers are powered by mains alternating current (AC) electricity, the motors within them can run on AC, direct current (DC) or both (in the case of universal motors). These motors can either be "brushed", meaning that the current to the rotor is delivered through a rotating mechanism that contains carbon brushes, or be "brushless", meaning that the current to the rotor is switched electronically. The four types of motor found in hand dryers are Brushed DC, Brushless DC, Induction AC, and Universal (which contain brushes). Brushed motors are simpler and cheaper to make than brushless motors. Due to the wearing out of their brushes through operation, brushed motors are less efficient, are noisier, have shorter lives and are less reliable than brushless motors. Notwithstanding the relative advantages of brushless motors over brushed motors, the lower initial cost (price) of the latter means that they are often preferred to brushless motors. Some motors have a 'soft start' mechanism hard coded into the motor's programming. This affects the initial fraction of a second to control the ramp up of the motor and has the benefit of improving the motor's lifetime. Manufacturers sometimes employ a variable speed drive (VSD), which can be used to control the torque and speed of the motor and thus its acceleration, deceleration and as a result, noise level. Fans are categorised according to the direction in which they blow air: either axial, centrifugal or mixed fans.

Other key components include air inlets, ducting and outlets; the printed circuit board (PCB) and wiring; the casing, wall plate, and fixtures. None of these are energy-using components, but some can and should be designed in ways to minimise noise.

Features found in hand dryers include:

- air speed control (fixed speeds of low, medium or high)
- heating control (typically on/off; less common are automatic ambient air temperature sensors)
- filters and air purifiers
- antimicrobial technologies
- lights, sound alarms and displays
- drip trays, water tanks and potential associated evaporation devices
- IoT and Bluetooth connectivity

Standard improvement options and best available technology (BAT) were identified for each main component and feature of hand dryers.

User Parameters

Relevant user-parameters are an important input for the assessment of the environmental impact of a product during its use and end-of-life phases. Concerning product life cycle, for category 2, 3 and 4 hand dryers, the main method to extend lifespan is to repair or replace the motor when it fails. For category 1 hand dryers, the motor runs at much slower speeds, which leads to substantially less wear. Not only does the motor last longer before needing repair, but it generally is easier to repair (with a new carbon brush) or replace, both of which result in category 1 hand dryers having a longer life expectancy. Viewing the hand dryer through an extended product approach allows consideration of use under operation modes, frequency and location.

Usage variability is affected by three components: the technology type (which will affect the length of a cycle required to dry hands), the user patience (users may leave before their hands are fully dry), and the hand dryer installation location, which affects the average number of uses per day. Minimum, maximum and average usage times vary per category type (ranging from an average of 12.9 seconds/use for category 4 to 17.2 seconds/use for category 1) and per location (ranging from an average of 163 cycles/day in office locations to 2355 cycles/day for airports). The user's hands, the wetting time and the employed mechanical action used during drying represent further variables influencing the average length of time taken to achieve a required level of dryness and the overall efficiency of the hand drying process.

Maintenance, Repairability and End-of-Life

Minimum, maximum and average economic and technical lifetimes were established for the four main hand dryer categories. Average economic lifetimes varied from 6.9 years for category 2 and 3 dryers up to 12.4 years for category 1 dryers. Average technical lifetimes were slightly shorter, ranging from 6 years for category 2 and 3 dryers to 10.9 years for category 1 dryers.

The prevailing improvement for life expectancy originates not from good maintenance but rather from the design and components used – notably the motor. The other major factors are linked to usage rates. Good maintenance practice for extending lifetime includes keeping the product clear of dust. This is done mainly through filters, notably high-efficiency particulate air (HEPA), which are expected to last from three months to a year before needing replacement (dependent on frequency of use and dustiness of the use environment).

In terms of recycling, collection and disposal, approximately 80-90% of a hand dryer can be recycled, if the dryers are adequately collected and sorted. However, the recycling rate for these materials is different in practice: the rate of recuperation and recycling for small plastics is near-zero despite most of these being recyclable. Current recycling processes focus on recuperating electronics and shredding the rest of the product. The separation recuperates and recycles most of the metals, however other materials are not recuperated as effectively.

The Market

Total EU-28 sales and trade for hand dryers using 2017 PRODCOM data was 978,388 units with a value of €44,461,860. The data reveals two important trends: the first being that the EU is heavily dependent on foreign imports, and that these imports are much cheaper per unit than internal production. 84.7% of the total EU sales and trade by volume is imported. However, these imports only account for 67.1% of the market value.

Installed base was calculated per hand dryer category. Total sales of hand dryers in the EU were determined using PRODCOM data and projected to grow to 2050 under a linear forecast from 2003-2018 datapoints. The manufacturer estimates were used to estimate the split of sales across the categories and the sales pre-2003. From these sales, and the product lifetimes, a model was run to determine the stock values.

A clear feature is the steady increase in expected total stock. Category 1 dryers are the majority, incumbent technology. However future sales forecasts show that high speed dryers are rapidly becoming the preferred technology. Recent years indicate growth across each category. This growth is expected to diminish for category 1 dryers as other technologies increase their market share. The stock of conventional versus high speed hand dryers is expected to be equivalent at some point between 2025 and 2030. The increase in hand dryer sales originates from the success of the high-speed technology. As the new hand dryers are effective at drying hands, their other advantages compared with other hand drying methods have been persuasive to end buyers, for example, lower total cost of ownership and lower maintenance costs. This has allowed end buyers to meet their environmental obligations and save money. For example, a switch from paper towels to hand dryers has also been used by end buyers to meet corporate targets on cost and carbon emissions.

Average prices as sold were determined from manufacturer feedback for category 1-4 dryers: €188 for category 1, €335 for category 2, €454 for category 3 and €715 for category 4 dryers. Average installation costs were estimated to be €100, with the average cost of consumables (i.e. filters) at €20/year.

Repair rates and costs were established from manufacturer feedback. 25% of category 1 dryers were estimated to be repaired over the course of their lifetime, with a rate of 30% for categories 2-4. Average repair material costs ranged from €27 (category 1) to €65 (category 4), with labour costs of €129. The effect was to extend lifetime by an estimated additional 25% for category 1 and 33% for category 2-4 dryers.

Base Cases

Multiple Bills of Materials (BoMs) were supplied by manufacturers for each of the four principle hand dryer categories, enabling a thorough component list for each base case. Table 2 overlays the hand dryer technology categorisation with the selected base cases for the economic and environmental assessment.

Table 2 Overlay of Hand Dryer Categories and selected Hand Dryer Base Cases

	Overlay			
Technology Category	1	2, 3	4	5
Associated Base Case	BC1	BC2	BC3	No BC – negligible sales re. overall stock

Table 3 presents each base case and includes information on the sales and stock and shows the percentage of each BC as a fraction of total EU28 in 2020.

Table 3 Overview of Hand Dryer Base Cases

Base Case	Product Category	EU28 Sales (2020)		EU28 Stock (2020)	
		Units	%	Units	%
BC1	Conventional single point hands under dryer	409,000	40%	5,179,000	62%
BC2	High speed single/multi point hands under dryer	431,000	42%	1,988,000	24%
BC3	High speed trough style hands in dryer	178,000	18%	1,120,000	14%

With the amalgamation of hand dryer categories two and three, the three base cases effectively capture the four primary hand dryer categories, as well as 99% of stock. The similarities between categories two and three outweigh the differences (principally the single vs. dual air stream).

For all three Base Cases, the Production and Use phases account for most of the environmental impacts created. The environmental impacts, consumer and societal costs were calculated for each of the three base cases. An extensive sensitivity analysis was performed on the impacts and costs to see how the calculations would change with a low and high usage scenario (i.e. cycles per day), with a low cycle duration (in seconds), and with different values for primary energy factor, the cost of externalities and electricity price. The values for these final three parameters have evolved from the assumed, fixed values in the MEErP following development in EC policy since the last update of the methodology in 2013.

Table 4 Energy Consumption and Life Cycle Costs per unit

	BC1	BC2	BC3
Total Energy Consumption in the Use Phase (MJ)	46,523	15,471	22,197
Total Life Cycle Cost to the Consumer (€)	1,092	802	1,588

Design Options

Options to improve the design of hand dryers were identified and used to assess the environmental impact improvement potential and life cycle cost (LCC) implications with a view to implementing them as policy. Out of a possible list of 26 potential design options, the following were evaluated:

- No heat – i.e. the removal of heating elements from hand dryers, with products relying on the speed of the airstream to dry user's hands.
- Standby – a maximum energy consumption whilst in standby.
- Sensor only & run-on time - mandating sensor only activation and limiting run-on time to 1 second.
- Energy efficiency – a minimum energy efficiency rating considering hand dryer consumption and drying time, thus calculating energy consumption per cycle.
- Assembly Design – to improve the assembly/ disassembly design allowing easier access, improving fault diagnosis and repair, and extending product lifetime. Also allowing for easier separation via disassembly and material recovery.
- A combination of all the above five design options.

The Design Options were prioritised because they target the key environmental impacts of hand dryers. Electricity consumption from the heating element is a significant consumer of energy, energy is wasted through standby and from hand dryers continuing to operate following the removal of the user's hands (run-on time). It was also important to identify circular economy principles within the design mix.

Each design option was assessed to identify which has the Least Life Cycle Cost (LLCC) and which is the Best Available Technology (BAT) with the lowest environmental impact. In summary, of the individual design options, the no heat option represents the LLCC and the combination option the BAT for all three base cases.

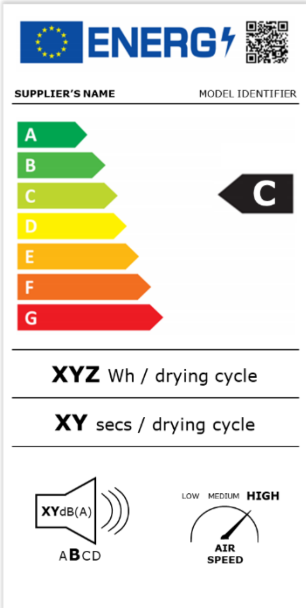
Scenarios

Ecodesign Minimum Energy Performance Standards (MEPS), energy labelling policy options and a combined MEPS + labelling policy scenarios were proposed and modelled.

The MEPS aim at removing the worst performing products from the market:

- Standby power consumption - limit standby power consumption in the form of two tiers. Tier 1 (2024) comprising an upper limit of 0.5W (1W where an information/status display is included in the product), reducing to 0.5W limit (whether or not the product is equipped with an information/ status display) in Tier 2 (2027).
- Sensor use – a measure to require all hand dryers to control activation (on and off) by sensor only, removing push button on/off, push button and timer, and sensor and timer activation controls.
- Run-on time – a requirement to cap run-on time to 1 second.
- Energy consumption – a measure to limit energy consumption to ≤10 Wh/cycle in Tier 1 reducing to ≤7.5 Wh/cycle in Tier 2.
- Heating elements – a measure for high-speed dryers to limit the rating of the heating element to 500W for category 2 and 3 and 550W for category 4 dryers.
- Circular economy aspects – measures to improve the availability of spare parts, access to repair and maintenance information, requirements for dismantling for material recovery and recycling and marking of plastic components.
- Assembly design – a measure to improve design requirements for electronics material recovery and improved repair.

- Use of Critical Raw Materials – an information requirement to report on an indicative weight range of neodymium found within hand dryers.



The introduction of an energy label (opposite) aims to rank hand dryers by their energy performance compared to the average performance on the market, incentivising consumers to buy more efficient products.

An Energy Efficiency Index (EEI) is proposed which is derived from dividing the energy consumption per cycle of the hand dryer by an average energy consumption per cycle. The energy consumption per cycle is the electricity power consumption (W) multiplied by the cycle length. The cycle length is the time taken to dry hands to a remaining moisture content of 0.25g, as declared by the manufacturer.

In proposing an energy label class distribution, consideration has been given to the new requirements under the revised Energy Labelling Regulation (EU) 2017/1369, article 11. No products are expected to fall into energy class A or B at the moment of the introduction of the label. The Ecodesign MEPS are designed to overlay onto the energy label classes, such that G-class hand dryers would not meet Tier 1 and F-class hand dryers would not meet Tier 2.

Resource use and environmental impacts, and socio-economic impacts of the scenarios have been modelled and compared to the business-as-usual (BaU) scenario. The key results are presented below:

- Energy consumption

Figure 1 and Figure 2 present the annual primary and final energy consumption of hand dryers in the EU between 2010 and 2050 for the different scenarios respectively, considering the Primary Energy Factor of 2.1. Table 5 and 7 present annual and cumulative primary energy savings and Tables 6 and 8 the annual and cumulative final energy savings accrued when implementing the proposed policies.

In the BaU scenario, the energy consumption remains roughly steady between 2020 and 2050 ranging between 6.2 and 6.8 TWh/year over the period as the market transitions from conventional to high-speed products which tend to be more efficient.

The MEPS scenario is more ambitious than the Labelling scenario in the short and medium-term. As the average electricity consumption in the BaU scenario catches up with the MEPS, less annual savings begin to be accrued and the distance between these two curves decreases over time.

The MEPS + Labelling scenario is the most ambitious policy option, reducing annual primary energy consumption by 17% in 2030 and 27% in 2050 compared to the BaU scenario. Cumulative Primary Energy savings accrued via this scenario are modelled as achieving up to 3.81 TWh by 2030 and reach 43.66 TWh by 2050.

Figure 1 Total annual primary energy consumption in the EU (TWh/year) – Electric Hand Dryers

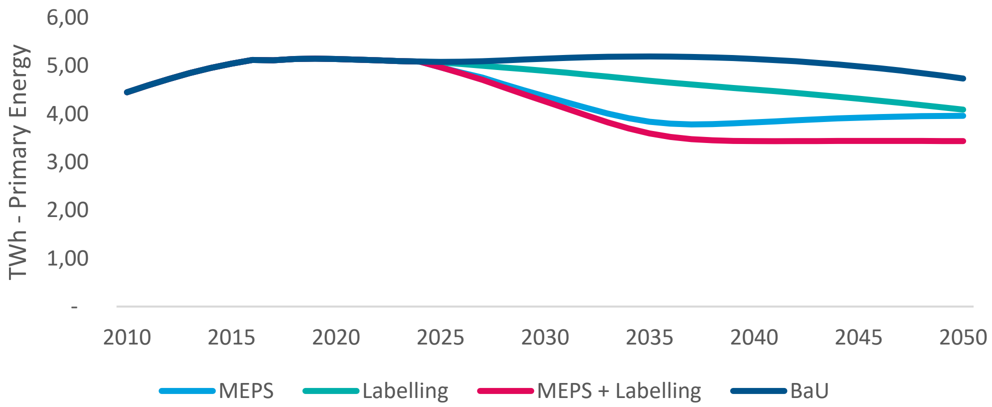


Figure 2 Total annual final energy consumption in the EU (TWh/year) – Electric Hand Dryers

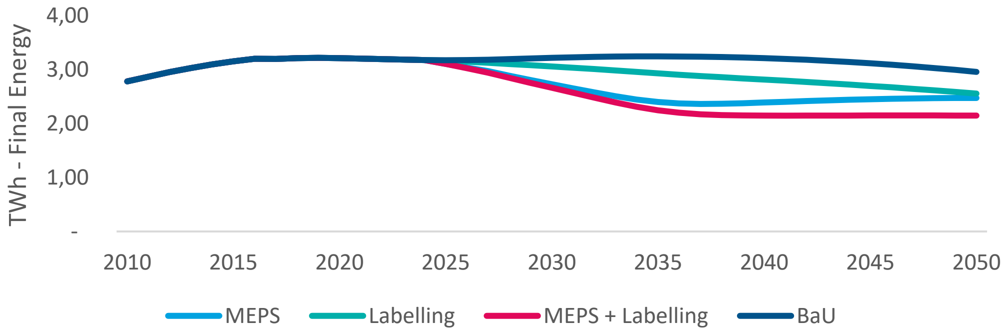


Table 5 Total annual primary energy savings in the EU (TWh/year) – Electric Hand Dryers

Annual primary energy savings (TWh/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	0.11	0.78	1.35	1.32	1.07	0.77
Labelling	-	0.01	0.25	0.50	0.63	0.67	0.64
MEPS + Labelling	-	0.11	0.89	1.60	1.70	1.55	1.30

Table 6 Total annual final energy savings in the EU (TWh/year) – Electric Hand Dryers

Annual final energy savings (TWh/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	0.07	0.49	0.85	0.82	0.67	0.48
Labelling	-	0.01	0.16	0.31	0.40	0.42	0.40
MEPS + Labelling	-	0.07	0.55	1.00	1.07	0.97	0.81

Table 7 Total cumulative primary energy savings in the EU (TWh) – Electric Hand Dryers

Cumulative primary energy savings (TWh)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	0.11	2.59	8.37	15.23	21.08	25.55
Labelling	-	0.01	0.75	2.80	5.77	9.08	12.38
MEPS + Labelling	-	0.11	2.90	9.61	18.13	26.23	33.26

Table 8 Total cumulative final energy savings in the EU (TWh) – Electric Hand Dryers

Cumulative final energy savings (TWh)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	0.07	1.62	5.23	9.52	13.18	15.97
Labelling	-	0.01	0.47	1.75	3.60	5.67	7.74
MEPS + Labelling	-	0.07	1.81	6.01	11.33	16.40	20.79

- GHG Emissions

Figure 3 presents the annual GHG emissions generated by the electricity consumption (use phase) and the disposal (end-of-life phase) of hand dryers in the EU between 2010 and 2050 for the different scenarios. Table 9 and 10 present annual and cumulative emissions savings accrued when implementing the proposed policies.

In the BaU scenario, GHG emissions reduce over time mostly because the GWP EU average electricity generating mix emissions factor is assumed to go down in the future, as the EU28 transitions to a low carbon economy and increasingly produces electricity from renewables.

Still, all policy scenarios modelled bring emission savings against the BaU, with annual GHG emissions being reduced by 17% and 28% in 2030 and 2050 respectively in the MEPs + Labelling scenario. Cumulative GHG emission savings accrued in this scenario add up to 4.33 MtCO2e by 2030, and reach 13.46 MtCO2e by 2050.

Figure 3 Total annual GHG emissions in the EU (MtCO2e/year) – Electric Hand Dryers

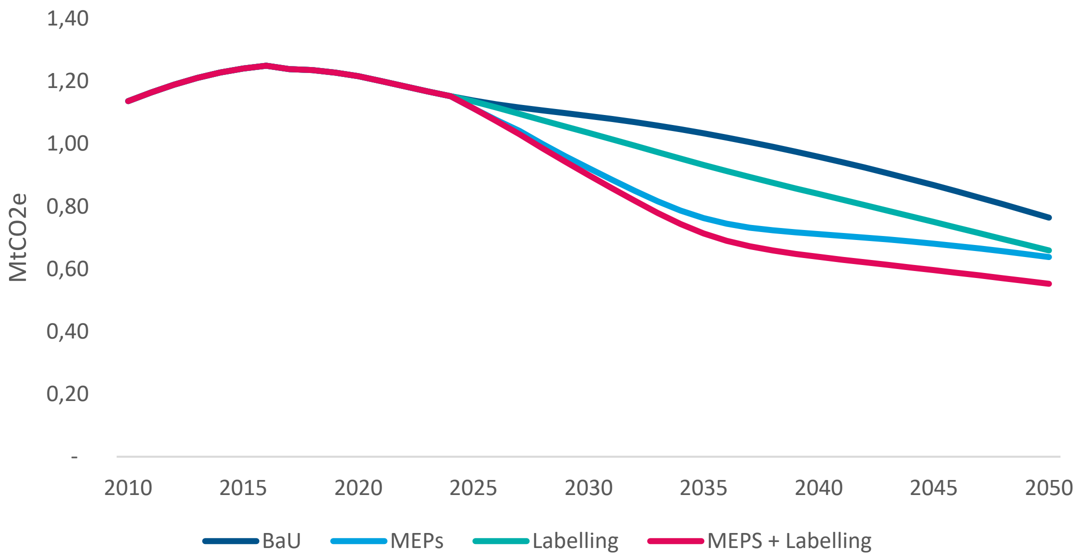


Table 9 Total annual GHG savings in the EU (MtCO2e/year) – Electric Hand Dryers

Annual GHG emission savings (MtCO2e/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	0.03	0.17	0.27	0.25	0.19	0.13
Labelling	-	0.00	0.05	0.10	0.12	0.12	0.10
MEPS + Labelling	-	0.03	0.19	0.32	0.32	0.27	0.21

Table 10 Total cumulative GHG savings in the EU (MtCO2e) – Electric Hand Dryers

Cummulative GHG emission savings (MtCO2e)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	0.03	0.56	1.75	3.07	4.12	4.87
Labelling	-	0.03	0.72	2.33	4.22	5.87	7.18
MEPS + Labelling	-	0.05	1.35	4.33	7.86	10.97	13.46

- Costs

Figure 4 presents the total annual cost of hand dryers in the EU between 2010 and 2050 for the different scenarios, including the purchase and installation costs, running costs and the societal cost of externalities. Table 11 and 12 present annual and cumulative cost savings accrued when implementing the proposed policies.

Between 2024 and 2027, the increased purchase prices lead to greater annual costs in the MEPS and MEPS + Labelling scenario. However, after 2028 the energy savings caused by the implementation of the policies begins to create cost savings and total cost is reduced by 5% in 2030 and 9% in 2050 in the MEPS + Labelling scenario versus BaU.

Cumulative cost savings accrued in this scenario add up to € 78 Million by 2030, and reach € 3.5 Billion by 2050.

It should be noted that, if MEPS and/ or Labelling policies were to be adopted, these would normally be subject to progressive review stipulations in the adopted regulation(s). These revisions over time, via the Commission's Comitology process, would revisit both MEPS and Energy Labelling boundaries to ensure that updated technologies and performance levels were included, and that the ambition incentives for manufacturers towards greater innovation were adequately rewarded by commensurate and dynamically-adjusted label ratings over time.

As such, the momentum of energy and related Greenhouse Gases savings could normally be maintained beyond 2035-2040, instead of tailing off as indicated. This is subject to the caveats that market and consumer spending conditions would permit such dynamism and technological progress.

Figure 4 Total annual costs in the EU (Million €, net of inflation) – Electric Hand Dryers

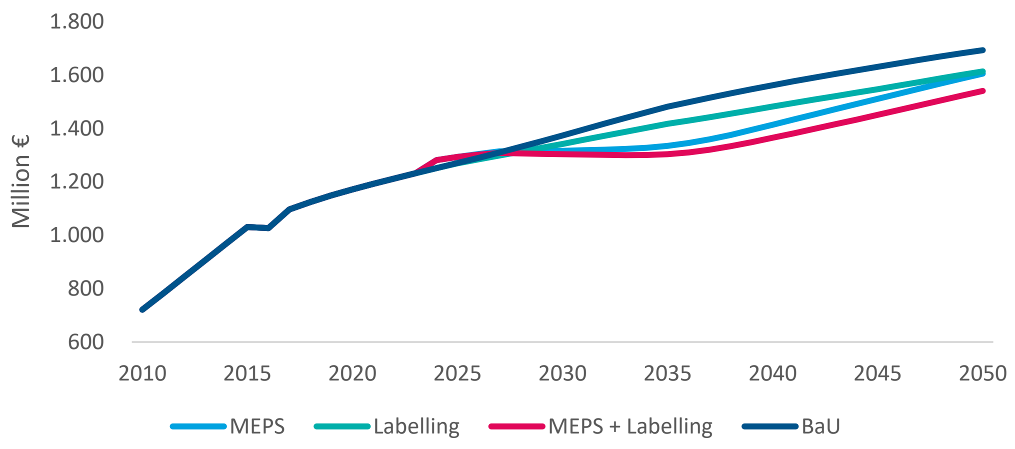


Table 11 Total annual cost savings in the EU (Million €/year, net of inflation) – Electric Hand Dryers

Annual savings (Million €/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	-23	57	146	148	120	88
Labelling	-	2	32	64	80	84	79
MEPS + Labelling	-	-23	70	177	197	180	152

Table 12 Total cumulative cost savings in the EU (Million €, net of inflation) – Electric Hand Dryers

Cummulative savings (Million €)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	-53	39	609	1,373	2,031	2,536
Labelling	-	2	93	351	727	1,141	1,549
MEPS + Labelling	-	-53	78	765	1,739	2,679	3,500

An extensive sensitivity analysis was performed on the cost and energy savings projections to see how the results would change with higher and lower electricity prices, higher and lower purchase prices, an alternative primary energy factor, cost of externalities and inflation values, and by a higher number of cycles per day. The results from the sensitivity analysis indicate that resource use, environmental impacts and life cycle costs are strongly affected by the number of cycles per day used in the modelling. Increasing the average 150 cycles/day figure to 361 cycles/day leads to a 132% increase to the annual primary energy savings and a consequent 207% increase to the total cost savings in 2030 in the MEPS + Labelling scenario. Furthermore, the Primary Energy Factor has a significant effect specifically on the estimates for energy savings, and price inputs (i.e. purchase price, electricity price, cost of externalities and inflation) affect only life cycle costs.

1 INTRODUCTION TO TASK 1 SCOPE

The aim of Task 1 is to classify and define the products covered by Lot 12. The classification and definitions need to be in line with European Union (EU) product harmonisation legislation as well as from a technical, functional, economic and environmental viewpoint. This classification and definition will be used as the basis for the preparatory study.

1.1 PRODUCT SCOPE

The first sub-task details the product classification and definitions, the product performance parameters and the results from the first screening. The first screening takes the product classification and presents resulting EU sales and trade data, as well as a first screening of environmental impacts and potential for improvement of the product group.

1.1.1 Product Classification & Definition

The product classification and definitions should be based on those provided within relevant Union harmonisation legislation, PRODCOM categories, other categories according to EN or ISO standards or other product specific categories drawn from labelling or sector specific categories, if not already defined by the above.

1.1.1.1 PRODCOM

There is one category defined within PRODCOM covering the product group for this preparatory study: *electric hand-drying apparatus*[4], number 27.51.23.50.

1.1.1.2 Definitions

There are no known EN or ISO standards from which to draw hand dryer definitions. Based upon existing third-party standards, hand dryers can be classified into one of four categories. The names and descriptions cited below in Table 1.1 have been drawn from UL's Product Category Rules (PCR) for preparing an Environmental Product Declaration for Hand Dryers[5]. The electric Hand Dryers (eHA) association have adopted the definitions used in the PCR[6]. Furthermore, a fifth category has been added reflecting a relatively new innovation in electric hand dryers, namely the air tap.

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

[5] http://bit.ly/29QtRXx

[6] With one addition to the definition for High Speed Trough Style (Hands In) Dryers, recognising that air streams are either a blade like stream, or from multiple points.

Table 1.1 Types of hand dryers

Type	Category	Description	Form[7]	Variations and sub-categories
1	Conventional single point (hands under) dryer	A hand dryer where hands are placed underneath the dryer exit nozzle for drying, having a predominantly single, unfocused direction air stream at the air exit plane and having average exit air velocity of less than 70 m/s (13,780 ft/min) when supplied with nominal supply voltage at 120V or 230V consistent with the product's certified electrical rating.		N/A
2	High speed single point (hands under) dryer	A hand dryer where hands are placed underneath the dryer exit nozzle for drying, having a predominantly single direction air stream focused for high velocity at the air exit plane and having average exit air velocity greater than or equal to 70 m/s (13,780 ft/min) when supplied with nominal supply voltage at 120V or 230V consistent with the product's certified electrical rating.		N/A
3	High speed multi-point (hands under) dryer	A hand dryer having exit air streams in at least two distinct independent air streams, intended for the left and right hands focused for high velocity at the air exit plane and having average exit air velocity greater than or equal to 70 m/s (13,780 ft/min) when supplied with		N/A

[7] Type 1, 2 and 4 images courtesy of the electric Hand Dryers (eHA) association. Type 3 image was sourced via Google images.

Type	Category	Description	Form[7]	Variations and sub-categories
		nominal supply voltage at 120V or 230V consistent with the product's certified electrical rating.		
4	High speed Trough style (hands in) dryer	A hand dryer where the user places their hands into the drying cavity that has generally opposing air streams in either a blade like stream, or from multiple points[8], for drying the palm and back side of the hands concurrently with an average exit air velocity greater than or equal to 70 m/s (13,780 ft/min) when supplied with nominal supply voltage at 120V or 230V consistent with the product's certified electrical rating.		Trough style hand dryers can either have a blade like air stream or the air can originate from multiple points.
5	Air tap	A hand dryer which is installed over the basin.	 	The air tap has two variants: standalone, designed to be housed next to water taps, or incorporating mains water in an all-in-one unit.

[8] Additional text from the eHA in addition to the definition provided in the PCR

Electric hand dryers use heat and/or airspeed to achieve dryness. Category 1 hand dryers primarily use heat and achieve dryness through evaporation whereas Categories 2-5 use airspeed that blows the water off the hands, often in combination with heat. Generally speaking, the former uses more energy but tends to be quieter and the hand drying cycle lasts longer, whereas the latter is more efficient (overall), but louder.

Hand dryers can use conventional heating from an element, employ adjustable heat, or use no heat at all. Where heat is used, some models can recover waste heat from the motor and avoid the need for a heating element.

Hand dryers can be activated through one of four activation methods: push button on/off, push button and timer, sensor and timer or sensor only. These methods are explained further within the Task 4 report on *Technologies*, including an analysis of the hand dryer's associated standby power consumption.

Manufacturers report that push-button hand dryers are sometimes trusted more by customers than sensor dryers. They can be used in environments where the lighting conditions could affect the functioning of a sensor hand dryer.

Category 4 trough style hands-in dryers can be divided into those which have drip trays, those which do not and those which connect the drip tray directly to the mains wastewater. In one example, a category 4 hand dryer incorporates an evaporator to remove the collected wastewater.

All these elements are explained further in the Task 4 report on Technologies, including analysis of the hand dryer's key components: the motor and the fan.

There are no other known sources of definitions for hand dryers. The hand dryer definition used by the UK's Energy Technology List (ETL) does not differentiate between the types of hand dryers. Rather the scheme employs a singular definition that amalgamates Types 2-4[9]. There are no definitions cited within Blue Angel's award criteria for electric hand dryers[10] or the NSF P335 Protocol[11].

Hand dryers also feature in transport applications (e.g. trains). After consultation with suppliers it is understood hand dryers are built specifically for transport applications with additional and specific transport related requirements on power supply, and are thus not considered further in this study.

1.1.1.3 Scope Exclusions

This preparatory study focuses on hand dryers and does not consider other forms of hand drying systems (e.g. paper towels or cloth roll towels) as these are not consistent with the definition for an *Energy-related Product*[12] as per article 2 *definitions*, paragraph 1 of the Ecodesign Framework Directive 2009/125/EC[13].

This was confirmed at the Inception meeting for the preparatory study.

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[9] *Incorporate an electrically driven blower that produces one or more jets of high speed air that can be used to dry human hands that are placed beneath, or into, the product* (High Speed Hand Air Dryers, 2014). https://www.gov.uk/government/publications/high-speed-hand-air-dryers-criteria-for-etl-inclusion

[10] https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%2087-201405-en%20Criteria.pdf

[11] http://info.nsf.org/Certified/Protocols/Listings.asp?Company=3E300&Standard=P335

[12] *'Energy-related product', (a 'product'), means any good that has an impact on energy consumption during use which is placed on the market and/or put into service, and includes parts intended to be incorporated into energy-related products covered by this Directive which are placed on the market and/or put into service as individual parts for end-users and of which the environmental performance can be assessed independently*

[13] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0125&from=EN

Furthermore, the *Methodology for the Ecodesign of Energy-related Products* (MEErP), which defines the method for delivering Ecodesign Preparatory Studies, provides additional relevant context and explanation. The methodology defines "direct" Energy-related Products (ErPs) as products that use energy during the use phase of the product's life cycle. Electric hand dryers are thus considered a direct ErP. The method also defines "indirect" ErPs, where the product does not use energy in the use phase, but has a significant impact on the energy consumption of products that are using energy within its system. Example indirect ErPs include insulation and glazing. Such indirect ErPs affect the energy consumption of heating systems, which operate within its wider system context. Paper and cotton towels would not be considered an indirect ErP because they do not affect the energy consumption of products in their system.

Industry stakeholders have advised that an unintended consequence of potential "over" regulation of electric hand dryers could be a sideways behavioural shift to other forms of hand drying, such as paper towels or cloth roll towels – dubbed a "substitution effect". The MEErP methodology, particularly in Task 6, considers the cost to manufacturers of introducing design improvement options and balancing costs against the expected environmental improvement resulting from their introduction.

Stakeholders raised the question of including electric paper towel dispensers in the scope of this preparatory study. Currently, there are no adequate sales data for this product group and the products sampled online are all battery powered. Consequently, they were not considered further in the study.

1.1.2 Product Performance Parameters

The primary product performance parameter or "functional unit" is the quantified performance of the product, which can be used as a reference point. UL's PCR defines the functional unit for hand dryers as **instances of use** (specifically 100,000). The ETL scheme for high speed hand air dryers also considers instances of use by setting a cap on electricity consumption per 1000 drying cycles.

To standardise what represents one use or drying cycle, a secondary performance parameter is introduced, namely **remaining moisture content**. Thus a drying cycle would be complete when the user's hands are dried to a certain level. For example, UL's PCR defines a remaining moisture content of <0.25g, the ETL criteria for high speed hand air dryers defines a remaining moisture content of <0.15g and the NSF P335 Protocol defines a remaining moisture content of <0.10g.

A third performance parameter of **time** can be included, to measure how long it takes to achieve the required remaining moisture content for a typical instance of use. The duration of the drying cycle to achieve the required moisture content is set within the ETL and NSF Protocol P335 criteria at ≤15seconds.

1.1.3 First Screening

In line with article 15 of the Ecodesign Framework Directive 2009/125/EC[14] the three pre-requisites for considering a product group for an implementing measure is that the product group represents:

- A significant volume of sales and trade, >200,000 units per year within the EU
- A significant environmental impact within the EU; and
- A significant potential for improvement in terms of its environmental impact, without entailing excessive costs

A first screening of hand dryers against these three criteria is presented below.

[14] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009L0125

1.1.3.1 Sales & Trade

The EU sales and trade data have been sourced directly from official EU statistics, namely the PRODCOM database. Table 1.2 presents the EU sales and trade data covering *electric hand-drying apparatus*.

Table 1.2 Extracted PRODCOM[15] 2017 EU hand-dryer sales and trade volumes

	Volume (units)
EU production sold	247,009
Intra-EU trade	189,184
Extra-EU export	97,240
Extra EU import	828,619
EU sales and trade	978,388

As can be seen, the EU sales and trade of 978,388 electric hand dryers in 2017, significantly exceeds the pre-requisite of 200,000 units.

1.1.3.2 Environmental Impacts

An initial identification and assessment of key environmental impacts from hand dryers was performed under the preparatory study to inform the third Ecodesign workplan[16]. The authors concluded that the majority of the environmental impact from hand dryers occurs during the use-phase of the product's life cycle, relating to electricity consumption.

The authors of the above-mentioned study noted other important environmental impacts from hand dryers, citing the following:

- Noise;
- Hygiene; and
- Circular economy aspects, namely:
  - Durability (i.e. the reusability, upgradability and reparability of hand dryers)
  - End of life (e.g. material composition, particularly metals); and
  - Presence of critical raw materials, flame retardants & plasticisers.

1.1.3.3 Potential for Improvement

To reduce the environment impact from electricity consumption, requirements could be designed to consider the electricity consumed by the hand dryer, either per use, or over an average number of uses. In order to be an effective and efficient use of electricity, consideration will likely need to be given to both the "dryness" of the hands as a result of using the hand dryer and the length of time taken to achieve the required level of dryness[17]. As highlighted already, the ETL test method for high speed hand air dryers defines a remaining moisture content of <0.15g; with the time taken to achieve this level of dryness set at ≤15seconds. Ensuring that the hand dryer dries hands in a suitable time to a suitable level, meeting reasonable user expectations.

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

[16] Task 4 Final Report, Preparatory Study to establish the Ecodesign Working Plan 2016-2019 http://ec.europa.eu/DocsRoom/documents/20374/attachments/5/translations/en/renditions/pdf

[17] For example, the test method for hand dryers on the UK's Energy Technology List defines a remaining moisture content of <0.15g; the time taken to achieve this level of dryness shall be ≤15.5seconds.

The preparatory study considered a range of noise levels resulting from the drying function of hand dryers, typically high speed hand dryers. The literature pointed to manufacturer declared data and data derived from independent measurement, and highlighted noise levels ranging from approximately 70 to 100db. Typically, noise from the motor and the *air rush* generated by the high speed hand dryer can increase when a manufacturer attempts to reduce the drying time and improve the energy efficiency of the product. The authors' concluded that to reduce noise, consideration could be given to the type of motor used and how the air is channelled.

The authors noted that existing literature reported concerns regarding a particularly sensitive issue for hand dryer manufacturers, namely the potential impact on personal hygiene resulting from their use (see NSF P335 Protocol). It has been reported that hand dryers can blow air with bacteria (from unwashed hands) onto the hands and faces of users. This is disputed and challenged by hand dryer manufacturers who note that research into the hygiene aspects of electric hand dryers are inconsistent and fail to show any consistent and meaningful conclusions. They note that a similar amount of studies exists regarding the hygiene effects of using other drying methods such as paper towels or linen towels. They conclude that the net result of the studies is that there is no significant difference between the different methods.

In terms of circular economy aspects, the authors found that hand dryers are typically made of materials that can be recycled (e.g. aluminium, steel and/or plastics). Designing for recyclability could ease treatment at the end-of-life. Further investigation and consideration of the durability of hand dryers could lead to options for improvement and extension of the lifetime of the products (for example designing for disassembly to facilitate repair). The presence or otherwise of critical raw materials, flame retardants & plasticisers in hand dryers will be researched and identified during the course of this preparatory study.

1.2 MEASUREMENT AND TEST STANDARDS

The second sub-task identifies relevant measurement and test standards for hand dryers and is comprised of a description of each of the identified standards together with a comparative analysis.

1.2.1 Identification and Description of Relevant Standards

There are no harmonised measurement or test standards for hand dryers covering the product performance parameters identified above. However there are a number of proprietary and free to access measurement and test standards covering the product performance parameters.

1.2.1.1 Product performance parameters

Six measurement and test methods for hand dryers have been identified which consider the product performance parameters of instances of use, remaining moisture content and length of drying cycle. Four of these are described below. The remaining two examples are thought to be proprietary and owned by Dyson, however it is not clear if these are still in use, or now defunct. They are:

- DTM 769, Evaluation of Hand Dryer Performance; and
- DTM 553, Evaluation of Hand Dryer Drying Times.

The four remaining measurement and test standards covering the product performance parameters for hand dryers are:

- UK's Energy Technology List Test Method for High Speed Hand Air Dryers
- NSF's Protocol P335 for Hygienic Commercial Hand Dryers
- Germany's Blue Angel Criteria for Electric Hand Dryers
- UL's Product Category Rule for Hand Dryer Environmental Product Declarations

Each of these test methods will be briefly described below. The proceeding section 1.2.2 provides a more detailed comparative analysis of the performance parameters and test methods.

Note that the Korean Eco-label criteria for electric hand dryers does not feature a measurement and test method.

Table 1.3 helps to illustrate the differences and similarities between the related eco-label schemes, and test and measurement standards.

Table 1.3 Summary of schemes and test standards for electric hand dryers

Name	Region	Type	Owner	Associated Measurement & Test Standard
Energy Technology List	UK	List of energy efficient high-speed hand dryers	BEIS[18]/ICF	Yes
NSF Protocol P335	Global	Health and sanitation protocol for hygienic hand dryers	NSF	Yes
UL Product Category Rule for Hand Dryer Environmental Product Declarations	Global	Test and Measurement Standard – including performance thresholds – for electric hand dryers	UL	Yes
Blue Angel	Germany	Eco-labelling scheme with criteria for electric hand dryers	Blue Angel	Yes
Korean Eco-label	Korea	Eco-labelling scheme with criteria for electric hand dryers	Korean Eco-label	No

UK's Energy Technology List Test Method for High Speed Hand Air Dryers (2014)

The ETL measurement and test standard[19] for testing high speed hand air dryers defines:

- Equipment requirements e.g. test room temperature and humidity, electricity supply, stopwatch accuracy, water bucket conditions, hand towel specification, digital scale accuracy and measurement parameters and tolerances.
- Test room setup requirements e.g. mounting of hand dryer, location of water bucket and digital scale, configuration of hand dryer, location of video camera.
- Selection of volunteers e.g. number, gender balance, selection procedure, hand measurement, consent.
- Hand wetting and drying procedure e.g. specific time periods when hands are held, paused and withdrawn from the wetting and drying procedure. Requirements for hand movement, positioning, and length of time between stages of the procedure.

[18] UK Government Department for Business, Energy and Industrial Strategy

[19] https://www.gov.uk/government/publications/energy-technology-list-etl-method-for-the-testing-of-high-speed-hand-air-dryers

- Determination of standard drying time. The requirements for the number of tests and over which time periods. The procedure for deriving an average drying time for each volunteer and calculating the standard drying time for the product.
- Measurement of product performance. The procedure for measuring the hand dryer's electricity consumption.

NSF Protocol P335 for Hygienic Commercial Hand Dryers (2007)

The National Sanitation Foundation (NSF) created protocol P335 to establish minimum requirements for the health and sanitation characteristics of hand dryers and launched the protocol in 2007. NSF's concern is with the hand dryer's discharge of ambient air which could contain bacteria, mould spores or viruses that could become entrapped on user's hands. Furthermore, NSF is concerned with the hand dryer's insufficient drying of hands where remaining moisture could facilitate transmission of microorganisms to and from other objects and people after leaving the machine. The protocol therefore contains minimum requirements for materials, design and construction, and performance of hand dryers that incorporate anti-microbial capabilities in their design and function. The protocol is proprietary and sits behind a paywall[20]. Currently 17 products are listed by NSF as meeting the Protocol[21] - all of which are from one manufacturer, Dyson.

The NSF requires a hygienic hand dryer to be 95% effective at achieving a residual moisture content of ≤0.1g within one operating cycle or 15 seconds – whichever is the shorter – when the test is replicated 20 times. The Protocol sets a continuous noise limit of 90dBA, to be measured one metre in front of the unit. Periodic noise shall not exceed 100dBA. There are further hygiene related requirements for airborne particle reduction, plenum seal leak rate and disinfection of hand wash effluent. As well as materials, design and construction requirements, the Protocol sets information requirements in the form of an owner's manual and an installation, operation, maintenance and troubleshooting manual.

The test procedure for measuring remaining moisture content and drying time defines:

- Mean maximum hand size, with sizes derived from AdultData – The Handbook of Adult Anthropometric and Strength Measurements – Data for Design Safety.
- Room test condition including temperature and humidity
- Hand preparation pre-test including removing jewellery and hand washing
- Paper towel type and pre-test weighing
- The procedure for wetting hands prior to the test, removal and use of the hand dryer to dry hands. Hand rubbing whilst drying is capped at two rubs every five seconds.
- Drying excess water from hands with the paper towel and weighing.

Germany's Blue Angel Criteria for Electric Hand Dryers (2014)

The appendix to the Blue Angel criteria for electric hand dryers specifies the method for determining the degree of dryness achieved by the electric hand dryer. The appendix, entitled *Determining the Degree of Dryness Achieved by Electric Hand Dryers*, states at the outset that it is based on the NSF Protocol P335. However, the procedure for determining the degree of dryness[22] is different in a number of ways. These differences are explored further in section 1.2.2. At a broad level, the test method defines:

- Volunteer test subject selection, number, gender, hand dimensions

[20] E.g. https://www.techstreet.com/standards/nsf-p335?product_id=1532445

[21] [Date accessed 8 January 2019] http://info.nsf.org/Certified/Protocols/Listings.asp?Company=3E300&Standard=P335

[22] The preferred term is remaining moisture content

- Test set-up (e.g. hand wetting water temperature, paper towels, scales), room conditions (e.g. temperature and humidity)
- Hand wetting procedure and requirements, including timing
- Measurement process for determining dryness
- Reporting requirements and calculation

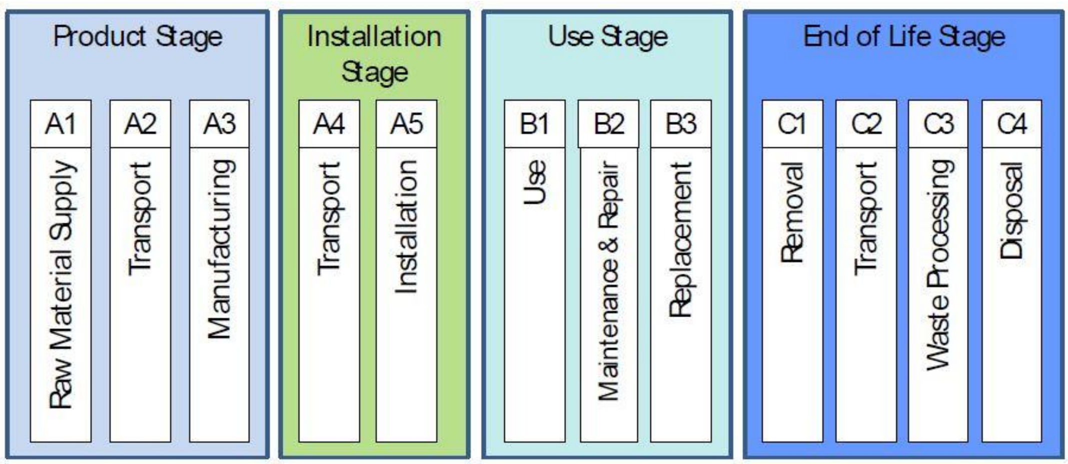
1.2.1.2 Resource use and emissions during product-life

There is one known assessment methodology for considering the environmental impacts from the full life cycle of a hand dryer.

UL's Product Category Rule for Hand Dryer Environmental Product Declarations (2016)

The Product Category Rule (PCR) for an Environmental Product Declaration for Hand Dryers considers important concepts such as the definition of a hand dryer's functional unit, preparation of system boundaries, definition of the key relevant aspects of a hand dryer's life cycle assessment and environmental impact categories. Figure 1.1 presents those stages which are worthy of considering with respect to identifying the key environmental impacts for hand dryers.

Figure 1.1 Environmental impacts: key stages of a hand dryer's life cycle



Appendix II of the PCR defines the *dry time testing* procedure to be employed when preparing an environmental product declaration for a hand dryer under the standard (section 8.1). The procedure defines:

- Volunteer test subject selection, number, gender, hand dimensions
- Testing and measuring equipment, including scales, paper towels, thermometer, stopwatch voltage meter, hygrometer and accuracy and tolerance requirements
- Positioning of hand dryers for test
- Regional electricity distribution and test conditions
- The hand wetting procedure
- Hand dryer category specific hand drying instructions covering the four categories of hand dryers identified in Table 1.1
- Appendix II of the PCR also defines the requirements and procedure for the *electricity consumption test* (section 8.2). This is further elaborated within table 1.5, the comparative analysis of the test standards for hand dryers.

Appendix II of the PCR also defines a testing procedure for declaring the *Reference Service Life* of the hand dryer (section 8.3). The Reference Service Life is defined by the PCR as the service life of a product which is known to be expected under a particular reference set of in-use conditions. The Reference Service Life is important when considering how many hand dryers are needed to deliver the PCR's functional unit of

100,000 hand drying instances. The PCR's Reference Service Life testing procedure defines:

- The relevant test voltage, depending on the intended geographic region for operation of the hand dryer. If the hand dryer can operate at both 120V and 230V, then the product shall be tested at both voltages.
- The relevant test frequency of either 50 or 60 Hz, consistent with the product's certified electrical rating.
- The duty cycle for the test, namely "on" time i.e. the run time of the hand dryer. The "off" time shall last 15 seconds.
- The number of units to test – six. The Reference Service Life shall be the average test service life of the six units tested[23].
- The acceptable variance in the supply voltage for the test, +/-4% of the nominal supply voltage (120V +/- 5V or 230V +/- 9V).
- The treatment of hand dryers with variable speed or heat controls. Testing will be conducted with product settings at the highest level of power consumption.
- The completion of the test life of an individual test unit is when the end of the natural motor service life is observed. A test unit featuring brushed universal motors is considered to have reached completion when normal motor function ceases due to motor brush or commutator wear. If the test unit contains replaceable motor brushes, motor brushes can be replaced once to extend service life.

1.2.1.3 Measuring noise emissions

Table 1.4 in the proceeding section demonstrates that three separate schemes for hand dryers set criteria for noise emissions.

The criterion for the Blue Angel scheme defines noise emissions as "sound power" outputs. This is in line with the former EC energy labelling regulation for vacuum cleaners which also utilises sound power level[24]. The regulation defines sound power level as *airborne acoustical noise emissions, expressed in dB(A) re 1 pW and rounded to the nearest integer*. The EC energy labelling regulation for washing machines also refers to *airborne acoustical noise emissions*[25].

Note that manufacturers declare noise emissions for hand dryers using either db or dB(A)[26]. An analysis of these declarations is presented within the Task 4 report on *Technologies*. All three hand dryer schemes which define noise emission thresholds set requirements with the parameter dB(A).

In terms of testing and measuring the noise emissions from hand dryers, the Blue Angel criteria refer to EN 60704-1[27]. The current version of the standard was last updated in 2012; a draft updated version was published for public consultation in December 2018. The Korean eco-label hand dryer criteria states that noise shall be measured according to ISO 1996-1[28]. There is no measurement method published in the NSF P335 Protocol, the third and final set of hand dryer criteria which specifies noise limits. Neither of the above cited EC energy labelling regulations cite a specific measurement and testing standard,

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[23] This is achieved by conducting accelerated testing in laboratory conditions

[24] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0665&from=EN

[25] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010R1061&from=EN

[26] The (A) refers to the addition of a weighting which reflects how the human ear perceives sound. Values not corrected to account for human hearing are written using db. http://www.dbnoisereduction.com/blog/db-vs-dba/

[27] https://shop.bsigroup.com/ProductDetail?pid=000000000030261395

[28] https://shop.bsigroup.com/ProductDetail?pid=000000000030275205

however the recent preparatory study for washing machines cited EN 60704[29] (the same standard referred to by the Blue Angel scheme).

In the UK, manufacturers report that installers have to comply with health and safety requirements which need calculations for "sound pressure"[30] in the measured environment to calculate exposure.

1.2.1.4 Filter standards

Standards for classification and testing of filters are contained within the ISO 29463 series of standards. The list below sets out the family of five standards. This family of standards replaced a previous set of 5 filter standards from the BS EN 1822 series. The titles of the part numbers 1, 2, 3, 4 and 5 for the now withdrawn BS EN 1822 series matches entirely with the new ISO 29463 series of standards.

- ISO 29463-1 2017 High efficiency filters and filter media for removing particles from air. Classification, performance, testing and marking[31].
- BS EN ISO 29463-2 2018 High-efficiency filters and filter media for removing particles in air. Aerosol production, measuring equipment and particle-counting statistics[32].
- BS EN ISO 29463-3 2018 High-efficiency filters and filter media for removing particles in air. Testing flat sheet filter media[33].
- BS EN ISO 29463-4 2018 High-efficiency filters and filter media for removing particles in air. Test method for determining leakage of filter elements. Scan method[34].
- BS EN ISO 29463-5 2018 High-efficiency filters and filter media for removing particles in air. Test method for filter elements[35].

1.2.2 Comparative Analysis of Relevant Test Standards

This section compares and contrasts the measurement and test methods for the hand dryer product performance parameters, introduced in the preceding section. It begins however with a horizontal and vertical presentation and comparison of the performance requirements for hand dryers employed across the four schemes as well as the Korean eco-label criteria for electric hand dryers. Whilst the Korean scheme sets performance requirements, there are no specific requirements for either drying time or remaining moisture content (which is why it was not introduced in section 1.2.1).

1.2.2.1 Performance Requirements

Table 1.4 presents the performance requirements across the five hand dryer schemes, including requirements for drying time, remaining moisture content, electricity consumption, noise and material efficiency.

[29] https://ec.europa.eu/jrc/en/publication/follow-study-preparatory-study-ecodesign-and-energy-label-household-washing-machines-and-household

[30] Sound pressure is effectively the *effect* of the sound power in the environment it is installed. The sound power is effectively the *cause.* Further information available here: http://www.sengpielaudio.com/calculator-soundpower.htm

[31] https://shop.bsigroup.com/ProductDetail?pid=000000000030342156

[32] https://shop.bsigroup.com/ProductDetail?pid=000000000030369290

[33] https://shop.bsigroup.com/ProductDetail?pid=000000000030369294

[34] https://shop.bsigroup.com/ProductDetail?pid=000000000030369282

[35] https://shop.bsigroup.com/ProductDetail?pid=000000000030369286

Table 1.4 Comparative analysis of the performance requirements from test standards for hand dryers

Requirement	Energy Technology List Criteria for High Speed Hand Air Dryers (2014)	NSF Protocol P335 for Hygienic Commercial Hand Dryers (2007)	Blue Angel Criteria for Electric Hand Dryers (2014)	Korea Eco-label Criteria for Electric Hand Dryers (2013)	Product Category Rule for Hand Dryer Environmental Product Declaration (2016)
Standard drying time	≤15 seconds (+/- 0.5seconds)	≤15 seconds	≤30 seconds		
Residual moisture content	≤0.15g	≤0.1g (when replicating the test 20 times)	90% dry		≤0.25g
Electricity consumption	≤5.5kWh of electricity per 1000 standard drying cycles		≤12Wh per drying cycle	A range of rated power consumption values (kW) depending on hand dryer type and operation time.	
Reference Service Life / Functional Unit					100,000 instances of hand drying use
Noise		≤90dBA (continuous) measured at a distance of 1 metre	≤85dBA in loudest operating state	≤70dBA	
		≤100dBA (periodic)			
Air temperature emitted from hand dryer		≤40C		≤50C	

Requirement	Energy Technology List Criteria for High Speed Hand Air Dryers (2014)	NSF Protocol P335 for Hygienic Commercial Hand Dryers (2007)	Blue Angel Criteria for Electric Hand Dryers (2014)	Korea Eco-label Criteria for Electric Hand Dryers (2013)	Product Category Rule for Hand Dryer Environmental Product Declaration (2016)
Wind speed				≥5m/s	
Air filtration efficiency		Fitted with HEPA filter. Aerosol penetration of ≤0.03% with aerosol of 10ug/L of DOP particles			
Standby consumption			≤0.5W	≤1.5W. N/A if the dryer has an electronic control system.	
Automatic switch-off			≤2 seconds		
Maximum on-time			60 seconds	30 seconds (for one-off sensor dryers)	
Stop operating state				For continuous sensor products, if nothing is detected, stop within 20 seconds. N/A if the dryer can control the time to stop.	
Plastic components – restrictions on additives			No carcinogenic, mutagenic and reprotoxic substances and no "particularly	No lead, cadmium, mercury and their compounds. No hexavalent chromium	

Requirement	Energy Technology List Criteria for High Speed Hand Air Dryers (2014)	NSF Protocol P335 for Hygienic Commercial Hand Dryers (2007)	Blue Angel Criteria for Electric Hand Dryers (2014)	Korea Eco-label Criteria for Electric Hand Dryers (2013)	Product Category Rule for Hand Dryer Environmental Product Declaration (2016)
			alarming" substances under REACH. No halogenated organic compounds in flame retardants. No flame-retardant materials classified as acutely toxic to aquatic organisms.	compound. No PBBs[36], PBDEs[37] and short chain chlorinated paraffins whose chlorine concentration is 50% or higher.	
Plastic components – restrictions on polymers			No halogenated polymers.	Halogenated synthetic resins, such as PVC, weighing ≥25g shall not be used. Halogenated compounds shall not be contained in plastic housing parts.	
Plastic components - recyclability				Synthetic resins weighing ≥25g and covering flat surface of ≥200mm^2 shall be marked with their material classification.	

[36] Polybrominated Biphenyls – part of a group of Brominated Flame Retardants (BFRs)

[37] Polybrominated Diphenyl Ethers, also part of the BFR group

Requirement	Energy Technology List Criteria for High Speed Hand Air Dryers (2014)	NSF Protocol P335 for Hygienic Commercial Hand Dryers (2007)	Blue Angel Criteria for Electric Hand Dryers (2014)	Korea Eco-label Criteria for Electric Hand Dryers (2013)	Product Category Rule for Hand Dryer Environmental Product Declaration (2016)
Plastic components – impact strength & durability				Shock absorbing materials shall comply with specified requirements.	
Guarantee			Option of 5 years		
Repairability and provision of spare parts			10 year availability following termination of the product.		In the case of a hand dryer model including replaceable motor brushes from the manufacturer, motor brushes can be replaced <u>one</u> time only to extend service life.
Recyclable design			Designed so it can be easily and quickly dismantled for repair and separation of recyclable components – using suitable connections and instructions for dismantling.		

1.2.2.2 Analysis

- The electricity consumption performance requirement used by the Blue Angel criteria is not an aggregated figure expressed over a number of cycles, unlike the ETL criteria or reflected in the Product Category Rule. Rather a 'consumption per use' is prescribed instead.
- Given that the Blue Angel is an eco-label, there are a number of material efficiency requirements which are not found in any of the other test methods. Equally, there is also a standby power consumption limit. The tenet of the material efficiency requirements echo the type of requirements the Commission have introduced as part of the suite of regulations included in the 2019 Ecodesign Package. These include measures to improve the availability of spare parts, access to repair and maintenance information, requirements for dismantling for material recovery and recycling and marking of plastic components.
- The performance requirement used by Blue Angel for declaring the dryness achieved by electric hand dryers is different to that specified within the ETL methodology. Furthermore, there is no challenging target for the time to achieve the specified level of dryness:
    - Regarding the performance requirement, the Blue Angel sets a percentage target for the *degree of dryness*, namely 90%, as opposed to an absolute ETL measurement of ≤0.15g remaining moisture content.
    - The time to achieve the requirement of 90% dryness is largely open, with a backstop of 30 seconds. By comparison, both the ETL and NSF methods use 15 seconds. The Blue Angel method requires an average drying time to be calculated based upon each of the six volunteers achieving the 90% degree of dryness.

1.2.2.3 Test Methods

An analysis of the four standards which test and measure the product performance parameters identified earlier is presented below in Table 1.5.

Table 1.5 Comparative analysis of the test standards for hand dryers

		Energy Technology List Criteria for High Speed Hand Air Dryers (2014)	NSF Protocol P335 for Hygienic Commercial Hand Dryers (2007)	Blue Angel Criteria for Electric Hand Dryers (2014)	Product Category Rule for Hand Dryer Environmental Product Declaration (2016)
Equipment and Test Room Requirements	Temperature	23C (+/- 5C)			23C (+/- 3C)
	Relative humidity	55 (+/- 5%)			50 (+/- 20%)
	Hygrometer				Accuracy to 2.5% relative humidity
	Power supply	230V AC, single phase, 50Hz			Table of test voltages, frequencies and tolerances provided.
	Voltage meter				Accuracy to 1V
	Stop watch	Accuracy ≤ +/- 0.1 seconds			Accuracy to 0.01 seconds
	Heated water	37C +/- 2C	37C	Minimum of 25C and maximum of 30C.	37C +/- 3C
	Thermometer				Accuracy 1C
	Paper towels	Scott 6633 single ply m-fold hand towel. Product code KC01114: 315x206mm		Pure pulp, chlorine-free bleached. 55g/qm, 220mm width and 400mm length. E.g. Profix premium FaHa, Art. 080850 from TEMCA GmbH or equivalent.	
		Scott multi-fold towels. Product code 01804: 238.8x236.2mm			Same, or equivalent C-fold paper towels with similar

<table>
<tr><th></th><th></th><th>Energy Technology List Criteria for High Speed Hand Air Dryers (2014)</th><th>NSF Protocol P335 for Hygienic Commercial Hand Dryers (2007)</th><th>Blue Angel Criteria for Electric Hand Dryers (2014)</th><th>Product Category Rule for Hand Dryer Environmental Product Declaration (2016)</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>size, weight and composition.</td></tr>
<tr><td></td><td>Digital Weighing Scale</td><td>Accuracy ≤ +/-0.01g</td><td></td><td colspan="2">Accuracy ≤0.01g</td></tr>
<tr><td></td><td>Measuring equipment to record</td><td>Room temperature, room humidity, water temperature, power consumption and voltage.</td><td></td><td></td><td>Voltage, humidity, water temperature, air temperature, paper towel weight</td></tr>
<tr><td></td><td>Exposure of measurement devices to test room temperature and humidity</td><td></td><td></td><td colspan="2">Expose measurement devices to test room conditions for at least 24hours prior to the test</td></tr>
<tr><td></td><td>Video recorder</td><td>✓</td><td></td><td></td><td></td></tr>
<tr><td>Test Set-up</td><td>Hand dryer mounting</td><td>Between waist and chest height</td><td></td><td></td><td>112cm +/- 5cm (for conventional or high speed single point hands under dryers). Hands-in trough style dryers shall be mounted according to manufacturer’s instructions +/- 5cm.</td></tr>
</table>

		Energy Technology List Criteria for High Speed Hand Air Dryers (2014)	**NSF Protocol P335 for Hygienic Commercial Hand Dryers (2007)**	**Blue Angel Criteria for Electric Hand Dryers (2014)**	**Product Category Rule for Hand Dryer Environmental Product Declaration (2016)**
	Water bucket	Located immediately beside dryer at basin height			
	Digital scale	Located immediately on the other side of the dryer			
	Hand dryer configuration	Start automatically when hands inserted			
Selection of Volunteers	Volunteer panel	3 adult male, 3 adult female. 6 in total.			Same number and composition but all within the ages of 18-60
	Hand measurement – middle finger height and maximum hand spread	According to ADULT DATA – The Handbook of Adult Anthropometric and Strength Measurements – Data for Design Safety, DTI, UK, 1998. Measurements 141 and 185.		According to DIN 33402-2 Ergonomics – Human Body dimensions – Part 2: Values	According to ADULT DATA – The Handbook of Adult Anthropometric and Strength Measurements – Data for Design Safety, DTI, UK,
	Mean middle finger height – male	193.3mm +/-5%			182 – 204mm (range not the mean)
	Mean middle finger height – female	174.9mm +/-5%			166 – 184mm (range not the mean)
	Mean maximum	212.9mm +/-10%	212.9mm +/-5%		194 – 231mm (range not the mean)

		Energy Technology List Criteria for High Speed Hand Air Dryers (2014)	NSF Protocol P335 for Hygienic Commercial Hand Dryers (2007)	Blue Angel Criteria for Electric Hand Dryers (2014)	Product Category Rule for Hand Dryer Environmental Product Declaration (2016)
	hand spread – male				
	Mean maximum hand spread – female	200.2mm +/-10%	200.2mm +/-5%		185 – 216mm (range not the mean)
	Hand width (width of palm, without the thumb) – male			95mm (maximum)	
	Hand width (width of palm, without the thumb) – female			85mm (maximum)	
	Hand length – tip of middle finger to wrist crease – male			208mm (maximum)	
	Hand length – tip of middle finger to wrist crease – female			196mm (maximum)	

		Energy Technology List Criteria for High Speed Hand Air Dryers (2014)	NSF Protocol P335 for Hygienic Commercial Hand Dryers (2007)	Blue Angel Criteria for Electric Hand Dryers (2014)	Product Category Rule for Hand Dryer Environmental Product Declaration (2016)
	Gender and hand dimensions recorded	✓		✓	✓
	Consent form, signed	✓			
Hand Wetting and Drying Procedure	Preparation	Wash hands immediately prior to testing. Remove rings and jewellery from hands and wrists.			
	Wrist crease	Marked with a black pen			
	Paper towels			Use double layer of paper towels (up to 10g).	Use 2 paper towels
	Immersion in water	Immerse to wrist crease and rub hands together for 5 seconds			
	Average amount of water on hands			3.5g women 4g men	
	Removal from water	Slowly remove hands, pausing for 5 seconds, hands and fingers should not be moved or shaken during this time.		Same, but for 10 seconds, with the remaining residual water corresponding to the values above. With deviation of +/-1g	Slowly remove hands, pausing for 5 seconds, hands and fingers should not be moved or shaken during this time.
	Measurement of water on hands			Measure the difference in weight between the damp and dry paper towel. The	

	Energy Technology List Criteria for High Speed Hand Air Dryers (2014)	NSF Protocol P335 for Hygienic Commercial Hand Dryers (2007)	Blue Angel Criteria for Electric Hand Dryers (2014)	Product Category Rule for Hand Dryer Environmental Product Declaration (2016)
			hands are then wet again as per above.	
Move to hand dryer	Immediately move without shaking hands and insert hands within 3 seconds		Moved immediately to the correct position to operate the dryer	Immediately move without shaking hands and start drying within 5 seconds
Timing	Stopwatch to start when hands start to be inserted. Stopped when fully removed.		Dry hands for a set time recommended by the manufacturer (maximum of 30seconds)	Stopwatch used to keep time.
Action when drying	Follow manufacturer's instructions for rubbing or rotating hands. But no more than 2 rubs / second.	Follow manufacturer's instructions for rubbing. But no more than 2 rubs / 5 seconds.	Follow manufacturer's instructions for rubbing hands together.	Follow manufacturer's instructions. If unavailable, follow provided specific instructions for conventional hands under single point dryer, high speed hands under single point dryer, trough style hands in dryer, multi-point hands under dryer.
Removing remaining moisture	At the end of the specified drying time, pick up a pre-weighed paper towel within 5 seconds of removing hands from dryer. Thoroughly rub both sides of the hands and between fingers.	Dry excess water from hands including between fingers and wrist with the weighed paper towel until hands feel dry.	After the drying time has expired, the remaining moisture content is determined. Dry between fingers and wrist creases. Drying time maximum of 20 seconds.	At the end of the drying cycle, pick up a pre-weighed paper towel within 3 seconds. Wipe down palms, tops of hands, wrists, each finger, each thumb and each of the eight crevices between

		Energy Technology List Criteria for High Speed Hand Air Dryers (2014)	NSF Protocol P335 for Hygienic Commercial Hand Dryers (2007)	Blue Angel Criteria for Electric Hand Dryers (2014)	Product Category Rule for Hand Dryer Environmental Product Declaration (2016)
					fingers and thumbs for 8 seconds +/- 2 seconds.
	Weighing	Fold or scrunch the used paper towel and place on scales. It should take ≤25 seconds from removing the hands from dryer to weighing the towel.	Roll the used paper towel into a ball and place on the scale within 5 seconds.	Weigh damp paper towel.	Within 3 seconds, roll the paper towel into a ball and place on the scale. Weigh the towel and record the weight within 5 seconds.
	Pause for hand dryer cool down				Wait a minimum of 60 seconds before replicating the test
Calculating Degree of Dryness	Calculation of degree of dryness			The remaining moisture on the hands from electric hand drying is divided by the remaining moisture on the hands from paper towel drying. The result is subtracted from 1 to deliver a percentage.	
	Achieving 90% dryness			Targeting a degree of dryness of 90%, the electric hand drying process is repeated, using a variety of times, until a dryness of 90% +/- 1% is achieved.	

		Energy Technology List Criteria for High Speed Hand Air Dryers (2014)	NSF Protocol P335 for Hygienic Commercial Hand Dryers (2007)	Blue Angel Criteria for Electric Hand Dryers (2014)	Product Category Rule for Hand Dryer Environmental Product Declaration (2016)
Determination of Standard Drying Time	Establishing drying profile	Measure residual moisture for each of the 6 volunteers after 10, 15 and 20 seconds. Each volunteer shall complete 5 tests at each time interval.		The measurements are repeated across all test subjects	Replicate test 6 times per panellist. The highest and lowest residual moisture measurements shall be discarded with the average of the four remaining values used.
	Calculating average drying time	Using a residual moisture content of <0.15g, the average time taken for each volunteer should be calculated using the data from the 3 time intervals.		The average drying time to achieve the 90% degree of dryness across all 6 test subjects is calculated.	Test the dryer across a range of durations. The range should be a minimum of 8 seconds (at two second increments) or 5 data points.
	Calculating standard drying time	Disregard the highest and lowest average drying times and take the average of the remaining 4 volunteers.			The data for all panellists will be averaged for each increment of duration tested. The data will be plotted with the Y-axis covering residual moisture and the X-axis covering the range of drying durations tested. The minimum published dry time will be the intersection of the average residual moisture content with the 0.25g threshold.

		Energy Technology List Criteria for High Speed Hand Air Dryers (2014)	**NSF Protocol P335 for Hygienic Commercial Hand Dryers (2007)**	**Blue Angel Criteria for Electric Hand Dryers (2014)**	**Product Category Rule for Hand Dryer Environmental Product Declaration (2016)**
Electricity Consumption	Scope				The calculation includes reactive power losses and operational power consumption (i.e. whilst drying, run-on time, and standby).
	Actual electricity consumption				Testing is performed on a per unit basis, over 6 individual units. Heat controls and speed levels are set to maximum. Run-on time is measured and included. Each operation mode is tested. The run time from the drying procedure is used and added to the run-on time. Each standby mode is tested.
	Average electricity consumption	The electrical power consumption is measured and calculated where each of the 6 volunteers run the test 5 times at the standard drying time. The average power consumption across the 30 tests is determined.			

		Energy Technology List Criteria for High Speed Hand Air Dryers (2014)	NSF Protocol P335 for Hygienic Commercial Hand Dryers (2007)	Blue Angel Criteria for Electric Hand Dryers (2014)	Product Category Rule for Hand Dryer Environmental Product Declaration (2016)
	Quality check	The average residual moisture content across the 5 tests for 4 of the 6 volunteers shall be <0.15g.			
	Calculation of electricity consumption	Calculate electricity consumption over 1000 standard drying cycles.			
Calculating Reference Service Life (RSL)	Test voltage and frequency				According to the intended geographic region; test to both if the dryer can operate at 120V and 230V, and the relevant frequency, either 50 or 60 Hz. Voltage variance of +/- 4%.
	Duty cycle				"On" time is the run time of the dryer. The "off" time shall last 15 seconds.
	Units under test				Six. The RSL shall be the average test service life of the six units tested.

		Energy Technology List Criteria for High Speed Hand Air Dryers (2014)	NSF Protocol P335 for Hygienic Commercial Hand Dryers (2007)	Blue Angel Criteria for Electric Hand Dryers (2014)	Product Category Rule for Hand Dryer Environmental Product Declaration (2016)
	Variable speed or heat controls				Set product settings to the highest level of power consumption.
	Completion of test life				When the end of the natural motor service life is observed. Conditions specified for brushless and replaceable motors and

1.2.2.4 Analysis

- NSF's P335 Protocol is far less prescriptive in the specification for the hand drying and wetting procedure compared with the ETL Method. Furthermore, the NSF Protocol does not explain how the volunteers should be sampled and how the resulting residual moisture content should be calculated from the test data. The Protocol simply states the 0.1g residual moisture content should be achieved 95% of the time over 20 cycles. Whereas the ETL test method involves a total of 90 tests to establish the drying profile and a further 30 tests to calculate the electricity consumption of the hand dryer.
- As noted earlier, the Appendix to the Blue Angel criteria for electric hand dryers which specifies the method for determining the degree of dryness achieved by the electric hand dryer, begins by stating that it is based on the NSF Protocol P335. However, the specific instructions which follow creates a number of deviations from the NSF Protocol. These can be seen from Table 1.1 above. Differences included specification of an alternative paper towel, hand measurements (size and method)
- The method used by Blue Angel for measuring and declaring the dryness achieved by electric hand dryers is different to that specified within the ETL methodology. In the calculation of the degree of dryness, Blue Angel employs a reference scenario of drying hands using a paper towel. The effectiveness of drying hands using an electric hand dryer is then compared against the reference scenario.
- A key difference in the approach between the ETL method and that used by the Product Category Rule to calculate the standard drying time is the amount of testing. The former requires 90 tests, whereas the latter, 36.
- The ETL and Product Category Rule approach calculating electricity consumption in different ways. Both utilise the calculated standard drying time or run time (although to different residual moisture content levels) but the ETL method extrapolates consumption over 1000 cycles, whereas the Product Category Rules tests individual units including all operation and standby modes and speed and heat control settings on maximum.
- There are some areas of alignment across each test method e.g. the test room temperature and humidity requirements.
- There are a number of commonalities across the four test methods for the hand wetting and drying procedure. These include:
    - Washing hands immediately prior to testing, removing rings and jewellery from hands and wrists
    - Immersing hands in the water to the wrist crease and rubbing hands together for 5 seconds
- The methods are broadly aligned on the time to pause when removing the hands from the water, before drying – 5 seconds.

1.2.3 New Standards under Development

There are no known new standards under development for hand dryers covering the product performance parameters.

1.2.3.1 Material Efficiency

In 2015 the European Commission issued mandate M543 to the European Standardisation Organisations (CEN, CENELEC and ETSI) requesting standards to support Ecodesign requirements on material efficiency aspects for energy-related products[38]. The standardisation request relates to the following three material efficiency aspects:

- Extending product lifetime;

[38] http://ec.europa.eu/growth/tools-databases/mandates/index.cfm?fuseaction=select_attachments.download&doc_id=1611

- The ability to re-use components or recycle materials from products at end-of-life; and
- The use of re-used components and/or recycled materials in products

The European Commission has requested that the outputs from the mandate deal with the following topics:

- The definition of parameters and methods relevant for assessing durability, upgradability and ability to repair, re-use and re-manufacture of products;
- Provision of guidance on how standardisation deliverables for assessing durability, upgradability and ability to repair and re-manufacture of products can be applied to product-specific standards;
- Ability to access or remove certain components, consumables or assemblies from products to facilitate repair or remanufacture or reuse;
- Reusability/recyclability/recoverability (RRR) indexes or criteria, preferably taking into account the likely evolution of recycling methods and techniques over time;
- Ability to access or remove certain components or assemblies from products to facilitate their extraction at the end-of-life for ease of treatment and recycling;
- Method to assess the proportion of re-used components and/or recycled materials in products;
- Use and recyclability of Critical Raw Materials to the EU, listed by the European Commission;
- Documentation and/or marking regarding information relating to material efficiency of the product taking into account the intended audience (consumers, professionals or market surveillance authorities).

The Commission requested that the outputs from the mandate be adopted by the end of March, 2019. Adoption meaning that the relevant European standardisation organisation making a standard available to its members or the public.

Technical Committee CEN-CENELEC TC10 is responsible for producing the standards resulting from the mandate. The following is a complete list of the suite of standards under the mandate, progress against which (including available drafts) is published on their committee website[39]. Those standards marked with EN are now published.

- 45550 – definitions related to material efficiency
- 45551 – guide on how to use generic material efficiency standards when writing ErP product specific deliverables
- 45552 – method to assess durability of ErPs
- 45553 – method to assess ability to remanufacture ErPs
- 45554 – method to assess ability to repair, reuse and upgrade ErPs
- EN 45555 – method to assess the recyclability and recoverability of ErPs
- EN 45556 – method to assess proportion of reused components in ErPs
- 45557 – method to assess proportion of recycled content in ErPs
- EN 45558 – method to declare use of critical raw materials in ErPs[40]
- EN 45559 – method to provide information on material efficiency of ErPs[41]

39 https://www.cenelec.eu/dyn/www/f?p=104:22:1183738753089601::::FSP_ORG_ID,FSP_LANG_ID:2240017,25

40 https://shop.bsigroup.com/ProductDetail/?pid=000000000030373793

41 https://shop.bsigroup.com/ProductDetail?pid=000000000030374197

1.3 EXISTING LEGISLATION

The third sub-task identifies existing legislation that may affect hand dryers. This is considered at the European and Member State level as well as Third Countries (e.g. Korea).

1.3.1 Legislation & Agreements at European Level[42]

The Blue Angel award criteria for electric hand dryers makes reference to the "observation" of the following European Directives and regulations:

- The Low Voltage Directive 2014/35/EU[43]
- The Electromagnetic Compatibility Directive 2014/30/EU[44]
- The WEEE Directive on Waste Electrical and Electronic Equipment 2012/19/EU[45]
- The RoHS Directive on Restricting the use of Hazardous Substances in electrical and electronic equipment, 2011/65/EC[46]
- The Machinery Directive 2006/42/EC[47]
- The REACH regulation, on the Registration, Evaluation, Authorisation and Restriction of Chemicals, Commission Regulation (EC) No 1272/2008[48]

1.3.1.1 Standby

The Blue Angel award criteria for electric hand dryers also makes reference to the Ecodesign regulation on standby, specifically:

- The Ecodesign implementing measure for network standby, Commission Regulation (EU) Nº 801/2013[49], amending Commission Regulation (EC) Nº 1275/2008[50] regarding Ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment.

Note the Ecodesign standby regulation 1275/2008 does not make explicit reference to hand dryers within Annex I. Reference is made to *body care appliances* in the context of *appliances for hair cutting, hair drying, tooth brushing, shaving, massage*.

After consultation with stakeholders there was consensus that the Ecodesign standby regulation does not currently apply to hand dryers.

Definitions of note from Regulation No 801/2013 (and 1275/2008), include the following:

- 'standby mode(s)' means a condition where the equipment is connected to the mains power source, depends on energy input from the mains power source to work as intended and provides only the following functions, which may persist for an indefinite time:
  - reactivation function, or reactivation function and only an indication of enabled reactivation function, and/or
  - information or status display;

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[42] Note that Task 3 makes reference to specific Ecodesign regulations for electric motors and fans that are both components of an electric hand dryer.

[43] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0035&from=EN

[44] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0030&from=EN

[45] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012L0019

[46] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32011L0065

[47] https://osha.europa.eu/en/legislation/directives/directive-2006-42-ec-of-the-european-parliament-and-of-the-council

[48] https://echa.europa.eu/regulations/reach/legislation

[49] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0801&from=EN

[50] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32008R1275

- 'reactivation function' means a function facilitating the activation of other modes, including active mode, by remote switch, including remote control, internal sensor, timer to a condition providing additional functions, including the main function;
- 'information or status display' means a continuous function providing information or indicating the status of the equipment on a display, including clocks;
- 'active mode(s)' means a condition in which the equipment is connected to the mains power source and at least one of the main function(s) providing the intended service of the equipment has been activated;

Note that the standby power consumption of hand dryers currently on the market is analysed and presented within the Task 4 report on *Technologies*.

1.3.2 Legislation at Member State Level

There is no known legislation governing the performance at Member State level of hand dryers, however there are two examples of voluntary schemes operating at Member State level.

1.3.2.1 UK's Energy Technology List

The Energy Technology List (ETL) is a UK government managed list of energy-efficient plant and machinery[51]. It is part of the Enhanced Capital Allowance (ECA) tax scheme for businesses. Businesses who pay income or corporation tax, can claim 100% accelerated tax relief on the purchase of eligible equipment. The ETL lists over 15,000 products across 57 different technology types – one of which is high speed hand dryers. As of October 2018 there were 35 high speed hand dryers listed from 10 manufacturers and suppliers[52]. Applicants are required to submit a video recording of the product test along with the test report.

The ETL requirements for High Speed Hand Air Dryers focuses on the standard drying time to achieve a remaining moisture content and calculation of energy consumption[53]. To be eligible, high speed hand dryers are required to dry hands to a remaining moisture content of <0.15g over a standard drying time of <15.5 seconds and consume ≤5.5 kWh of electricity per 1,000 standard drying cycles (i.e., equivalent to an "average" 5.5 Wh/cycle over the 1,000 cycles).

Applicants can choose to have the product tested in their own laboratories or those of an independent third party.

1.3.2.2 Germany's Blue Angel

Blue Angel is a German government backed ecolabel scheme, setting high standards for environmentally friendly product design[54]. The Blue Angel has a category for electric hand dryers which includes hot air hand dryers and high speed hand dryers within its scope (i.e. categories 1-4 according to the definitions in section 1.1.1.2). There are six electric hand dryers which have been awarded the Blue Angel, all from the manufacturer Mediclinics[55].

1.3.3 Third Country Legislation

There is one known example, outside of the EU, which sets voluntary criteria for hand dryers.

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51 https://www.gov.uk/guidance/energy-technology-list

52 https://etl.beis.gov.uk/engetl/fox/live/ETL_PUBLIC_PRODUCT_SEARCH/search

53 https://www.gov.uk/government/publications/high-speed-hand-air-dryers-criteria-for-etl-inclusion

54 https://www.blauer-engel.de/en

55 https://www.blauer-engel.de/en/products/business-municipality/haendetrockner/haendetrockner (date checked: 13 December 2018).

1.3.3.1 Korea's Eco-label

The Korean Eco-label scheme has published criteria for electric hand dryers, reference EL208:2013[56]. The performance requirements have already been presented in Table 1.4.

1.3.3.2 U.S. Environmental Protection Agency's (EPA) ENERGY STAR Program

Electric hand dryers are not included within the ENERGY STAR program, however the product group has previously been under consideration. It is believed that the EPA were reticent to use real human hands within the test method to determine the effectiveness of hand dryers. EPA were concerned with the subjectivity the use of human hands brings to the testing process and the resulting number of variables e.g. size, shape, hair, gender, range of motion etc.

[56] http://el.keiti.re.kr/enservice/enpage.do?mMenu=2&sMenu=1

2 INTRODUCTION TO TASK 2 MARKETS

The aim of Task 2 is to research, identify and present a suite of key market data relating to the hand dryers product group. This includes sales and trade volumes within the EU-28 as well as installed base or “stock” estimates, and annual sales growth rate and replacement rate forecasts. The Task 2 report will also present insight on the latest market trends including product design as well as a set of price data.

2.1 GENERIC ECONOMIC DATA

The first sub-task details the following key economic data for the hand dryers product group, presented in physical units for the year 2017 and broken down by each Member State:

- EU production sold
- Extra-EU trade
- Intra-EU trade
- EU sales and trade (i.e. EU production sold + Intra-EU trade – Extra-EU trade)

The data presented below are derived from official EU statistics, namely the PRODCOM category covering the product group for this preparatory study: *electric hand-drying apparatus*[57], number 27.51.23.50. 2017 was chosen as the reference year because it represents the latest full year for which at least half of the Member States have reported data into PRODCOM. In 2017, all 28 EU countries have reported values to PRODCOM on their imports, exports and production of hand dryers.

Table 2.1 presents the available PRODCOM EU production sold data for hand dryers for 2017. Member States excluded from the table have no hand dryer production, according to the PRODCOM data. Production data from the UK and Denmark is declared, while production from France, Germany, Italy, Spain and Romania is kept confidential. The total production volume for these five Member States is 136,170 units with a value of €19,389,169. This represents 55% of production and 74.5% of the value.

Table 2.1 EU hand-dryer production sold in 2017

Member State	Volume (units)[58]	Value (€)[59]
UK	108,875	5,907,582
Denmark	1,964	717,339
France	Confidential	Confidential
Germany	Confidential	Confidential
Italy	Confidential	Confidential
Spain	Confidential	Confidential
Romania	Confidential	Confidential
EU 28 total	247,009	26,014,090

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

[58] Theses values are confirmed to be in units per piece, NOT thousands of pieces

[59] PRODCOM reports the "value of production sold during survey period". This data is gathered by Member State authorities asking manufacturers, via a survey, to report the value of their production sold. The estimated value would be different from the product price as it does not include pricing elements such as VAT and profits. For the full methodology please refer to: https://ec.europa.eu/eurostat/web/prodcom/methodology

These values indicate that the average hand-dryer produced in the EU has a value of €105.32. UK production accounts for 44% of EU production, which suggests the UK is the biggest producer of hand dryers within the EU. However, with a value per unit of only €54.26, the UK accounts for only 22.7% of EU production by value. This is in sharp contrast to the production from Denmark, which only accounts for 0.8% of total EU production, but at €365 per unit, covers 2.75% by value.[60]

The Member States listed in the PRODCOM data mostly match the manufacturers contacted for this study, along with their locations, such as Dyson in the UK, Ffuuss and Mediclinics in Spain, JVD in France and Starmix in Germany. The manufacturers in Italy, Romania and Denmark are yet to be identified.

Table 2.2 presents the available PRODCOM EU import and export data for hand dryers for 2017. The data do not indicate on a national level the ratio between internal and external trade to the EU.

Table 2.2 PRODCOM 2017 Export/Import data for Member States

Member States	EXPORT Volume (units)	EXPORT Value (€)	IMPORT Volume (units)	IMPORT Value (€)
Austria	1,140	188,540	5,830	1,217,540
Belgium	6,297	458,370	15,026	1,751,940
Bulgaria	226	9,950	2,510	92,310
Croatia	1,101	436,300	5,386	857,860
Cyprus	0	0	2,014	53,350
Czech Republic	1,598	134,590	9,501	1,201,310
Denmark	6,778	1,742,580	11,146	695,110
Estonia	12	700	869	58,800
Finland	13	2,680	217	21,800
France	20,483	2,309,940	112,915	4,131,750
Germany	24,187	4,654,530	28,785	2,858,980
Greece	778	23,610	24,701	563,530
Hungary	58	20,000	13,055	542,910
Ireland	11,710	1,130,350	33,622	1,633,720
Italy	18,192	1,695,960	68,362	2,529,910
Latvia	251	14,560	1,920	101,320
Lithuania	7,063	397,880	6,229	451,600
Luxemburg	692	119,380	1,290	298,200

[60] The values reported are in terms of "estimated value" not "price" at manufacturer. It is therefore only an indicative value and does not represent the consumer price which would be increased by other components such as VAT, profit margin and supply chain intermediaries.

Member States	EXPORT Volume (units)	EXPORT Value (€)	IMPORT Volume (units)	IMPORT Value (€)
Malta	0	0	693	66,050
Netherlands	22,375	1,756,310	40,787	1,367,750
Poland	4,008	396,500	38,151	2,384,870
Portugal	1,881	247,620	13,416	1,180,990
Romania	987	108,230	15,382	838,100
Slovakia	557	860	2,871	111,170
Slovenia	1,065	42,000	1,879	182,570
Spain	97,273	7,687,230	99,258	3,307,000
Sweden	7,224	656,100	4,209	503,470
United Kingdom	50,543	2,322,790	457,711	14,638,390
EU28TOTALS	97,240	11,382,970	828,619	29,830,740

Detailed import and export data have been provided by PRODCOM for the year 2017 for all EU Member States and the EU as a whole. However, the split of extra-/intra-EU on a Member State basis is not provided. Table 2.3 shows the trade for the EU as a block. Note that:

- Extra-EU accounts for trade by a Member State with a non-EU country, where imports are products entering the EU, and exports are products leaving the EU.
- The Intra-EU trade is exclusively delivered between Member States.
- EU sales and trade is defined as the sum of the EU production and intra-EU imports to which is deducted the units exported out of the EU (the Extra-EU Export).

Table 2.3 Extracted PRODCOM 2017 hand-dryers trade data[61]

	Volume (units)	Value (€)	Value per unit (calc. €)
EU production sold	247,009	26,014,090	105
Intra-EU trade	189,184	14,493,075	77
Extra-EU export	97,240	11,382,970	117
Extra-EU import	828,619	29,830,740	36
EU sales and trade	978,388	44,461,860	

[61] Data collated from PRODCOM [Accessed 04/12/2018], intra EU trade data prior to 2017 was not accurate within PRODCOM. After report to Eurostat in December 2018, the faulty data was subsequently removed.

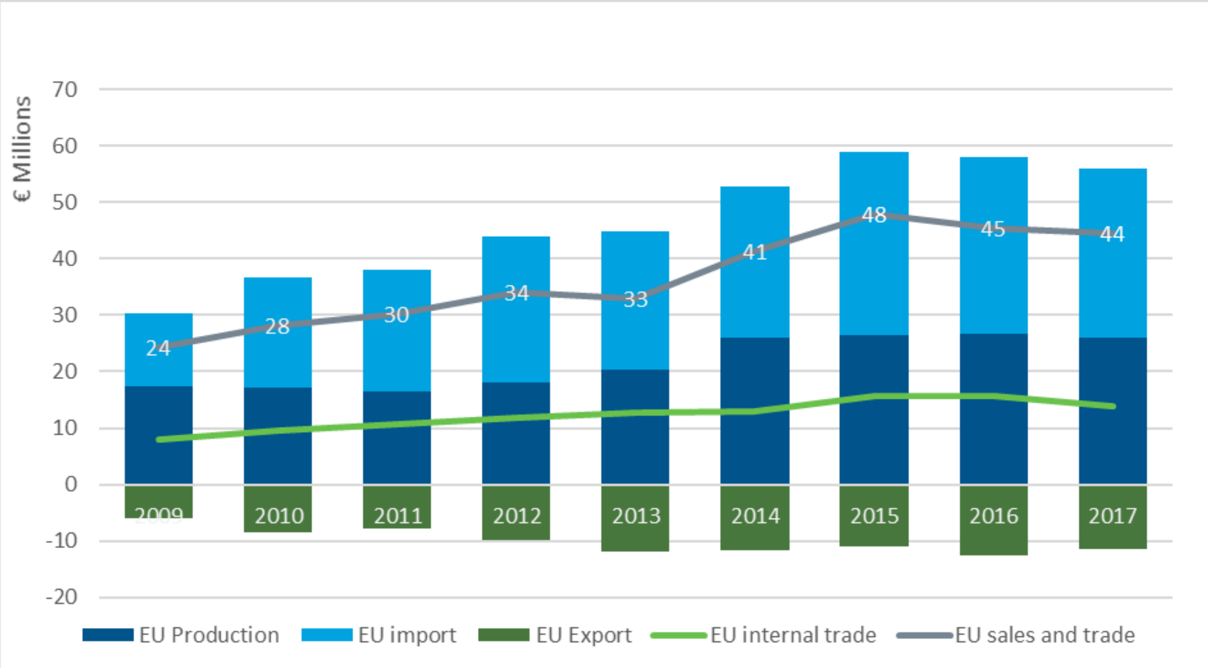
Table 2.3 data reveals two important trade points regarding hand dryers in the EU: the first being that the EU is heavily dependent on foreign imports, and that these imports are much cheaper per unit than internal production. On the former, 84.7% of the total EU sales and trade by volume is imported. On the latter, however, these imports only account for 67.1% of the market value. Comparing the average value of product imported into the EU (€36 per unit) to the average value of an EU produced product (€105 per unit), the EU production is €84 more expensive per unit.

Most Member States appear to import more hand dryers than they export, even for Member States with their own internal production. For example, the UK produced 108,875 units in 2017, yet still imported 457,711 units and exported only 50,543 units. Sweden and Lithuania are the exceptions, which, as shown in Table 2.2, have a net positive balance of 3,015 and 834 units respectively. It is worth noting that Table 2.1 indicates that neither of these Member States has an internal production, which may indicate an issue with the PRODCOM data.

The average value of imports per unit is lower than that of exports. This is true for most Member States except for Austria, Belgium, Czech Republic, Estonia, Lithuania, Luxemburg, Slovakia, Slovenia and Sweden. None of these Member States are producers of hand dryers, supporting the previous assumption that the EU produces higher monetary value hand dryers than extra-EU ones.

To analyse the trade from previous years, Figure 2.1 was collated using production data from PRODCOM and import/export data from Comext. This data is available at an EU level. Value of sales and trade in the EU was tracked below.[62]

Figure 2.1 EU-28 Hand Dryer trade progression[63]



The calculated "sales and trade balance" values are a reliable depiction of hand dryer consumption within the EU. As trade between EU countries is removed from the calculation, this avoids double counting which can occur as imports to Europe can be subsequently relabelled and resold across multiple borders.

[62] The same graph cannot be created for the quantity of hand dryers unfortunately as PRODCOM data is reported in units and Comext in kg.

[63] Data collated from Prodcom for production data and Comext data for import/export. [Accessed 14/06/2019]

This graph indicates the clear success of the industry, with an average 8% annual increase in sales and trade in the EU from 2009 to 2017. Production value has increased on average by 6% per year, not quite keeping up with the demand growth, which is compensated by an average growth in EU imports of 12% per year. Although EU imports are high, the demand for European hand dryers outside of the EU is increasing by an average of 10% per year, showing the EU has a growing domestic manufacturing sector, with international appeal.

2.2 MARKET AND STOCK DATA

The second sub-task details the following market and stock data for the hand dryers product group, presented in physical units for the EU-28:

- Installed base (stock)
- Annual sales growth rate
- Average technical and economic product life
- Replacement and retrofit rates

2.2.1 Manufacturer and Supplier Engagement

The study team approached 68 hand dryer manufacturers and suppliers to participate in this study. A number of prominent hand dryer manufacturers participated; however, many more companies did not respond to the study enquiry. These companies have been identified from a variety of sources, including the electric Hand dryer Association (eHA), those identified by third party market research reports and those registered on the UK's Energy Technology List (introduced under Task 1)[64]. These are estimated to be the bulk of the market players. Four companies have declined the invitation. The majority of companies identified did not respond. It is expected that this list is constituted largely of product suppliers, not manufacturers.

From the manufacturers participating in the study, the submitted questionnaires were on average 60% completed. These manufacturers have continued to be engaged throughout the study, providing feedback beyond the initial questionnaire as draft task reports were published. This feedback was provided during consultations and through email communications. This information has been published as meeting minutes and a feedback log[65].

There is a concern that the majority of the market participants supplying conventional single point hands under dryers have not engaged with the study. As a market dominated by SMEs, market viewpoints were expected to be more diverse. Nevertheless, a number of manufacturer participants also produce category 1 dryers.

2.2.2 Installed base (stock)

Manufacturers and suppliers have provided market and stock data for hand dryers in their questionnaire responses. This includes estimates of the hand dryer installed base. Total sales of hand dryers in the EU were determined using Prodcom data[66], and projected to grow to 2050 under a linear forecast from 2003-2018 datapoints. The manufacturer estimates were used to estimate the split of sales across the categories and the sale numbers pre-2003. From these sales, and the product lifetimes detailed in Table 2.9, a model was run to determine the stock values.

Table 2.4 presents this data according to the hand dryer definitions explained in the Task 1 report (i.e. conventional single point (hands under) dryer, high-speed single point (hands under) dryer, high-speed multi-point (hands under) dryer and high-speed trough style (hands in) dryer). Conventional single point hands under dryers are the oldest

[64] https://www.gov.uk/guidance/energy-technology-list

[65] http://www.ecohanddryers.eu/documents-3

[66] Data extracted from prodcom on 17.10.2019 for 27512350 – Electric hand-drying apparatus

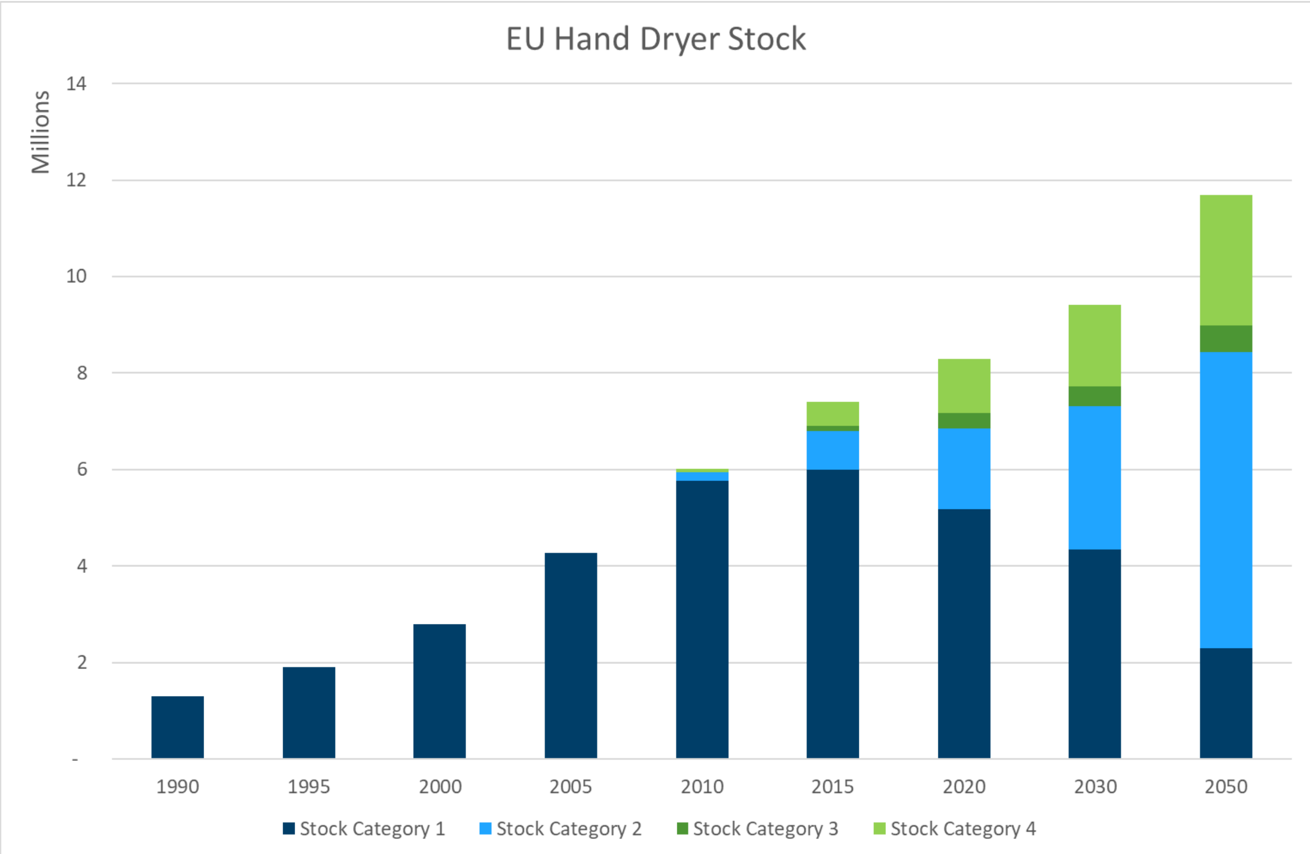
technology on the market and are therefore much more prevalent in stock compared to other technologies in for example 2015.

Table 2.4 Hand Dryer Installed stock Base (in thousands)

Hand dryer category	1990	1995	2000	2005	2010	2015	2020	2030	2050
Conventional single point	1,293	1,897	2,795	4,266	5,773	5,994	5,179	4,338	2,295
High speed single point	0	0	0	0	163	810	1,670	2,979	6,144
High speed multi-point	0	0	0	0	0	108	318	406	540
High speed trough style	0	0	0	0	81	482	1,120	1,693	2,710

For improved visibility, the stock base is graphed in Figure 2.2. A clear feature is the steady increase in expected total stock. The conventional single point hands under dryers are expected to become the minority technology, with the high-speed single point hands under dryers covering more than 50% of the market by 2050.

Figure 2.2 EU Hand dryer installed stock



Manufacturer feedback indicates that the **air taps** technology has yet to gain significant stock base. These require new buildings or renovation in order to be installed under the counter. Only up to 2000 units are estimated to be present on the market.

2.2.3 Annual sales growth rates

As detailed in section 2.2.2, sales figures were modelled from PRODCOM data and manufacturer feedback. These are shown in Table 2.5, long with Table 2.6 showing the calculated annual growth rate for each category of hand dryer.

Table 2.5 Hand Dryer EU28 sales (in thousand units)

Hand dryer category	1990	1995	2000	2005	2010	2015	2016	2017	2020	2030	2050
Conventional single point	182	260	398	636	534	436	383	416	409	359	113
High speed single point	0	0	0	0	97	300	284	332	373	581	1,131
High speed multi-point	0	0	0	0	0	54	51	58	58	71	93
High speed trough style	0	0	0	3	36	159	150	173	178	237	368

Table 2.6 Average annual sales growth rate (%)

Hand dryer category	1990	1995	2000	2005	2010	2015	2016	2017	2020	2030	2050
Conventional single point		9%	11%	12%	-3%	-4%	-12%	9%	-1%	-2%	-8%
High speed single point						42%	-5%	17%	4%	5%	3%
High speed multi-point							-6%	14%	0%	2%	1%
High speed trough style					220%	68%	-6%	15%	1%	3%	2%

Conventional single point hands under dryers are the majority, incumbent technology. However future sales forecast show that high speed hand dryers are rapidly becoming the preferred technology. Recent years indicate growth across each category. This growth is expected to diminish for conventional single hand dryers as other technologies increase their market share. The stock of conventional versus high speed hand dryers is expected to be on par at some point between 2025 and 2030. The **Air Taps** market share is estimated to be quite small at approximately 3%. The sales of the product are often limited to new building projects or renovations which would design the bathrooms to accommodate for the technology to fit under the sink. Although visibility and enquiries of the product have increased, due to their limitations they do not sell as successfully as category 2 hand dryers. Expectations are therefore not high for the product market share to significantly grow, possibly to 5% of the market by 2030. Therefore, due to these low expectations, this study will not complete a full model of the impact of this technology.

The increase in hand dryer sales has been from the success of the high-speed technology. As the new hand dryers are effective at drying hands, their other advantages compared with rival hand drying methods have been persuasive to end buyers. For example, lower total cost of ownership and lower maintenance costs. This has allowed end buyers to meet their environmental obligations and save money by switching to hand dryers.

The split of sales values for new stock and replacement sales was derived and shown in Table 2.7 and Table 2.8. A model was created for each technology based on the sales values in Table 2.5 and the estimated lifetimes in Table 2.9. The assumption is made that any hand dryer at the end of its life is replaced with a new hand dryer of the same category.

Table 2.7 Derived replacement sales (in thousand units) [67]

Hand dryer category	1995	2000	2005	2010	2015	2020	2030	2050
Conventional single point	107	157	230	345	436	409	359	113
High speed single point	0	0	0	15	82	203	430	915
High speed multi-point	0	0	0	0	0	31	62	85
High speed trough style	0	0	0	0	12	66	185	305

Table 2.8 Derived new stock sales (in thousand units)

Hand dryer category	1995	2000	2005	2010	2015	2020	2030	2050
Conventional single point	153	241	406	189	0	0	0	0
High speed single point	0	0	0	82	218	170	151	216
High speed multi-point	0	0	0	0	54	27	9	8
High speed trough style	0	0	3	36	147	112	52	63

2.2.4 Product lifetime

The technical lifetime is defined as the time the device will continue operating without need for repair. The economic lifetime is defined as the time the device will be used before it is replaced, which may be shortened from the technical lifetime by early replacement or extended through repair. Feedback from manufacturers on lifetime varied and is summarised in Table 2.9.

Table 2.9 Reported product lifetimes (in years)

Hand dryer category	Average Economic lifetime	Maximum Economic lifetime	Minimum Economic lifetime	Average Technical lifetime	Maximum Technical lifetime	Minimum Technical lifetime
Conventional single point	12.4	20	6	10.9	20	6
High speed single point	6.9	20	3	6	20	3
High Speed multi-point	6.9	10	3	6	10	3
High speed trough style	8.58	15	3	7.83	15	3

Some questionnaire responses indicate that the economic lifetime is the same as the technical lifetime, suggesting the repair market is minor. Others quoted the economic lifetime as 1 – 2 times longer than the technical lifetime, due to repair. One responder made a point about extending lifetime through product repair. Feedback from the first stakeholder consultation corroborated this information that the economic lifetime can be up to double that of the technical lifetime on the condition that the end buyer repairs the device.

Air taps are suspected to have similar life expectancy to Category 2 as the inner mechanisms are similar. Usage patterns however may vary as one can expect fewer cycles per day on air taps, as other dryers are rarely installed at a one to one ratio with

[67] As total sales are expected to decrease for category 1 hand dryers below the replacement rate required, all sales in 2050 are assumed to be used for replacement

taps. This should in theory mean that air taps would last a little longer than most category 2 hand dryer installations.

The economic lifetime of hand dryers can depend on the purchaser's attitude. Initial qualitative feedback from manufacturers indicated that hand dryer owners are more likely to simply replace than repair it. This was further developed and quantified with manufacturers and presented in 2.6.5.

Referring to Task 3 section 3.1.2. on hand dryer daily usage by location, one can reverse calculate that for office buildings, where the lifetime is estimated at its highest, the lifetime would match the values represented in Table 2.9. However, reverse calculating from the most used hand dryers, one could estimate that a hand dryer in an airport would be worn out after only 6 months of use. In practice however, this is not the case, as manufacturers will estimate the number of cycles per day in a location and sell to manufacturers a product which would last appropriately for the given location. For example, in airports, a more robust motor would be installed in the hand dryer in order to slow the wear and increase lifespan.

2.2.5 Replacement and Retrofit rates

Feedback from manufacturers indicates that electric hand dryers are rarely (if not never) displaced by other hand drying mechanisms. On the contrary Hand dryers have been displacing other technologies. Hand dryers may be repaired to increased life expectancy (as detailed in section 2.6.5). However, if not repaired, it is estimated that a faulty hand dryer would be replaced by a new unit.

Replacement and retrofit rates of hand dryers are often included in the normal total renovation cycle of public and semi-public places, which is usually between five and eight years. Also, of relevance, is the cycle in commercial office leases, typically 5-10 years, and the influence that plays on refurbishment practices. Otherwise replacements are installed only if the previous product fails. The attitude seems to be more towards replacement than repair.

2.3 MARKET CHANNELS

The third sub-task presents key market insights for the hand dryers product group according to the following five sub-sections:

- Channels to market
- General trends in product design and product features
- Competitive analysis of the market
- Market segmentation
- SMEs

2.3.1 Channels to market

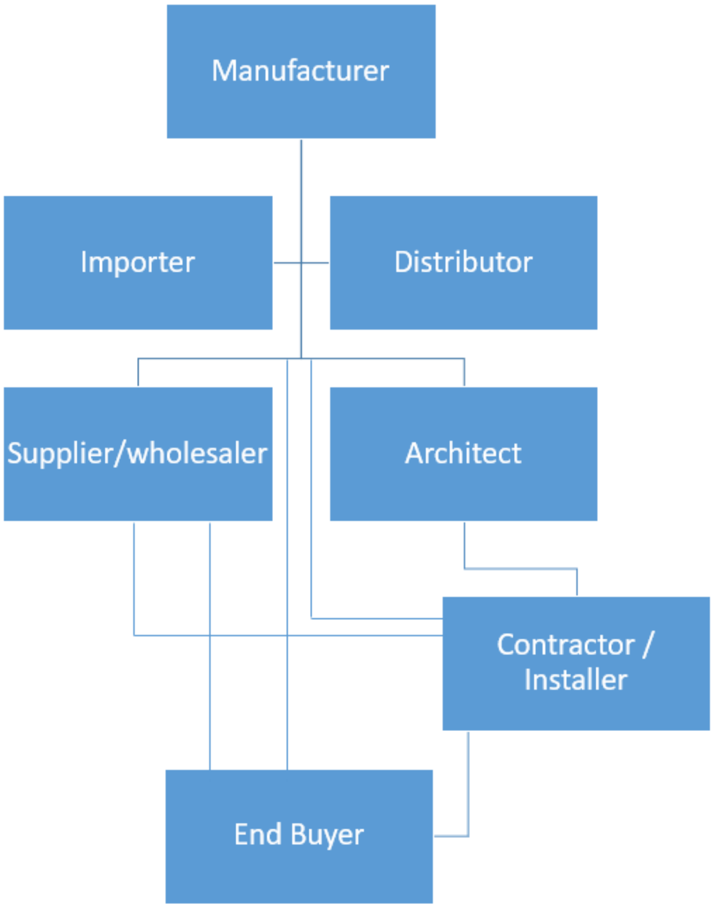
Figure 2.3 represents the different routes to market for hand dryers. Feedback from manufacturers indicates that the majority of product is sold by distributors, wholesalers or suppliers, to reach contractors and installers. Although present, direct trading to the end user is very limited. The distributors, wholesalers and suppliers may use an importer to bring the products into the EU. For tailored products, architects and contractors will occasionally approach manufacturers directly for design specification (for example to incorporate the hand dryers into "over sink" configurations).

To understand Figure 2.3, the following definitions have been used:

- Manufacturer: a company which makes goods for sale
- Importer: a company that brings products into a country for sale
- Distributor: an agent who would distribute hand dryers in a country, who may include their name on the product label. The distributor represents the manufacturer in the country of distribution.
- Supplier/wholesaler: a company that provides products

- Architect: a person or company who designs buildings and supervises their construction[68]
- Contractor: a person or firm that undertaking works such as construction under an architect's plan or an outfitter of a washroom.
- Installer: a person or company who places product in position ready for use. This would typically be an electrician brought in for the installation.
- End Buyer: The company/person offering the washroom service to users. This could be the building owner, the tenant, or a facilities service company.
- End User: the patrons who use the hand dryers.

Figure 2.3 Schematic of the channels to market for hand dryers

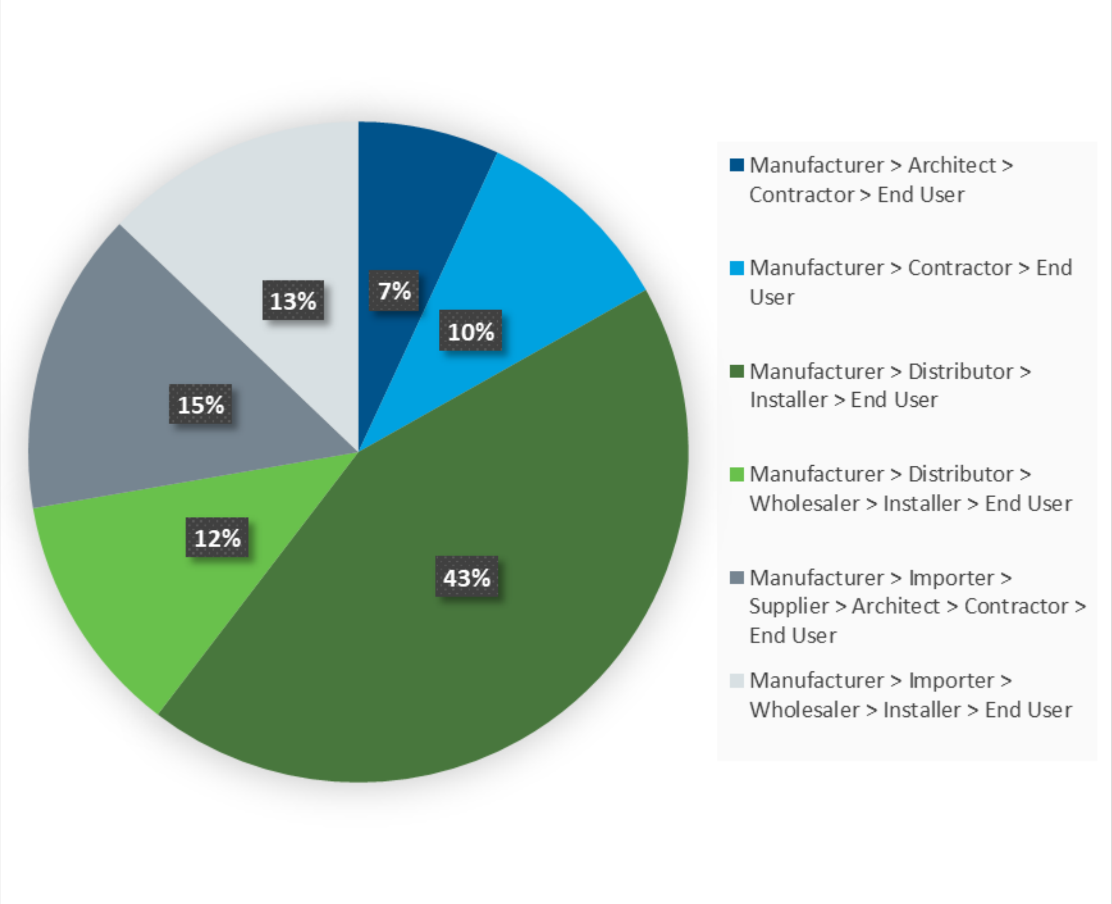


Manufacturers can choose to sell their product in a country through many routes, which may potentially overlap, either directly or use an importer or a distributor as an intermediary. Once in the country, most manufacturers do not track the route to market of their product. It may be sold directly to the end buyer, or a supplier for retail distribution. An architect may recommend for a contractor to install a specific hand dryer but wouldn't directly purchase the hand dryer for installation.

Manufacturers were requested to apportion the average value of business performed according to each channel in Figure 2.3. The results are presented below in Figure 2.4.

[68] Architects do not purchase hand dryers directly, but they will propose the use of specific hand dryers to their clients and hence influence the supply chain.

Figure 2.4 Hand dryer routes to market breakdown[69]



2.3.2 Direct sales to customers

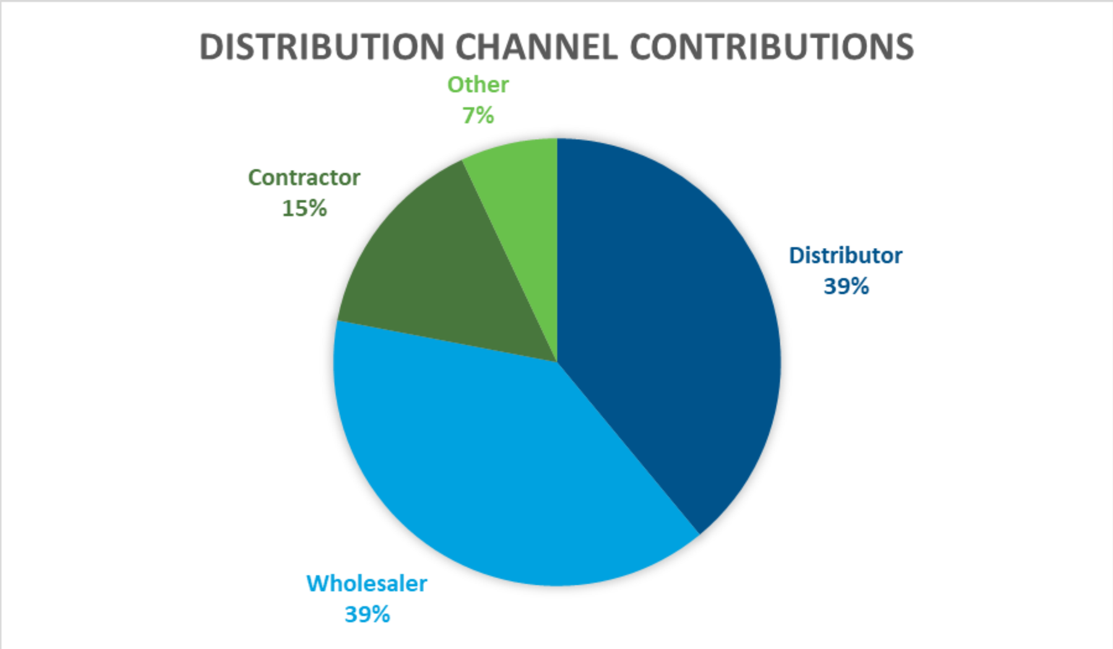
Manufacturer feedback concluded that direct sales to customers only accounted for 9% of total sales. These sales are estimated to be from a manufacturer or a local distributor representing the company, directly to the end buyer. This sort of direct sales is expected for clients with a high need for hand dryers (and potentially their own electrician workforce), such as airports. 91% of sales would have a further intermediary, such as a wholesaler or contractor.

2.3.3 Distribution routes

In addition to the question mapping the various channels to market (see section 2.3.1) the MEErP methodology requires the distribution channels, between retail and wholesale, to be estimated. The answers provided by manufacturers varied, but the average estimates from five manufacturers is presented in Figure 2.5.

[69] The route averages were deduced from the input values from only 3 manufacturers and hence may not be representative of the market at large. Other routes to market are possible but deemed too small to report in this graph

Figure 2.5 Market share of distribution channels for hand dryers[70]



Distribution through a distributor or wholesaler are the dominant methods of reaching the customer, representing 78% of sales according to Figure 2.5. Sales through contractors are less frequent at 15%, which may be due to relationships from designing and supplying tailored products for specifics sites or acquired contractor experience on the installation of certain products and keeping to familiar processes. If sales to contractors are assumed to be direct and hence wholesale, the wholesale market account for 54% of sales, whereas the retail market through the distributors account for 39%.

2.3.4 Installation services

Feedback from all but one manufacturer indicates that manufacturers do not participate in installation activities. Assuming an installation manual is provided, hand dryers can be installed by a qualified electrician with no need for special training.

Regarding installation, one manufacturer indicated working with their distributors and the end user maintenance personnel. They have created a collection of detailed videos to educate installers on the required processes on installation and repair. It is suggested that these efforts are designed to improve the customer experience rather than due to necessity.

2.3.5 Market Channels Discussion

Sections 2.3.1, 2.3.2 and 2.3.3 present different datasets representing how hand dryers reach the end buyer. The data was gathered from manufacturer feedback, which unfortunately does not correlate. For example, distribution accounts for 55% in Figure 2.4 and 39% in Figure 2.5. This lack of consistency shows how the market routes are numerous and not clear for manufacturers. Nonetheless the following key points can be drawn:

- Hand dryers are mainly sold through a Business to Business route. Manufacturers are rarely in direct contact with the end buyer and are more likely to sell their products to intermediaries. Products will tend to enter a market through the legal cover of an importer or a distributor, accounting for approximately 80% of hand dryer total sales.
- Most product is sold through wholesalers, selling product to bulk customers, or distributors, which may represent the manufacturer in the country.

[70] Manufacturer feedback

- Architects, installers, building and service contractors have a role in bringing the product to the end buyer, either purchasing the product directly themselves or through recommendations. Products sold through recommendations from architects represent approximately 22% of the market.

2.4 GENERAL TRENDS IN PRODUCT DESIGN AND PRODUCT FEATURES

2.4.1 Trends for all hand dryer types

Manufacturer feedback across all hand dryer categories, indicated a future design focus to reduce energy consumption. To reduce energy consumption, electrical power input and time of use are design considerations. Usually faster drying (and hence less time) would require more power input.

The use and improvement of HEPA[71] filters improves the life expectancy of the motor unit. These filters act to trap particulate matter from entering the hand dryer air stream. As matter is trapped in the filter, this can block the access of air which would stop the hand dryer from functioning, and then need replacement/cleaning. Filter design is therefore focusing on improving air flow in filters and making them last longer, requiring less maintenance and dryers to replace them, or possibly even self-cleaning mechanisms.

One manufacturer cited concern that across all hand dryer categories, cheaper non-EU manufacturers may copy models (even if patented).

To save space in bathrooms, manufacturers are designing "hands under" products to fit above the sink, incorporated behind a mirror. This design does need improvement as there is a risk for some of the water to be splashed up from the sink.

2.4.2 Trends by hand dryer category

2.4.2.1 *Conventional single point hands under dryers*

Manufacturer feedback indicated that this is the incumbent technology with a large majority of installed stock and market share. Manufacturer feedback indicates that product development in this sector is focused on price reduction, cover design and lower energy consumption. Compared to high speed hand dryers, the low noise aspect of these dryers and the ability to perform in cold environments are put forward as unique selling points by manufacturers. However, manufacturers of both "conventional" and "high speed" hand dryers are more focused on developing the latter product. Market share has been in decline as high-speed single point hands under dryers are developing. A review of conventional single point hands under dryers currently on the market is shown in Table 2.10. This table presents the features from a sample of conventional single point hands under dryers.

[71] High Efficiency Particulate Air – a type of air filtration to system.

Table 2.10 Overview of the features of conventional single point hands under dryers[72]

Brand	Model	Automatic operation	Push Button Operation	Claimed Drying time =<12s	Max. Power Consumption at 240V	Heating	Heat ON/OFF	Antimicrobial Technology	ADA compliance[73]	Brush motor with thermal protection	Brushless motor	Noise level[74]
Airdri	Quantum	✓			200 W				✓			85 dBA
Airdri	Qatro	✓			2000 W	✓						74 dB
Genwec	E-Flow	✓			900 W	✓	✓				✓	72 dBA
HOKWANG	1800W	✓	✓		1800 W	✓					✓	64 dB
JVD	Zephyr	✓			2100 W	✓						69 dB
JVD	Ouragan	✓	✓		2600 W	✓						78 dB
Mediclinics	Speedflow	✓		✓	1150 W	✓	✓		✓	✓		67 dBA
Mediclinics	Mediflow	✓			2750 W	✓			✓	✓		65 dBA
Starmix	T 70 E	✓			1400 W	✓						66 dB
Starmix	ST 2400 E	✓			2400 W	✓						69 dB
World Dryer	SLIMdri	✓			950 W	✓	✓	✓	✓	✓		
World Dryer	AirMax	✓			2400 W	✓			✓	✓		

As indicated by manufacturers, these dryers are consistently equipped with heating components. Note that only one model has a claimed drying time of under 12 seconds, whereas most other hand dryer categories can meet this claimed drying speed. None are equipped with HEPA filters, which renders the maintenance of the device simpler. A point of note on this table is that the noise levels reported are similar to those reported by the other hand dryer categories (see later tables), which runs counter to manufacturer feedback regarding the unique selling point of conventional single point hands under dryers.

[72] Based on manufacturers' websites and products' spec sheets

[73] Standards for Accessible Design under Americans with Disabilities Act (ADA) (https://www.ada.gov/regs2010/2010ADAStandards/2010ADAStandards.pdf)

[74] dB sound pressure levels are unweighted. dBA are sound pressure levels weighted to frequencies of the human ear

2.4.2.2 *High speed single point hands under dryers*

Manufacturers indicated that the first high speed hands under dryers were created in in the 1990s, with the first models reaching the EU market in the late 2000s. Manufacturers indicated that the market is starting to reach maturity. Distribution channels, buyers and users are fully aware of the technology and there is a diverse group of manufacturers. These products are progressively taking market share from the conventional single point hands under dryers, due to their faster and more effective drying. However, the product is more expensive, and is expected to wear faster than conventional hand dryers, hence reducing the lifetime (Table 2.9), and increased noise. Manufacturers report that design improvements are focused on reducing the energy consumption of these devices, improving their lifetime and reducing noise levels. A review of the high-speed single point hands under dryers is shown in Table 2.11. This table presents the features from a sample of high-speed single point hands under dryers.

Table 2.11 Overview of the features of high-speed single point hands under dryers[75]

Brand	Model	Automatic operation	Claimed Drying time	Max. Power Consumption at 240V (W)	HEPA filters	Adjustable speed	Heating	Heat ON/OFF	Antimicrobial Technology	ADA compliance	Brushed motor with	Noise level
Excel	XLERATOReco	✓	✓	530 W	✓	✓			✓	✓	✓	
Excel	ThinAir	✓		950 W		✓	✓	✓	✓	✓	✓	
Genwec	SCREENFLOW	✓		1100 W			✓	✓				68 dB
HOKWANG	EcoTap	✓	✓	1000 W			✓					63 dB
HOKWANG	HK-JA	✓		1600 W		✓	✓	✓				74 dB
JVD	Airwave	✓		1400 W			✓	✓				77 dB
Mediclinics	Machflow	✓	✓	1100 W	✓		✓	✓				74 dBA
Mediclinics	Speedflow Plus	✓	✓	850 W	✓		✓	✓		✓	✓	65 dBA
Starmix	XT 1000 EcoFast	✓		1000 W			✓					75 dBA
World Dryer	VERDEdri	✓		950 W	✓	✓	✓		✓	✓		
World Dryer	eXtremeAir EXT	✓	✓	540 W		✓				✓	✓	81 dBA

These dryers are often equipped with HEPA filters, which require change and maintenance. Six of the eleven reported dryers have a claimed drying time under 12 seconds, with many of the products having a similar noise level compared with conventional single point hands under dryers.

[75] Based on manufacturers' websites and products' spec sheets

2.4.2.3 *High speed multi point hands under dryers*

High speed multi-point hands under dryers were an innovation developed from the initial single point design. This market is also seen as reaching maturity, with buyers and distribution channels aware of the product and a variety of manufacturers making it. This product has a shorter lifetime than conventional dryers (Table 2.9) and increased noise level. Manufacturers report that design improvements are focused on reducing the energy consumption of this technology, increasing their lifetimes and reducing their noise levels. The features of high-speed multi-point hands under dryers are listed in Table 2.12.

Table 2.12 Overview of the features of high-speed multi-point hands under dryers[76]

Brand	Model	Automatic operation	Claimed Drying time =<12s	Max. Power Consumption at 240V	HEPA filters	Drying speed >150m/s	Heating	Antimicrobial Technology	ADA compliance	Brushless motor	Rotating nozzle	Noise level
Dyson	Airblade V	✓	✓	1000 W	✓	✓		✓	✓	✓		79 dB
Dyson	Airblade Wash Dry wall	✓		1000 W	✓	✓		✓	✓	✓		80 dB
JVD	SupAir	✓	✓	500 W		✓		✓				75 dB
JVD	COPT'AIR	✓	✓	500 W		✓		✓			✓	80 dB
Starmix	AirStar T-C1	✓		1000 W								69 dB

These hand dryers are often equipped with HEPA filters, which require change and maintenance. Three of the five reported dryers have a claimed drying time under 12 seconds. The hand dryers reviewed are slightly noisier on average compared to the conventional single point and high-speed single point hands under dryers.

2.4.2.4 *High speed trough style hands in dryers*

The first high speed hand dryer created was trough style and was developed in Japan in 1992. The product came onto the EU market in the mid-2000s and has been steadily growing since, though not as quickly as hands under high speed hand dryers. . Manufacturers commonly reported hygiene concerns with this category of product. For example, user's hands may touch the edges of the trough and water might accumulate within the trough. Design development is focusing on reducing these risks and associated maintenance in this regard (emptying and cleaning the drip tray). One manufacturer indicated a design focus is to design a more "friendlier" user experience. Just as with other high-speed hand dryers, there is also a general development requirement for energy efficiency, longer lifetimes and noise reduction. The features of high-speed trough style hands in dryers are listed in Table 2.13.

[76] Based on manufacturers' websites and products' spec sheets

Table 2.13 Overview of the features of high-speed trough style hands in dryers[77]

Brand	Model	Claimed Drying time =<12s	Max. Power Consumption at 240V	HEPA filters	Adjustable speed	Heating	Heat ON/OFF	Antimicrobial Technology	ADA compliance	Brushless motor	Bluetooth technology	Noise level
Dyson	Airblade dB	✓	1600 W	✓				✓	✓	✓		84 dB
FFUUSS	HD1	✓	1100 W	✓		✓		✓	✓		✓	
FFUUSS	HD2	✓	1100 W	✓				✓	✓		✓	
Genwec	BLADEFLOW	✓	1400 W	✓		✓	✓			✓		76 dB
Genwec	BLADEFLOW 2	✓	1650 W			✓						75 dB
JVD	Exp'Air	✓	800 W					✓				75 dB
JVD	Stell'Air	✓	800 W					✓				73 dB
JVD	Alphadry	✓	2050 W	✓		✓	✓			✓		80 dB
Mediclinics	Dualflow	✓	1500 W	✓		✓	✓	✓	✓			72 dBA
Starmix	XT 3001	✓	1000 W	✓				✓		✓		80 dB
World Dryer	Vmax	✓	1200 W	✓	✓			✓	✓			

These dryers are often equipped with HEPA filters (eight out of eleven). All of the eleven dryers have a claimed drying time under 12 seconds. The noise levels of this category are on average higher than that of the conventional single point hands under dryers. Nonetheless the noise range is comparable, especially as the noisiest of all dryers is a conventional single point hands under dryer at 85 dB.

2.4.3 All high-speed dryers – improvement challenges

Study participants indicated that manufacturers of modern hand dryers (mainly "high speed") are considering new features such as increased monitoring through enabling connectivity/Internet of Things (IoT)[78], and new revenue streams incorporating screens onto the dryer for advertising purposes[79]. Condition monitoring through IoT can enable

[77] Based on manufacturers' websites and products' spec sheets

[78] https://www.handdryerffuuss.com/en/handryer1/

[79] https://www.savortex.com/hand-dryers/the-addryer/

manufacturers to gather data on their product's performance, usage times, optimal locations, average drying speed and tighter maintenance regimes. This might cut maintenance costs on current hand dryers and optimise future hand dryer designs in line with learned behaviour.

2.5 MARKET SEGMENTATION

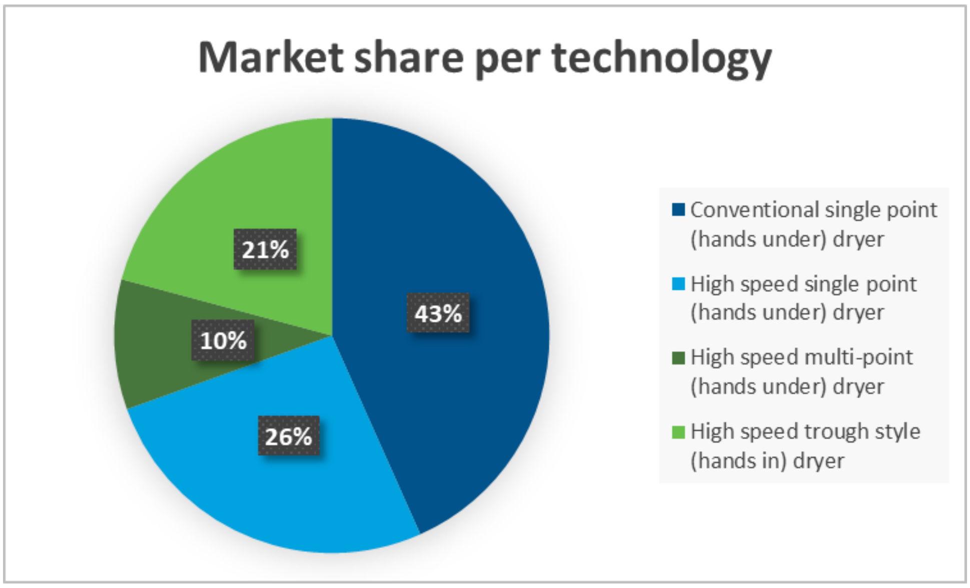
This section aims to review the market segmentation for hand dryers, including reviewing the market share of major players.

2.5.1 Market share of major players

Responses on market share were very scattered[80]. Overall, it seems for hand dryers the market is very diverse, with manufacturers only attributing 15%- 41% of the market to the top seven market names (Dyson, Excel Dryer, JVD, Mediclinics, World Dryer, Ffuuss, Hokwang), with the rest of the market being split amongst other manufacturers and suppliers. However, this diverse market does not seem to apply to all hand dryer categories, notably for trough style dryers, one report placed 50% of the market with Dyson.

Figure 2.6 details how the market is split across the hand dryer categories according to manufacturer feedback. The most contentious issue is the position of the category 1 product, with some reports estimating it at 90% of the market, and others at only 20%. These estimates are consistent with the market trends described previously. As the incumbent technology, the conventional single point hands under dryers hold the highest share of the market. However, the high-speed single point hands under dryer market is nearly at full maturity. Single point high speed dryers are rapidly becoming the preferred technology, estimated to overtake the conventional single point hand dryer sales values by 2022.

Figure 2.6 Market share per Hand dryer technology



2.5.2 Manufacturer Product Ranges

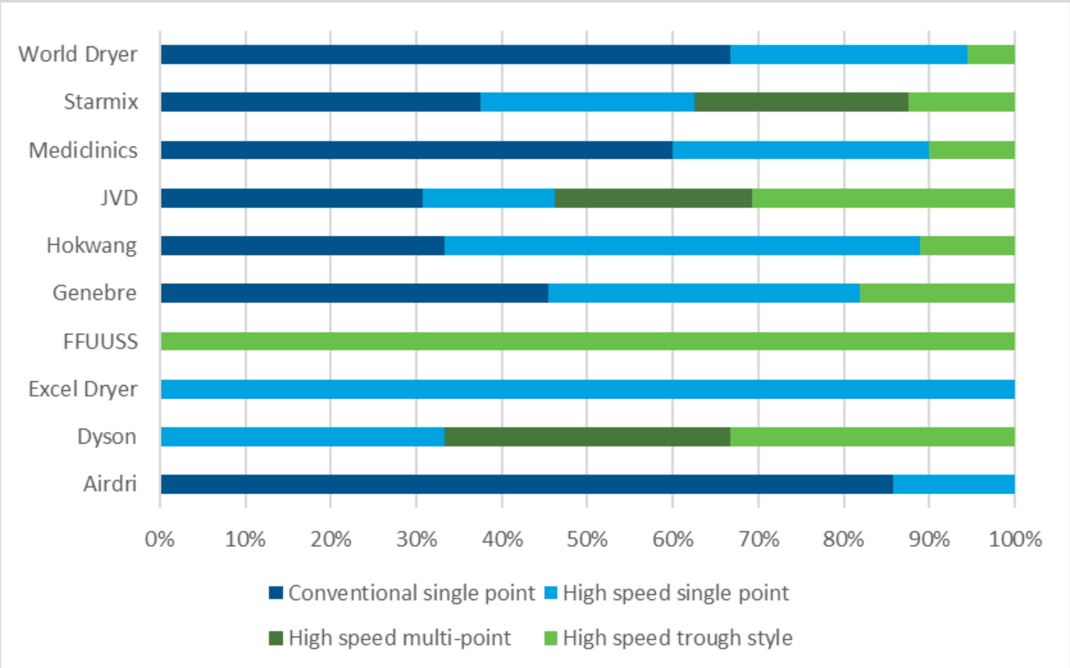
Ten manufacturers have already contributed to the study by submitting manufacturer questionnaires. These are: Airdri, Dyson, Excel Dryer, Ffuuss, Genebre, Hokwang, JVD, Mediclinics, Starmix and World Dryer. Table 2.14 and Figure 2.7 show how the manufacturers have split their product ranges according to each hand dryer category. This indicates the market presence of each manufacturer. **The data in Figure 2.7 and Table 2.14 is not a reflection of market share by sales.**

[80] The values reported by one manufacturer were reported from a 3rd party source

Table 2.14 Manufacturer product ranges[81]

Manufacturer	Conventional single point		High speed single point		High speed multi-point		High speed trough style	
	No	%	No	%	No	%	No	%
Airdri	6	15	1	4	0	0	0	0
Dyson	0	0	1	4	1	17	1	8
Excel Dryer	0	0	3	12	0	0	0	0
FFUUSS	0	0	0	0	0	0	2	15
Genebre	5	13	4	15	0	0	2	15
Hokwang	3	8	5	19	0	0	1	8
JVD	4	10	2	8	3	50	4	31
Mediclinics	6	15	3	12	0	0	1	8
Starmix	3	8	2	8	2	33	1	8
World Dryer	12	31	5	19	0	0	1	8
Total	39		26		6		13	

Figure 2.7 Manufacturer Product Ranges[82]



[81] Table completed using inputs from supplier questionnaire feedback, at the exception of World dryer, where dryers were identified using their website: https://www.worlddryer.com/products/hand-dryers

2.5.3 *Market segmentation by technologies*

2.5.3.1 *Conventional single point hands under dryers*

Feedback from manufacturers indicated that the market for this technology is mature and crowded. Manufacturers most cited within the questionnaires are Hokwang, Mediclinics and World Dryer. However, it was reported that most manufacturers make conventional single point hands under dryers, except those solely focused on high speed technologies, notably Dyson and Ffuuss.

2.5.3.2 *High speed single point hands under dryers*

For this category of hand dryers, the most cited manufacturers in the questionnaires were Mediclinics, Excel Dryer, Hokwang and World Dryer. Dyson, JVD, Airdri and Starmix were also mentioned.

2.5.3.3 *High speed multi point hands under dryers*

For this category of hand dryers, the most cited manufacturer in the questionnaires was Dyson. Others were Hokwang, JVD, Starmix, Excel Dryer and Mediclinics. Fewer manufacturers produce these products compared with high speed single point hands under dryers because it is seen as a premium product with higher prices.

2.5.3.4 *High speed trough style hands in dryers*

As with the multi-point high speed hand dryers, the high-speed trough style hands in dryers were developed as an improvement from the high-speed single point hands under dryers. Manufacturer feedback indicates that the main market players in this field are Ffuuss and Dyson. Other manufacturers were also mentioned: Mediclinics, Panasonic, Hokwang, Young San, Vama, Toto and JVD.

2.5.4 *SMEs*

All manufacturer responses indicate that the hand dryers market is dominated by SMEs[83], with notable exceptions being Dyson, Mitsubishi and World Dryer. Study participants estimated an average 78% market share of SMEs within the hand dryer market. SMEs occupy all segments of the market: manufacturing, importing, wholesale, distribution, architect, contracting and installation. The majority of eHA members are SMEs.

2.6 CONSUMER EXPENDITURE BASE DATA

The fourth sub-task presents price data in Euros for the hand dryers product group. This establishes the consumer expenditure base for use later in the preparatory study under Tasks 5 and 6 (establishing the life cycle cost base case and design options).

2.6.1 *Prices as sold*

Six manufacturers have provided average prices. The data is presented in Table 2.15 according to the four hand dryer categories.

Table 2.15 Hand dryer sold prices (incl. VAT)

Hand dryer category	Sample size	Average value (€)
Conventional single point dryer	6	188
High speed single point dryer	6	335

[82] Figure completed using inputs from supplier questionnaire feedback, at the exception of World dryer, where dryers were identified using their website: https://www.worlddryer.com/products/hand-dryers

[83] SMEs are defined by staff headcount and their turnover or balance sheet. The EC's full definition is available here: http://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition_en

Hand dryer category	Sample size	Average value (€)
High speed multi-point dryer	4	454
High speed trough style dryer	7	715

Due to their small market share, exact prices for air taps were not estimated here. However, qualitative feedback has shown that air taps cost approximately 80% higher than category 2 hand dryers.

2.6.2 Production Costs

Manufacturers were invited to provide feedback on the production costs for Hand dryers. This is commercially sensitive information, which most manufacturers did not report. Only 1 to 3 figures were reported on each hand dryer category, which is too small a sample size to report whilst preserving manufacturer confidentiality.

2.6.3 Installation Costs

Four manufacturers have provided installation costs. The costs range from €20 to €250, with an average reported value of **€100**. The manufacturer does not typically perform installation. Different labour requirements may be required depending on the product category. According to manufacturers, the greater variability is based on the availability of power in the washroom, the number of hand dryers being installed and the use of an outside electrician rather than internal qualified labour. Installation of air taps is a little more expensive than for other hand dryers as these require drilling a hole in the basin counter and space under the sink.

2.6.4 Cost of Consumables

The consumables identified for hand dryers are the HEPA filters. These are used to ensure that the air flowing from the hand dryer is clean. However, these are not used by all hand dryers, as they are an optional feature. Their replacement rate is also not always constant and will vary according to usage patterns and cleanliness of hand dryer location. Table 2.16 gathers feedback from manufacturers on filter consumption.

Table 2.16 Filter consumption data[84]

	Percentage of units operating with a filter (%)	Filter usage estimate (filters/ year)	Filter cost (€)	Economic lifecycle (year)	Weighted lifetime filter cost (€)
Category 1	0	0	20	10.9	0
Category 2	30	1	20	6	36
Category 3	30	1	20	6	36
Category 4	100	1	20	7.83	156.60

2.6.5 Repair & Maintenance Costs

Manufacturer feedback has indicated that according to the category of the hand dryer, there are variances in: the rate at which the products are repaired, the components more likely to fail and the cost of the repair.

For category 1 hand dryers, manufacturers estimated that **25%** of all hand dryers are repaired in their lifetime. 75% of the time, the repair requires the replacement of the

[84] Manufacturer feedback gathered post-consultation

sensor unit, with the remaining occasions being for replacing the carbon brush (15% of repairs) or the motor itself (10% of repairs). As replacing the motor or motor brush would double the life expectancy of the hand dryer, on average a repaired hand dryer would have an extended life expectancy of **25%.** Motors have been estimated by manufacturers to cost approximately 10% of the product price. For category 1 hand dryers, the cost of sensor unit is estimated at £31.17[85] and has been converted and brought to an EU price down from the UK price index to €30.86[86]. In the same manner, the carbon brush was sourced to cost £15 and was converted to cost €14.85 on average in the EU. As a weighted price average, the material cost of a repair for category 1 hand dryers is of **€27.25** (this figure does not include initial installation costs, these are covered in 2.6.3).

For category 2, 3 and 4 hand dryers, manufacturers estimated that **30%** of the hand dryers are repaired in their lifetime. Two-thirds of the time the repair requires the replacement of the PCB unit, with the remaining occasions being for replacing the motor (33% of repairs). As previously mentioned, replacing the motor would increase the life expectancy of the hand dryer; on average a repaired hand dryer would have an extended life expectancy of **33%.** Motors have been estimated by manufacturers to cost approximately 10% of the product price. For category 2, 3 and 4 hand dryers, the cost of the PCB unit is estimated at £63[87] and has been converted and brought to an EU price down from the UK price index to €62.37[88]. The weighted average price of repair for each category has been calculated in Table 2.17.

Air taps having similar parts to category 2 hand dryers would be expected to have similar repair requirements, with motors and PCB being the most frequently required repair parts.

For many cases, the biggest cost to repair is labour. The costs would cover 2 visits: an initial inspection and fault diagnosis, parts-ordering and return for install. To calculate the labour cost of repair in Europe, we will first estimate the cost for a French electrician. The cost per hour is estimated at €45 with an extra 20% VAT, hence totalling at €54. Travel costs are estimated between €20-40, and hence assumed to be an average of €30 for the sake of this study. Hence per visit, the electrician is estimated to charge €84, amounting to €168 for both visits and total material repair costs.[89] Reviewing the labour rates in the EU, the French rate is €35.80 and general EU28 rate is €27.40[90]. Therefore, the average labour cost for hand dryer repair in the EU is €128.58. Labour costs will vary depending on the member state, and if the user has an in-house electrician or calls an external electrician. These calculations are summarised in Table 2.17.

[85] https://www.direct365.co.uk/supplies/hand-dryers/replacement-parts

[86] https://ec.europa.eu/eurostat/statistics-explained/index.php/Comparative_price_levels_of_consumer_goods_and_services#Price_levels_for_energy.2C_furniture.2C_household_appliances_and_consumer_electronics

[87] https://www.ehanddryers.com/accessories/hand-dryer-spare-parts/excel_dryers-aertek-o3_group-heat_outdoors-newlec-sensor

[88] https://ec.europa.eu/eurostat/statistics-explained/index.php/Comparative_price_levels_of_consumer_goods_and_services#Price_levels_for_energy.2C_furniture.2C_household_appliances_and_consumer_electronics

[89] https://monelectricite.pro/tarif-electriciens/

[90] https://ec.europa.eu/eurostat/statistics-explained/index.php/Hourly_labour_costs

Table 2.17 Hand dryer repair rates data

	% of Hand dryers repaired in their lifetime	Average material cost per repair (€)	Average labour cost per repair (€)	Average total per repair (€)	Weighted average repair costs (€_	% life extension after repair
Category 1	25%	€27.25	€ 128.58	€ 155.83	€ 38.96	25%
Category 2	30%	€52.75	€ 128.58	€ 181.33	€ 54.40	33%
Category 3	30%	€56.72	€ 128.58	€ 185.30	€ 55.59	33%
Category 4	30%	€65.42	€ 128.58	€ 194.00	€ 58.20	33%

Maintenance costs have been calculated for maintenance required to ensure general functioning of the device, hence surface cleaning costs have not been considered. For category 1, 2 and 3 hand dryers, the only maintenance accounted for is the labour costs involved with replacing the filters. These values are displayed in Table 2.18.

In line with the filter considerations in Table 2.16, it is assumed that the replacement of filters is undertaken by non-specialised staff and requires 10 minutes. For category 4 hand dryers, another part of maintenance is to empty the water tray, which is estimated to take 30 seconds. Labour costs are under the average EU minimum wage: € 7.10 per hour.[91]

Table 2.18 Hand dryer maintenance costs

	Average Filter replacement maintenance (€/year)	Water tray maintenance (€/year)	Annual maintenance cost (€/year)	Economic lifecycle (year)	Lifecycle maintenance cost (€)
Category 1	0	0	0	10.9	0
Category 2	0.36	0	0.36	6	2.13
Category 3	0.36	0	0.36	6	2.13
Category 4	1.18	21.60	22.78	7.83	178.36

The cleanliness of the washroom environment should not be underestimated. If the hand dryers are kept in a dusty/dirty environment, they are exposed to higher levels of particulate matter in the air. The HEPA filters are meant to trap particles up to 0.1 microns wide (0.3 microns in the US). This may protect the hand dryer motor from these particulates but means the maintenance costs are higher in order to replace the HEPA filters as they become saturated faster.

Air taps also use filters. These can be simple carbon filters or HEPA.

2.6.6 Costs for Disposal

Disposal costs include tariffs and/or taxes. Manufacturers are either not aware of these tariffs or indicated that there are too many to discuss in the questionnaire. The only specific tariffs discussed were the WEEE Directive and an €0.08 / kg tariff in Spain for

[91] 2019 minimum wage values collected from: https://www.eurofound.europa.eu/publications/article/2019/minimum-wages-in-2019-first-findings (Denmark, Italy, Cyprus, Austria, Finland and Sweden not included as no minimum wage)

high-speed trough style hands in dryers. It is possible that manufacturers are not aware of the tariffs, as these costs are paid by other agents in the supply chain. As such a local distributor sourcing hand dryers from outside the EU would be more aware of the tariffs.

Disposal for Hand dryers is covered under WEEE by using a Producer Compliance Scheme. The supplier (defined as the one placing the product on the market), must declare how much of the product is brought onto the market. From the total mass of product submitted, the supplier will pay a compliance scheme to collect and ensure adequate end of life treatment.

For hand dryers it is expected that if they do not end up in a landfill, they would be recuperated and shredded. The metal is recuperated and recycled after shredding. Other materials however are rarely recuperated in this process and are disposed of. Further detail on the recycling and end of life flows for these materials is provided in Task 4, *Technologies*.

2.6.7 Cost summary

For ease of review, the summary of consumer costs for each category of hand dryer have been collated and presented in Table 2.19.

Table 2.19 Hand Dryer consumer costs summary

Costs per unit	Conventional single point dryer	High speed single point dryer	High speed multi-point dryer	High speed trough style dryer
Prices as sold (€)	188	335	454	715
Production (€)	N/A	N/A	N/A	N/A
Installation (€)	100	100	100	100
Consumables – filters over lifetime (€r)	0	36	36	156.60
Average weighted cost of repair (€)	38.96	54.40	55.59	58.20
Lifecycle Maintenance costs (€)	0	2.13	2.13	178.36
Disposal (€)[92]	0.43	0.38	0.38	0.74

[92] Cost of disposal calculated using the weight of hand dryers determined in Task 4 and 0.08€/kg quote from Spain WEEE

3 INTRODUCTION TO TASK 3 USERS

Relevant user-parameters are an important input for the assessment of the environmental impact of a product during its use and end-of-life phases. The aim of Task 3 is to consider these user parameters for electric hand dryers and to retrieve and analyse data on user behaviour and their associated environmental impacts during the use and end-of-life phases.

3.1 SYSTEMS ASPECTS OF THE USE PHASE FOR ErPs WITH DIRECT IMPACT

The first sub-task requires the impacts from the use of electric hand dryers to be considered and analysed at different component, product and system levels. The first two of which are the most significant and appropriate for considering the environmental impacts from the use of electric hand dryers:

- A strict product/component scope
- An extended product approach
- A technical and functional "systems" approach

Each of which will be discussed below.

3.1.1 Strict Product/Component scope

This approach considers the use of electric hand dryers under nominal load conditions. Under a strict product/component scope, the components within a hand dryer are considered from both a technical and an economical viewpoint.

Some components such as motors and fans are themselves regulated under the Ecodesign Framework Directive. For example, the current Ecodesign regulation for electric motors Commission Regulation (EU) No 4/2014 amends the previous Regulation (EC) No 640/2009 on electric motors with a power rating between 0.75 kW to 375 kW[93]. The aforementioned 2014 regulation was revised in October 2019 by Ecodesign Regulation (EU) 2019/1781 for electric motors[94]. The study team's analysis has found hand dryers that operate from 200W to 2750W, meaning that not all electric motors for hand dryers are included in the scope of the current regulation. However, note that most types of motors in hand dryers are now included within the scope of the 2019 revised electric motors Ecodesign regulation, with its expanded scope including motors from 120 W up to 100 kW. The 2019 revised regulation still excludes motors with brushes, those powered by Direct Current (DC) and also universal motors. Although AC brushless motors are found only in a minority of Category 1 hand dryers (i.e., the majority are AC motors with brushes). Hence, many hand dryer motors are still excluded from the Motors Ecodesign regulation, even in its updated form.

While the electric motors within hand dryers may be running efficiently, they may be incorporated within a suboptimal or potentially poorly designed hand dryer and, hence running an inefficient process. The same might be said for fans. The fans Ecodesign regulation 327/2011[95] covers fans operating with motors of a power rating ranging from 125W to 500kW. From the study team's market analysis conducted so far, all hand dryers would incorporate a fan within scope of this regulation.

From a technical perspective, a hand dryer is constituted of multiple components working together. These are displayed within Figure 3.1. The design of a hand dryer would usually also include components such as:

- fan impellers, which experience aerodynamic losses associated with the physical impeller shape;

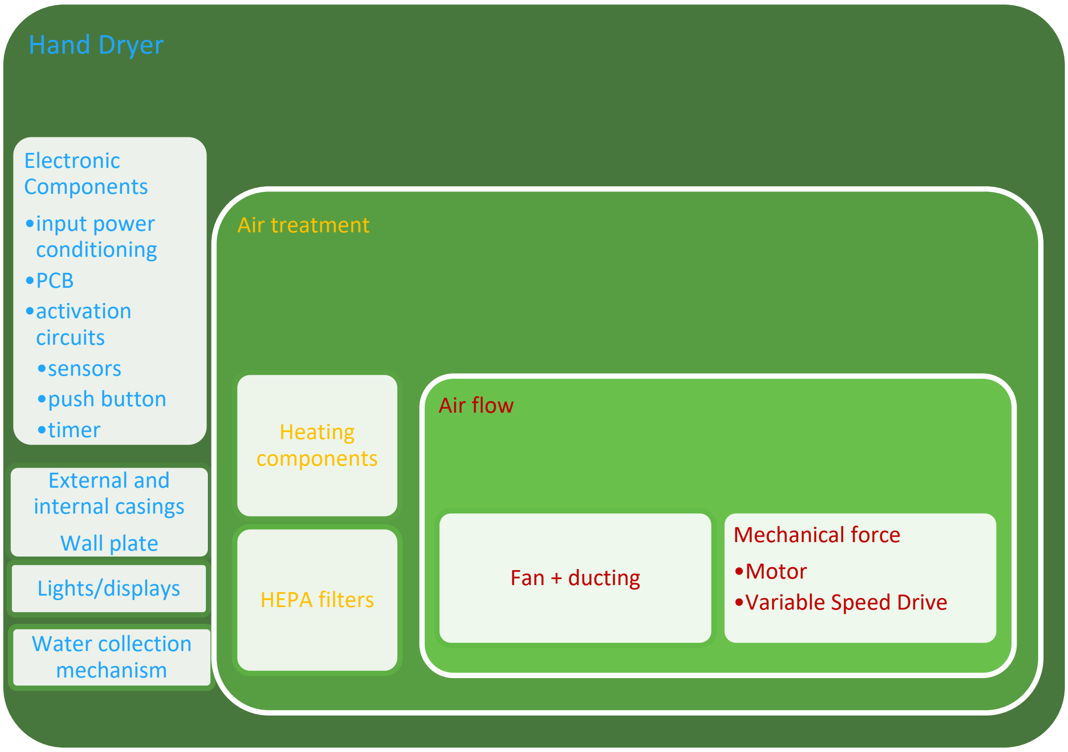
[93] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1521113260047&uri=CELEX:32014R0004

[94] https://ec.europa.eu/energy/sites/ener/files/documents/c-2019-2125_en_act_part1_v3.pdf

[95] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32011R0327

- a motor with a variable speed drive, which incurs losses in converting electricity to rotational mechanical energy[96]
- the physical shape of the air inlet and outlet ducting affects the airflow, causing losses through friction and turbulence;
- a heating element may be included in the airstream to encourage evaporation. Losses occur in both conversion of electricity to heat and transfer of heat to the airflow;
- a filter, potentially up to a high efficiency particulate air (HEPA) filter quality, may be included, where frictional losses occur through obstruction to the airflow;
- A sensor or a push button and timer which will affect the usage of the device, if it remains on unnecessarily; and
- Input power conditioning system, likely a capacitor to smoothen mains power.

Figure 3.1 Schematic of the components that may be contained within a hand dryer



All these components are subject to losses and can influence each other to increase (or reduce) the losses of the total product. As such, a review of the total hand dryer product, rather than a component review, is appropriate.

Concerning life cycle, for category 2, 3 and 4 hand dryers, the main method to extend these hand dryer lifespans is to repair (or more likely replace) the motor. For category 1 hand dryers, the motor runs at much slower speeds, which leads to substantially less wear. For these hand dryers, the sensor unit is the component with the smallest life expectancy. Not only does the motor last longer before needing repair, but it generally is easier to replace or repair (with a new carbon brush), which results in category 1 hand dryers having a longer life expectancy. Reviewing the hand dryer as a product allows consideration of design solutions to increase the life cycle of the product beyond its smallest life cycle component. Therefore, taking an extended product approach of hand dryers is more appropriate that considering the individual components.

[96] The revised Ecodesign regulation for electric motors now includes variable speed drives: https://ec.europa.eu/energy/sites/ener/files/documents/c-2019-2125_en_act_part1_v3.pdf

3.1.2 *Extended Product Approach*

This approach considers use of electric hand dryers under various operation modes, as well as frequency and characteristics of use (hours in-use, standby and off mode).

3.1.2.1 *Category specific average usage time*

Usage variability is affected by three components: the technology type which will affect how long a usage is required to dry hands, the user patience (who may leave before their hands are fully dry), and the hand dryer installation location, which affects the average number of uses per day

Table 3.1 contains data aggregated from a database of hand dryer product datasheets[97] and a study, from the University of Auckland, detailing the average usage time on hand dryers[98]. Hand Dryer datasheets report the "dry time" of a device, known as the time it takes for the hands to be dried. However, the hand dryers are usually equipped with a sensor which will switch off after hands are removed from the device. This means the hand dryer is on for the "dry time" and a supplementary "run on" time, reported to be 1.5 seconds on average by manufacturers.

The study from the University of Auckland determined that on average, hand dryer users would leave the hand dryer after 15.15 seconds of use, irrelevant of dryness achieved. If these hand dryers are operated via a sensor, we can estimate that the operation would finish 1.5 seconds after the hands have been removed, hence the hand dryer would be on for 16.65 seconds. This study having been conducted in 1997, it would in all likelihood have been conducted solely on category 1 hand dryers. However, we have made the assumption that consumer behaviour would be consistent regarding maximum time of use across all categories. From our database, we have gathered drying times which have been averaged. As some hand dryers are operated via a timer push button, rather than a sensor, these have been estimated to cycle at the length advertised in their product datasheet.

A weighted average was taken between the push-button and the sensor operated hand dryers for category 1. Manufacturer feedback has indicated that a total of 8% of category 1 hand dryers are operated via push button. The cycle length of push button dryers was estimated to be the cycle length on product datasheets. The cycle length for the sensor only hand dryers was taken from the collected product datasheets with a supplementary 1.5 seconds for "run-on" time, where drying time was capped at 16.65 seconds in line with the findings from the University of Auckland study. Category 2, 3 and 4 hand dryers are assumed to all be operated via a sensor.

Table 3.1 Average usage time for each hand dryer category

Hand dryer category	Average usage time (seconds/use)	Minimum usage time (seconds/use)	Maximum usage time (seconds/use)
Conventional single point dryer	17.17	11.5	45
High-speed single point dryer	14.57	9.5	30
High-speed multi-point dryer	14.09	11.5	17
High-speed trough style dryer	12.78	9.5	17

[97] Detailed further in Task 4

[98] Patrick, 1997: *Residual moisture determines the level of touch-contact-associated bacterial transfer following hand washing*

As expected, the high-speed hand dryers are faster than the conventional single point dryers. Time of use needs to be taken into account when considering the total energy consumption of the device and the customer experience.

Limited feedback on air taps has indicated that the technology has a comparable motor structure to category 2 hand dryers, and therefore is expected to take a slightly longer time to dry hands than category 2 dryers, due to the drying air needing to travel through a tube.

3.1.2.2 *Operating modes*

Hand dryers would usually function in two modes: on, with the air flowing, and standby, waiting for the sensor or button to activate the airflow. Manufacturers agree on these two modes. The length of time the hand dryer spends in each of the two modes will vary.

The average number of uses for a hand dryer will vary greatly according to location, as developed in Table 3.3. Nevertheless, manufacturer feedback indicates that on average, a hand dryer is estimated to be used **150** times a day. The values in Table 3.2 are determined from Table 3.1 and the average daily use. When the dryer is not in use, it is estimated to be in standby by default.

Table 3.2 Average hand dryer time spent on/ standby per day per category

Hand dryer category	Average time on (seconds/day)	Average time on standby (seconds/day)
Conventional single point dryer	2576	83824
High-speed single point dryer	2186	84214
High-speed multi-point dryer	2114	84286
High-speed trough style dryer	1917	84483

3.1.2.3 *User variables*

The user's hands, the wetting time and the employed mechanical action during drying represent further variables influencing the average length of time taken to achieve a required level of dryness[99] and the overall efficiency of the hand drying process. User hands will vary by size, shape, hair, gender, skin type, wrist creases and the presence of jewellery, amongst other factors. These are all variables that the measurement and test methods quoted in Task 1 have attempted to control.

3.1.2.4 *Location specific average daily usage*

Table 3.3 presents data aggregated from four manufacturer questionnaires and shows the average estimated usage of hand dryers per day, according to the location of the hand dryer.

[99] either quantified through a targeted remaining moisture content or through subjective user expectations

Table 3.3 Average number of uses/day for hand dryers, by location[100]

Hand dryer location	Average usage per day	Minimum usage per day	Maximum usage per day
Airports	2355	300	3000
Railway Stations	950	250	2000
Shopping, commercial and multiplexes	800	200	2000
Education Institutions	625	150	2500
Hospitals	550	100	2500
Hotels & Restaurants	166	25	500
Office Buildings[101]	163	50	300

The busiest locations are the ones with highest footfall and longest toilet/restroom opening times. Airports have the highest average number of uses. Office buildings and hotels are at the opposite end of the scale but are far more numerous than airports. The usage pattern affects the maintenance schedule (including costs) and lifetime of the device.

Lifetime expectancy is dependent on the wear of the motor, and hence usage. The duration of the warranty offered therefore varies with the manufacturer's assumption of usage.

The average number of uses per day by location reported in Table 3.3 were familiar to the authors of the Product Category Rules for preparing an Environmental Product Declaration for hand dryers[102]. UL however chose a lower average usage rate of 70 to 100 uses / day and 500 uses per week, which had been a previous assumption from an earlier proprietary hand dryer Life Cycle Assessment study.

3.1.3 Systems Approach

This approach would place electric hand-dryers within a larger technical and functional system (e.g. a public washroom) and would consider whether through controlling certain features of hand dryers the product can influence the environmental impacts of the larger system it operates within. Throughout the MEErP methodology we are considering what constitutes a defined energy-related product, within the context of the Ecodesign Framework Directive, as elaborated within Task 1. Therefore, other hand drying systems are out of scope of this study. No evidence has so far been collated to justify how controlling features of hand dryers would influence the environmental impact of the wider system, such as a public washroom. A systems approach is not considered adequate for this study.

The environmental impacts of hand dryers can best be considered from an extended product approach – which considers the environmental impacts of the hand dryer (and the aggregated performance of its components) within the context of varying usage

[100] A fifth manufacturer gave a usage per day of 200 uses for high traffic areas. Further values per building type were not provided as it was indicated that the usage would vary greatly even within the same building type.

[101] The use at weekends in offices will be zero, or close to zero. This could increase the prominence of electrical standby power consumption.

[102] http://bit.ly/29QtRXx

characteristics (e.g. by time and location). Task 4 will consider the hand dryer technology itself.

3.2 SYSTEM ASPECTS OF THE USE PHASE FOR ErPs WITH INDIRECT IMPACT

Electric hand dryers are considered a *direct* ErP, as the product uses energy during its use phase. The objective of the second sub-task of the MEErP is to consider *indirect* ErPs. An indirect ErP is a product which does not use energy in the use phase but has a significant impact on the energy consumption of products that are using energy within its system[103]. Examples of indirect ErPs include insulation or glazing. The system in which these indirect ErPs operate is the building envelope. As an example, more effective insulation will influence the energy consumption of the space heating within its wider system, namely the building envelope. However, hand dryers are a direct ErP, and as a result the focus of this report is not on indirect ErPs but follows the analysis performed and reported above in sub-task 3.1.

3.3 MAINTENANCE, REPAIRABILITY AND END OF LIFE BEHAVIOUR

The objective of the third sub-task is to collect and analyse example user requirements for maintenance, reparability and end-of-life aspects for hand dryers.

3.3.1 Product Use and Stock Life

The product use and stock life are defined within the MEErP as the time between purchase and disposal. This has been interpreted as the technical and economic lifetime of the product. The technical lifetime was defined in Task 2 as the time the device will last without need for repair. The economic lifetime is defined as the time the device will be used before it is replaced, which may be shortened from the technical lifetime by early replacement or extended through repair. Feedback from manufacturers on technical and economic lifetime varied and is summarised in Table 2.9.

Table 3.4 Technical and economic lifetime of hand dryers (in years)

Hand dryer category	Average Economic lifetime	Maximum Economic lifetime	Minimum Economic lifetime	Average Technical lifetime	Maximum Technical lifetime	Minimum Technical lifetime
Conventional single point	12.4	20	6	10.9	20	6
High speed single point	6.9	20	3	6	20	3
High Speed multi-point	6.9	10	3	6	10	3
High speed trough style	8.58	15	3	7.83	15	3

Some responses indicate that the economic lifetime is the same as the technical lifetime, suggesting the repair market as minor. Others quoted the economic lifetime as 1 – 2 times longer than the technical lifetime. One responder made a point about extending lifetime through product repair.

As reported in Task 2, it appears that the economic lifetime of hand dryers depends on the purchaser's disposition. Manufacturer feedback indicates that in the majority of cases, if a hand dryer breaks, it is likely to be replaced rather than repaired, as described in 2.6.5. However, circumstances might dictate that a hand dryer is replaced, before breakdown occurs, in favour of a higher performance model. Also, replacement could be a result of washroom renovation, in an effort to have a newer matching set of dryers.

[103] Chapter 3, Methodology for the Ecodesign of Energy related Products (MEErP) 2011 Part 1 Methods http://ec.europa.eu/growth/industry/sustainability/ecodesign_en

Manufacturers have also mentioned a separate business model where hand drying is provided as a service. In this context, if the product breaks down, the dryer will be removed and replaced to maintain the drying function for the user(s), and potentially be repaired offsite.

It is important to note that one of the most significant aspects determining the lifetime of a hand dryer is how many times it is operated per day. This is due to the wear on the motor being the most likely cause of failure of the hand dryer. As such, a dryer operating in an office could last a decade but only three months in a busy airport (please refer to Table 3.3).

To fit the usage patterns of specific locations, such as very frequently used airport bathrooms, manufactures will adapt the internal components of the hand dryer. In the case of a high usage location, the motor may be replaced for a higher quality motor which would last longer before it would wear and require repair.

Hand dryers design is oriented towards durability with covers consisting mainly of metal castings and construction grade materials. Product replacement/repair commonly occurs due to an internal part failing, rather than cover damage or aesthetics. However, depending on cover material, these can be degraded through chemical abrasion from exposure to cleaning products or harsh environments. Manufacturers will usually advise on the appropriate hand dryer cover for each environment, along with preferred cleaning products.

Regarding aesthetics, trough style hand dryers will require more maintenance through cleaning and tray emptying, in order to maintain appearance.

3.3.2 Good practice in product use

Feedback was amalgamated from nine manufacturers on good practice for operating hand dryers. The prevailing improvement to the life expectancy of the product was stated not to be from practice but simply from the design and the components used in the device – notably the motor. The other major factors on lifetime was clearly linked to usage rates, as previously mentioned.

Good practice descriptions for preventative maintenance is included for users within the installation manual. Keeping the product clear of dust is the main method to increase life expectancy. This is done mainly through filters, notably HEPA, which are expected to last from three months to a year before needing replacement, dependent on frequency of use and dustiness of the environment. For hand dryers without HEPA filters, manufacturers advise a design allowing for easy opening and cleaning of the product and for this to be done annually. Designs incorporating pressure sensors exist to advise users on the need for cleaning.

Specifically, for trough style hand dryers, good practice requires regular emptying and cleaning of the water reservoir. The emptying of the water tray is estimated to take approximately 30 seconds and is conducted daily by cleaning staff.

3.3.3 Poor practice in product use

Hand dryer installation have been reported to be relatively simple for wall mounted dryers, the requirements for which are a holding and securing mechanism to the wall and a connection to an electrical supply. Poor practice from the perspective of the dryer installation could be regarding not adequately securing the unit to the wall, placing the dryer too near water taps or not respecting the initialisation cycle time for the capacitive sensor antennae to calibrate. The main concern for installation however is regarding the surrounding electrical work, where rewiring is required to bring power to the facilities. If poorly executed, exposed wiring would become a danger to life. Installation of category 4, high speed trough style hands in dryers can also be problematic, when the device water drainage is poorly connected to the mains resulting in water spillage.

Air taps have specific requirements for installation, as the hand dryer needs to be installed under the counter. Piping for the hot air needs to be installed, requiring drilling a hole in the counter. Poor practice in installations can result in instances where the piping seal or general plumbing is poor, resulting in water splash onto the hand dryer under the counter, leading to an electrical short-circuit. The space under the counter must also allow for air flow and be dust free for the hand dryer to function properly.

Poor practice during usage involves maintenance, notably regarding the filters. Not placing a suitable filter can cause particulates to accelerate the deterioration of the interior with, for example, grime accumulating in the motor. If a HEPA filter is left in the hand dryer when it is saturated (requiring replacement), this will impede the air flow of the device, resulting in poor performance, and high probability of overheating the motor. Another form of malpractice is exposing a hand dryer to power washing without first shutting off the power to the dryer. This may trigger the automatic sensor and cause substantial water sucked in through the air intake, which is likely to destroy the electronics. For metal covers, adequate cleaning products are required in order to ensure that the device is not exposed to a corrosive cleaning product.

For category 4 high speed trough style hands in dryers, an extra concern during use is the water reservoir which can require regular emptying (if not connected to the mains). Failure to do so may result in water spillage. Not all category 4 dryers have a water revisor.

On a side note, vandalism is a potential risk for all hand dryer installations. Although some designs may be more robust (for example a metal cover), these are not designed assuming exposure to vandalism. Electrical connection is also kept away from public access, as although it allows for hand dryers to be turned off at the plug rather than left on standby, there is a risk that the cable/plug/switch are damaged by vandals.

3.3.4 Maintenance practices

Maintenance is deemed to be low cost for certain hand dryer categories. Feedback from a sample of six manufacturer questionnaires stated that the maintenance for "hands-under" dryers were only associated with the replacement and cleaning of HEPA filters. As detailed in Task 2, filters are not used in every hand dryer, and the task of replacing the filter is expected to take 10 minutes, with no specific qualification to undertake. On average, filters are changed once a year. This results in filter maintenance costs varying from €0 to €1.18.

Furthermore, feedback from the work compiling the Product Category Rules for preparing an Environmental Product Declaration for hand dryers, noted that the replacement of motor brushes was a maintenance practice (in older dryer designs). Motor brushes are used to conduct current between stationary wires and the rotating part of the motor, and they can degrade more quickly than other parts in the dryer. Most high-speed hand dryers use brushed motors, some also use long life motor brush designs. Motors are investigated further in Task 4, Technologies.

Maintenance costs for trough style "hands in" hand dryers are estimated to be higher as there is a need to regularly clean and empty the water tray. This is estimated by manufacturers to be done daily and take 30 seconds to complete, costing on average at €21.60 per year.

3.3.5 Reparability

As detailed in Task 2, Hand dryer failures are mainly due to a faulty sensor unit, a faulty PCB, motor breakdown or motor brush replacement. The motor and the motor brush failures are proportional to the usage of the hand dryer. This means the more daily cycles the hand dryer performs, the faster it will wear and require repair. Replacement of those pieces would then expect to double the life expectancy of the product. This work would involve 2 visits by an electrician, which along with the replacement parts was estimated in task 2 to cost €155 to €194.

To allow for reparability, two manufacturers indicated that they had spare parts available (up to 10 years after the last hand dryer was sold on the market).

Outside of the received manufacturer questionnaires, evidence was identified online from one hand dryer supplier who offered a "free" repair service[104]. The service charges for collection of the product requiring repair, the required components and re-delivery of the repaired product. The cost of labour to process the repair does not appear to be charged.

Other third-party services offer repair of hand dryers as well[105].

The reparability of products has been a significant consideration during the current phase of Ecodesign regulatory reviews. This includes obligations on manufacturers to a) design for disassembly, for example by avoiding glued/sealed joints b) provide distinct lists of spare parts and repair and maintenance Information to professional repairers and end users and c) make recovery of recyclable parts and materials straightforward.

3.3.6 Second-hand use

Amongst the feedback from the questionnaires, the six manufacturers who answered this question indicated that there was either "no real" second-hand market, or that they weren't aware of one. One pointed out that hand dryers could potentially last up to 20 years if adequately maintained but it was unheard of for hand dryers to be transferred to a new building.

An indication was given by one manufacturer that an artificial second-hand market may appear from resellers and contractors looking to offload surplus new hand dryers after an over-order. There is also evidence that manufacturers may resell a lesser quality product with an initial flaw or recuperate and repair products which failed warranty. These would be sold under diminished warranty conditions[106].

Outside of the received manufacturer questionnaires, evidence was identified online from a source called Terapeak[107], an e-commerce business, which provides market intelligence data to product sellers. Table 3.5 gathers data on the transactions listed as "sold" on eBay across the EU (only non-zero sales countries are reported in the table). It is important to keep in mind that there is a second-hand market outside of eBay, but this data is a good estimate on the size of the market.

Table 3.5 Transactions for used, pre-owned and refurbished hand dryers in the past 12 months[108]

Source	Country[109]	Volume	Average Sold Price (€)[110]
Hand dryer Ebay.co.uk	UK	2,887	154.82
Handtrockner on Ebay.de	Germany	39	95.93
Händetrockner on Ebay.de		268	237.34
Asciuga mani on ebay.it	Italy	1	15.22
Sèche main on ebay.fr	France	13	229.47
Sèche main on befr.ebay.be	Belgium	13	229.47

[104] https://www.intelligenthanddryers.com/blog/hand-dryer-spares-and-free-repairs

[105] https://fast-hand-dryers.co.uk/hand-dryer-repairs

[106] https://www.intelligenthanddryers.com/category/used-hand-dryers

[107]Source: Terapeak. https://www.terapeak.com/company/

[108] Source: Terapeak. https://www.terapeak.com/company/. [accessed 15/01/2019]

[109] The list of countries will be expanded to further quantify the instance of second hand purchase of hand dryers across the EU

[110] Source in £ converted to € using xe.com rate (1.11927 € / £) [accessed 18/06/2019]

Source	Country[109]	Volume	Average Sold Price (€)[110]
Händetrockner on ebay.at	Austria	268	237.29
Handtrockner on ebay.de	Luxembourg	39	154.79
	EU total	3528	166.52

The market size is calculated to be of €587,515. Reviewing sales numbers from Task 2, the total second-hand volume of hand dryers sold in the EU accounts for approximately 1% of total new product sales. This data therefore corroborates the manufacturer feedback that the second-hand market, although present, is negligible for the hand dryer industry.

3.3.7 Refurbishment

Refurbishment of hand dryers requires the collection of a hand dryer, its repair, and then further resell of the product. Amongst the manufacturers consulted, six indicated that they either didn't know of such a market or that its impact was very small. This was despite the indication that hand dryers are easy to repair and spare parts available. One manufacturer estimated that the cost of the motor and PCB can each be 10-25% of the product cost (excluding labour costs).

Evidence of refurbishment was identified online from one hand dryer supplier who sold used hand dryers that are either reconditioned or former demonstration units with diminished life expectancy[111].

3.3.8 Recycling, collection and disposal

Manufacturers agreed that the recycling of hand dryers in the EU occurred in accordance with the Waste Electrical and Electronic Equipment (WEEE) Directive (referred to under Task 1). From the manufacturers' perspective, under the WEEE Directive, they pay associations to recycle the hand dryers they place on the EU market. However, manufacturers stated they do not track how these associations deliver against their goals and what the representative final recycling rates are.

According to manufacturers, 80-90% of a hand dryer can be recycled, if these are adequately collected. Reviewing the bill of materials under Task 4, most of the materials would be recyclable and hence in line with the manufacturer feedback. However, the recycling rate for these materials is different in practice, for example, as is detailed in Task 4, the rate of recuperation and recycling for small plastics is near-zero in practice despite the material being recyclable. Current recycling processes would focus on recuperating electronics and shredding the rest of the product. The separation recuperates and recycles most of the metals, however other materials are not recuperated as effectively. It has been indicated that collection rates may change under the WEEE II directive, which has improved reporting structure and would allow for improved data collection[112].

3.4 LOCAL INFRASTRUCTURE (BARRIERS & OPPORTUNITIES)

The objective of the fourth sub-task is to analyse local infrastructure aspects – and consider the associated environmental impacts related to the use of electric hand dryers. These could include reliability and availability of energy, the availability and technical expertise of installers and the physical environment in which the product is installed. Of these, the final two are the most relevant.

[111] https://www.intelligenthanddryers.com/category/used-hand-dryers

[112] Commission implementation Regulation (EU) 2019/290, C/2019/1113

3.4.1 Electricity generation

The nature of the electricity generation fuel mix in the respective Member State will affect the environmental impacts from the use of the electric hand dryer. Consideration of the electricity generation fuel mix, including fossil fuels (coal, oil and gas), nuclear and renewables, will be part of the carbon factor attributed to the electricity generation. This will be considered later in the study within the modelling for Tasks 5, 6 and 7, where official EU statistics for carbon factors will be used.

3.4.2 Installers

Six of the manufacturers engaged in the study detailed how the installation of hand dryers did not require special training beyond the instructions found in the installation manual, for which a licensed electrician or qualified internal staff would be competent. Finding this expertise was not seen to be a barrier to installation. However, three manufacturers explained that they worked to provide clear installation instructions within their manuals and on their company website in order to facilitate effective installation of their hand dryers.

Regarding installation, one manufacturer indicated working with their distributors and the end user maintenance personnel. They have created a collection of detailed videos to educate installers (on installation and repair) on the required processes. It is suggested that these efforts are designed to improve the customer experience rather than due to necessity.

Routine maintenance of hand dryers such as cleaning, emptying water trays, etc. require no specific qualifications and can be performed by any member of the cleaning staff.

3.4.3 Physical Environment

The MEErP methodology requires consideration of the physical environment in which the product operates, specifically what the *possibilities for sharing* might be. Hand dryers are shared by washroom users. This sharing can be spread amongst more than 2000 users in a day, as indicated in Table 3.3. As such, this option has already been utilised.

The physical environment around the hand dryers can be affected by water residue onto the floor. For a hand dryer without a mechanism to collect water, increased maintenance of the facilities is required to clean the floors and walls from the water spray. However, a hand dryer with water collection would not require as much work from cleaning staff on the floors but would require the water tray to be emptied regularly (or another water disposal system: evaporators, water drainage mains connection, etc.).

4 INTRODUCTION TO TASK 4 TECHNOLOGIES

The task 4 report for the Ecodesign preparatory study on electric hand dryers is divided into three main sections. Sub-task 4.1 provides a technical product description, including an explanation of how electric hand dryers work. Sub-task 4.2 presents the results from the quantitative data collection covering the production, distribution and end-of-life phases of electric hand dryers, including the Bill of Materials (BoM). Task 4 concludes with recommendations for the base cases to be taken forward during the Task 5 environmental and economic modelling of electric hand dryers.

The data presented in task 4 originates from three main sources. For sub-task 4.1, data originates from the submission of product technical specifications from manufacturers and suppliers via the Task 2 questionnaire and the authors' own internet research. For sub-task 4.2, data is provided via submission of example BoMs directly from manufacturers. From these sources the authors have compiled a data set of 106 models from 14 product suppliers, grouped according to the product category definitions set out in the Task 1 report. The data set is comprised of 47 conventional single point (hands under) dryers, 30 high speed single point (hands under) dryers, 6 high speed multi-point (hand under) dryers, 19 high speed "trough style (hands in) dryers and 4 air taps.

4.1 TECHNICAL PRODUCT DESCRIPTION

Sub-task 4.1 provides a technical product description of electric hand dryers. This section includes an explanation of the fundamental engineering principles underpinning the functioning of electric hand dryers as well as the identification of key components (e.g. motor) and features (e.g. controls). This sub-task also includes identification of standard improvement options for electric hand dryers and an assessment of what might represent Best Available Technology (BAT) – both in terms of components and features. Sub-task 4.1 concludes with a discussion on possible Best Not Yet Available Technology (BNAT) for electric hand dryers.

4.1.1 Existing Products

4.1.1.1 *Basic steps of the hand drying process*

Hand dryers are essentially fan systems. As such, all hand dryers perform their function through the same basic steps:

1. **Activation from standby** – either manually, by means of a push button, or automatically, by means of a sensor.
2. **Draw air in** – by means of a fan motor via one or more inlets and ducting. Incoming air may be cleaned by means of a filter and, once inside, may be warmed by means of a heating element, the motor or through compression in order to encourage evaporation of water from the user's hands.
3. **Blow air out** – by means of the same fan motor via ducting and one or more outlets onto the user's wet hands. Water removed by the scraping effect of the moving air, rather than by evaporation, may be collected in a tank or drained directly to a wastewater pipe.
4. **Return to standby** – automatically, by means of either a sensor or a timer.

The components within a hand dryer are shown in Figure 4.1.

Figure 4.1 Schematic of components that may be contained within a hand dryer

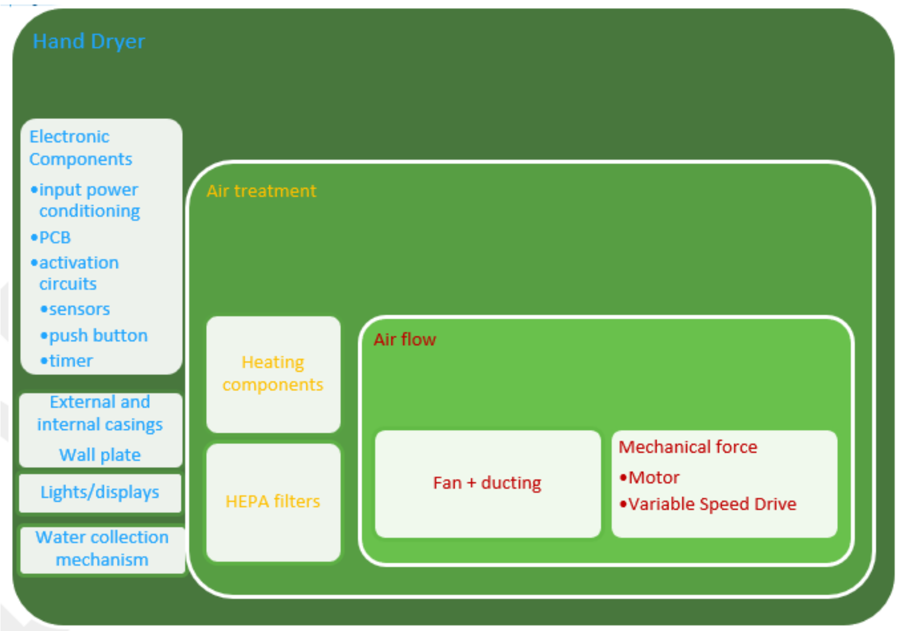


Figure 4.2 shows the flow of air (in pale blue) through a hand dryer, in this case a high-speed trough style (hands-in) dryer.

Figure 4.2 Flow of air through a hand dryer

With this type, the air (1) is drawn in through inlets at the base, passes through a filter (2), circulates around the dryer's electronics (3), fan motor (4) and ducting (5), and is expelled into the outlet drying cavities (6 and 7).

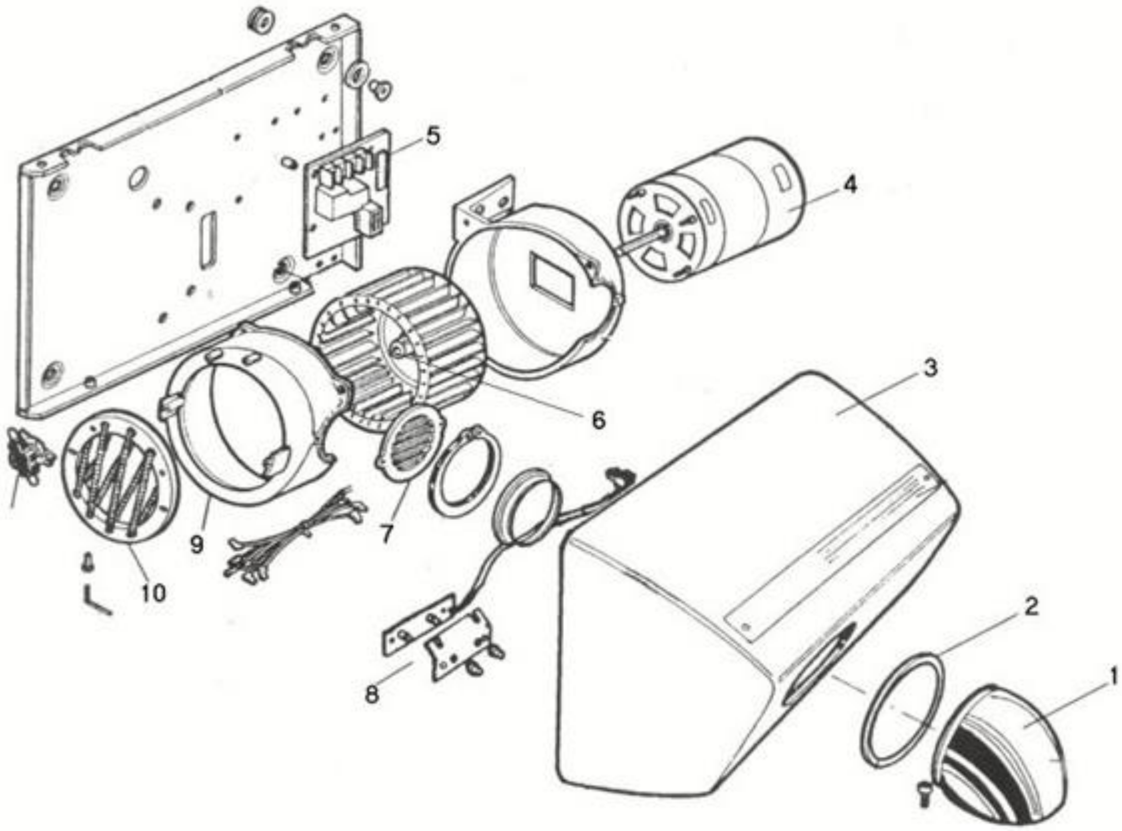
Source: Dyson

4.1.1.2 *Hand Dryer Categories*

Conventional Single Point (Hands Under) Dryer

Figure 4.3 shows the parts within a conventional, single-point, "hands under" dryer. As it typically contains a heating element, this type of dryer dries hands through evaporation of water as well as through the scraping effect of the air flow.

Figure 4.3 Exploded view of a conventional single-point hands under dryer



Key

(1) Nozzle; (2) External ring; (3) Casing; (4) Motor; (5) Circuit board; (6) Fan impeller; (7) Grill outlet; (8) Sensor assembly; (9) Fan housing; (10) Heating element

Source: http://www.inventex.com/10-parts-for-hand-dryers.html

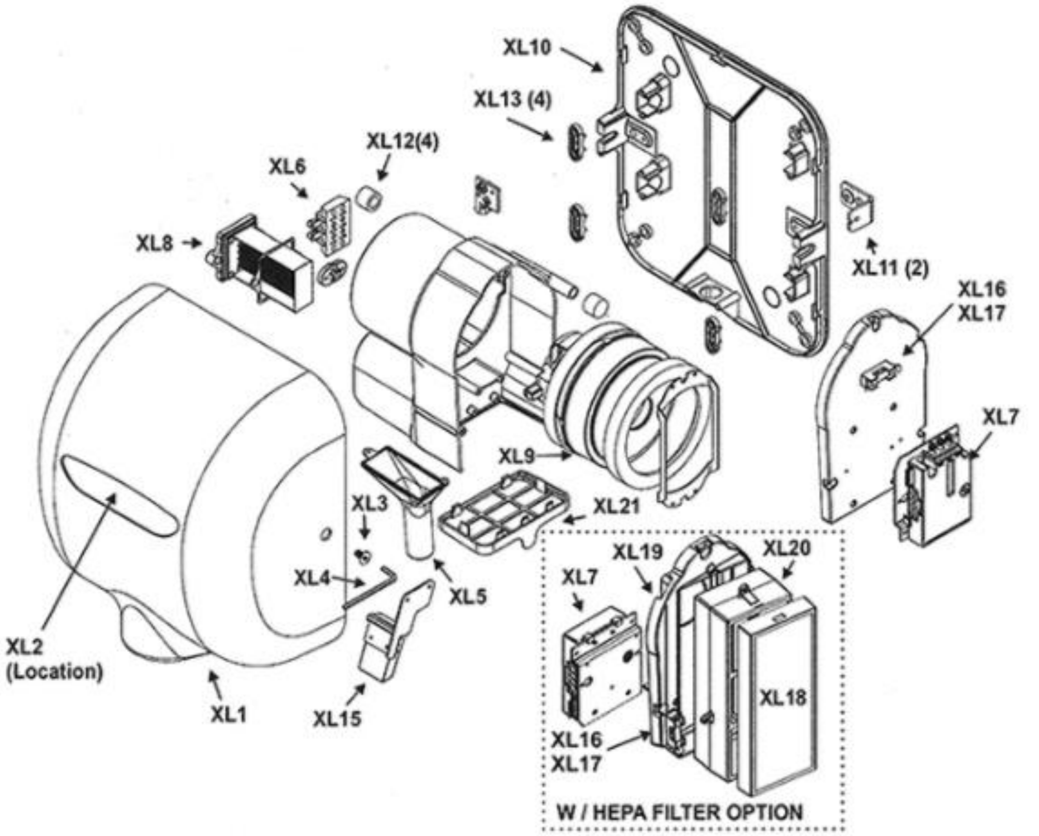
The energy-using parts are the motor, heating element, timer (which is part of the circuit board) and the user-detecting sensor (if present). The inlet, fan impeller, ducting and outlet also affect the energy efficiency of the hand dryer and the noise that it emits.

Sources of noise are the airflow and the motor (especially if it is a brushed motor). As air speed is lower than for high speed hand dryers, the air flow is quieter.

High Speed (Hands Under) Dryer

Figure 4.4 shows the parts within a high-speed, single-point, "hands under" dryer. This type of dryer dries hands either exclusively through the scraping effect of the air flow or, if it contains a heating element, through evaporation of water as well.

Figure 4.4 Exploded view of a high-speed (single-point) hands-under dryer



Key

(XL1) Cover; (XL2) Nameplate; (XL3) Tamperproof bolt; (XL4) Tamperproof wrench;

(XL5) Air outlet; (XL6) Terminal block; (XL7) Control assembly and sensor;

(XL8) Heating element assembly; (XL9) Motor; (XL10) Base plate assembly;

(XL11) Cover mounting brackets; (XL12) Housing grommet; (XL13) Housing retainer

(XL15) Sensor; (XL16) Fuse holder; (XL17) Fuse; (XL18) HEPA pre-filter;

(XL19) HEPA filter adapter; (XL20) HEPA filter; (XL21) Pre-filter

Source: XLERATOR Manual[113],

The energy-using parts are the motor, heating element (if present), timer (which is part of the circuit board), user-detecting sensor, and any lights and displays. The inlet, fan impeller, ducting and outlet also affect the energy efficiency of the hand dryer and the noise that it emits. Sources of noise are the motor and the airflow itself.

113 available at https://www.exceldryer.com/wp-content/uploads/2018/07/XLERATOR-XLERATORecoManual_English.pdf

High Speed Trough Style (Hands In) Dryer

Figure 4.2 in Section 4.1.1.1 shows the main parts within a high-speed, trough style, "hands in" dryer. Some models have a tray at the base of the dryer which collects water removed from the users' hands and requires emptying when full. Other models drain this water directly into the mains.

The energy-using parts are the motor, heating element (if present), any mechanism for evaporating water collected in the tray (if present) at the base of the hand dryer, the timer, sensors for detecting a user's hands or water at a certain level in the tray (if present), and any lights, displays and alarms, e.g., for indicating when the filter is clogged or the water tray is full.

The inlet, fan impeller, ducting and outlet also affect the energy efficiency of the hand dryer and the noise that it emits. Sources of noise are the motor and the airflow itself.

Air Tap

Figure 4.5 shows the flow of air through an air-tap hand dryer.

Figure 4.5 Overview of an air-tap hand dryer

The air (1) is drawn in, passes through a filter (2), circulates around the dryer's electronics (3), fan motor (4) and ducting (5), and is expelled via the blade outlets (6 & 7).

The energy-using parts are the motor, heating element (if present), the timer, sensors for detecting a user's hands, and any lights, displays and alarms, e.g. for indicating when the filter is clogged.

The inlet, fan impeller, ducting and outlet also affect the energy efficiency of the hand dryer and the noise that it emits. Sources of noise are the motor (especially if is a brushed motor) and the airflow itself.

Source: Dyson

4.1.1.3 Key components

These components are found in all hand dryers, regardless of type.

Activation controls

Hand dryers are activated from, and returned to, standby by one of four means:

- **Push button on/off**
  A user presses a button to send a signal via a relay or a motor controller to activate the hand dryer and presses the button again to send a signal this time to deactivate the hand dryer[114].
- **Push button and timer**
  A user presses a button to send a signal to the motor controller to activate the hand dryer. After a pre-set time, an internal time delay relay disconnects the motor, or an internal timer sends a signal to the motor controller to return the dryer to standby

  Note that "run-on time" can result when the user withdraws their hands but the pre-set time has not elapsed. This results in the hand dryer continuing to operate and consume energy.
- **Sensor and timer**
  The hand dryer activates automatically when an infrared sensor detects the user's hands being placed within the drying cavity (hands-in dryer) or under the air outlet (other dryer types) and sends a signal to the motor controller. After a pre-set time, an internal timer sends a signal to the motor controller to return the dryer to standby. Detection time may be as short as one second or one-tenth of one second.
- **Sensor only**
  The hand dryer activates automatically when an infrared sensor detects the user's hands being placed within the drying cavity (hands-in dryer) or under the air outlet (other dryer types) and sends a signal to the motor controller. The hand dryer returns to standby automatically when the sensor[115] detects the user's hands have been removed from the air cavity, or from under the air outlet, and sends a signal to the motor controller. Detection time may be as short as one second or one-tenth of one second.

  Note that "run-on time" can result when the user withdraws their hands but the sensor has not instructed the dryer to stop immediately. This results in the hand dryer continuing to operate and consume energy. Feedback indicates manufacturers provide a few seconds minimum run-on time after the sensor has detected hands under, to allow for those hands to go momentarily out of range without stopping the dryer.

Figure 4.6 shows two views of an optical sensor for an Excel XLERATOR hand dryer. The upper view is of the body of the sensor and its wiring (which connects it to the motor controller via a printed circuit board); the lower view is of the sensor face.

[114] https://www.hygienesuppliesdirect.com/products/prod132947-jet-flow-brushed-steel-manual

[115] Note that stakeholder feedback has identified other sensor types besides infrared, such as capacitive sensors

Figure 4.6 Example of an optical sensor

Source: www.restroomdirect.com[116]

The different means may be used in combination with each other. For example, a timer may be used as a back up to a sensor to ensure that the hand dryer cannot be left activated indefinitely in the event of vandalism.

Assuming that users who need to activate the hand dryer more than once to dry their hands completely will do so, the "sensor only" means will be more energy efficient than the two timer-based means. "Push button and timer" is a more energy-efficient means than "sensor and timer", but only marginally so since the power consumption of the sensor circuit is small – and, like the power consumption of a timer circuit, is part of the standby power consumption (see section 0). Manufacturers' estimates of power consumption from the sensor ranged from 0.05W to 0.48W.

Table 4.1 shows the distribution of sensor and push buttons among hand dryers in the market research data received by ICF. The models which exist with a push button are made available to customers as either push button or sensor operated. Manufacturer feedback indicates that approximately 35% of customers choose the push button operation.

Table 4.1 Type of control – sensor and push button

	Sensor	Push button	Sample size
Conventional single point (hands under) dryer[117]	100%	23%	45
High speed single point (hands under) dryer	100%	0%	30
High speed multi-point (hands under) dryer	100%	0%	6
High speed trough style (hands in) dryer	100%	0%	19
Air Tap	100%	0%	4
Total	100%	10%	104

Source: Manufacturer's Technical Specifications

[116] https://www.restroomdirect.com/excel-dryer-xlerator-part-XL-15.aspx

[117] There are models available with sensor and push button

Fan motor

A fan consists of a bladed impeller[118] housed in a casing[119]. In hand dryers, a fan motor consists of a fan connected directly to the shaft of an electric motor. Figure 4.7 shows two fan motors: for a Dyson Air Tap hand dryer (axial air flow) and for a World Dryer conventional hands-under dryer (centrifugal air flow).

Figure 4.7 Examples of fan motors

Source Dyson and www.restroom.com[120]

Although hand dryers are powered by mains alternating current (AC) electricity, the motors within them can run on AC, direct current (DC, obtained by rectifying the input current) or both (in the case of Universal motors). These motors can either be "brushed", meaning that the current to the rotor is delivered through a rotating mechanism that contains carbon brushes, or be "brushless", meaning that the current to the rotor is switched electronically.

Using the electric motor categorisation used in the Ecodesign Lot 11 Motors preparatory study, the four types of motor found in hand dryers are Brushed DC, Brushless DC, Induction AC, and Universal (which contain brushes). Their relative advantages and disadvantages are summarised in Table 4.2.

Brushed motors are simpler and cheaper to make than brushless motors. Due to the wearing out of their brushes through operation, brushed motors are less efficient, are noisier, have shorter lives and are less reliable than brushless motors. Furthermore, the wearing out of the brushes can cause contamination of the outgoing airflow with carbon particulates.

Table 4.2 Relative advantages and disadvantages of motors used in hand dryers

	Brushed DC[121]	**Brushless DC**	**Induction AC**	**Universal brushed motor**
Complexity	Medium	High	Medium	Medium
Reliability	Medium	High	High	Medium
Efficiency	Medium	High	Medium	Medium

[118] The impeller may also be called the rotor or the wheel.

[119] Adapted from definition of fan in the Lot 11 Preparatory Study on fans

[120] https://www.restroomdirect.com/Nova-4-Nova-5-Blower-Motor-Assy.aspx

[121] Note that many manufacturers fed back about the advantages of brushed DC motors compared with brushless DC motors. The majority of comments were prefaced with "quality" brushed DC motors. In conclusion, there appears to be a breadth of quality amongst brushed DC motors on the market.

	Brushed DC[121]	Brushless DC	Induction AC	Universal brushed motor
Electromagnetic interference	High	Low	Low	High
Initial cost	Low to Medium	High	Low to Medium	Medium

Source: ICF, after Lot 11 Preparatory Study

Notwithstanding the relative advantages of brushless motors over brushed motors, the lower initial cost (price) of the latter means that they are often preferred to brushless motors, as can be seen in Table 4.3, which shows the prevalence of brushed and brushless hand dryers in the market research data received by ICF.

Table 4.3 Relative prevalence of brushed and brushless motors in hand dryers

	Brushed motor	Brushless motor	Sample size
Conventional single point (hands under) dryer	67%	33%	30
High speed single point (hands under) dryer	86%	14%	14
High speed multi-point (hands under) dryer	60%	40%	5
High speed trough style (hands in) dryer	53%	47%	19
Air Tap	67%	33%	3
Total	66%	34%	71

Source: Manufacturer's Technical Specifications

Table 4.4 shows the prevalence of each of the four types of motor used in hand dryers reported in the market research data received by ICF.

Table 4.4 Relative prevalence of motor types in hand dryers

	Brushed DC	Brushless DC	Induction AC	Universal brushed motor	Sample size
Conventional single point (hands under) dryer	17%	19%	11%	47%	36
High speed single point (hands under) dryer	12%	6%	0%	82%	17
High speed multi-point (hands under) dryer	40%	40%	0%	20%	5
High speed trough style (hands in) dryer	17%	44%	0%	39%	18
Air Tap	0%	33%	0%	67%	3
Total	16%	25%	5%	52%	79

Source: Manufacturer's Technical Specifications

Manufacturers were asked to list and prioritise the factors they consider in selecting a motor for their dryer. A range of different responses were received, with the following key factors identified: energy efficiency (higher speed, shorter drying time), application/location of the dryer, durability, noise and safety. Priorities varied but energy efficiency was consistently identified as well as the intended location of the dryer – which is related to the dryer's expected durability (i.e. in high usage environments such as airports a brushed motor might not be as durable). Noise was a common factor, but it was recognised this can also be influenced by optimal design of the inner airflow.

Some motors have a 'soft start' mechanism hard coded into the motor's programming. This affects the initial fraction of a second to control the ramp up of the motor and has the benefit of improving the motor's lifetime.

An electronic system known as a Variable Speed Drive (VSD) can be used to control the torque and speed of the motor (and thus its acceleration, deceleration and as a result, noise level) by regulating the frequency and voltage applied to it.

Fans are categorised according to the direction in which they blow air:

- **Axial** fans blow air in a direction parallel to the fan motor shaft;
- **Centrifugal** fans blow air in a direction perpendicular to the fan motor shaft;
- **Mixed** fans blow air in a direction between perpendicular and parallel to the fan motor shaft.

Fan selection is a complex process that depends on a good understanding of system operating requirements and conditions such as air flow rates, temperatures and pressures, airstream humidity and particulate content, layout and space constraints, and other considerations such as cost, operating life, materials, and maintenance, as well as efficiency. This means that comparing categories of fan solely in terms of their efficiency without consider the system is of limited use. It also means that a highly efficient fan system is not merely a system with an energy efficient motor[122]. A "systems approach" is required when choosing a fan, or indeed when designing a hand dryer. Hence, fans of all three categories may be found in hand dryers.

Manufacturers were asked to identify the factors they consider when selecting a fan for their dryer. Responses were consistent: manufacturers select the fan type which works most effectively with the type/power of the motor and the intended features and type of dryer. For example, with conventional single point dryers, axial fans can be used which deliver low noise and high air volume. For high-speed dryers, centrifugal fans can be used which deliver high air speed and pressure.

Care should be taken not to oversize the fan motor as, although this is a precaution against underperformance, this leads to excessive energy consumption and a set of associated operating problems including excess noise and vibrations and poor reliability. Similarly, the fan motor should be operated at its best efficiency point to the extent possible. It should also be remembered that the relationship between fan speed and airflow rate is linear, whereas the relationship between fan speed and power consumption is cubed[123].

Other key components

These components include air inlets, ducting and outlets; the printed circuit board and wiring; the casing, wall plate, and fixtures. None of these are energy-using components, but some can and should be designed in ways to minimise noise.

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[122] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Improving Fan System Performance: A Sourcebook for Industry.* Washington DC, 2003.

[123] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Improving Fan System Performance: A Sourcebook for Industry.* Washington DC, 2003.

Air inlets, ducting and outlets should be designed to ease airflow, prevent leakage, attenuate noise, and minimise the work that the fan motor needs to do. To this end, the ducting should be as straight, smooth and wide as possible, but spatial constraints may necessitate the use of devices such as airflow straighteners and turning vanes. Other methods for reducing noise include insulating the ducting and mounting the dryer on rubber or a spring isolator[124].

4.1.1.4 *Features*

The proceeding section presents components which are not found in all hand dryers. These features include air speed control, heating technologies and control, filters and other air purifiers, antimicrobial technologies, lights, displays and sound alarms, drip trays and evaporation devices and Bluetooth connectivity.

Air speed control

In general terms, higher air flow results in faster drying, more noise and greater energy consumption by the motor in the hand dryer.

Contemporary hand dryers commonly have two fixed speed settings (High/Low) or three (High/Medium/Low) to enable adjustment of the air speed according to local need. For example, air speed might be set to High in "high-traffic" restrooms, such as airport restrooms, or to Low in environments where quiet is needed, such as restrooms in schools and hospitals.

Typically, changing the air speed is performed by a maintenance operative by means of a switch control that is intentionally inaccessible to users.

An adjustable resistor can be retrofitted to certain models of hand dryers. This enables air speed (and noise) to be set precisely to a (lower) level chosen by a maintenance operative[125] rather than to a pre-set level.

Table 4.5 shows the prevalence of fixed speed settings among the hand dryers in the market research data received by ICF.

Table 4.5 Prevalence of air speed controls in hand dryers

	Air Speed Controls	Sample size
Conventional single point (hands under) dryer	7%	45
High speed single point (hands under) dryer	43%	30
High speed multi-point (hands under) dryer	17%	6
High speed trough style (hands in) dryer	32%	19
Air Tap	50%	4
Total	24%	104

Source: Manufacturer's Technical Specifications

Manufacturers were asked how they control air speed within their dryers. In line with the data in Table 4.5 some manufacturers stated their models did not control air speed. Other manufacturers confirmed they use variable speed drives (VSDs) to control air

[124] ibid.

[125] https://www.restroomdirect.com/pdf/Excel%20Dryer/Xlerator%20Series/Speed%20Control%20Stock%20No.%2040112%20and%2040113%20Instructions-02-07-14.pdf

speed, notably in high speed trough style dryers, and similarly VR-dimmers within high speed single point dryers. Manufacturers confirmed the benefit of air speed control allows the user to optimise the balance between energy consumption and noise for the dryer's particular location/application.

Heating technologies and controls

Most hand dryers make use of heating technologies to encourage drying through evaporation. Regardless of hand dryer type, the heating technology is typically a coiled nichrome heating element which heats up when an electric current is passed through it (Figure 4.8). Other technologies include compression of the air drawn into the (high-speed, hands-under) hand dryer and using waste heat from the motor to pre-heat air drawn in. A further example of heat recovery is used in the InstaDry conventional single point hands under dryer from Bobrick. The motor, whilst working, dissipates its heat and heats up the air stream without consuming energy from a heating element.

Figure 4.8 Example of a heating element

Source: www.restroomdirect.com[126]

Although it reduces drying times, **heating represents a very significant consumption of energy**. According to market research data received by ICF, maximum power demand from hand dryers that contain heaters ranges from 800 to 2750W whereas maximum power demand from hand dryers that do not contain heaters ranges from 200 to 1800W. For this reason, heaters are less prevalent among newer types of hand dryer, which rely on a high-speed flow of air to blow water from the user's hands, than they are among conventional hand dryers.

Manufacturers validated the research by confirming that conventional dryers have a power demand ranging from 950 to 2100W, and up to 500W for high-speed dryers.

In general terms, the warmer the air flow, the faster the drying time, but the greater the energy consumed by the heating element. This is the case for conventional hand dryers. For high-speed hand dryers, manufacturers note that warm air flow is unlikely to have a significant effect on drying efficiency with its prime benefit being the addition of comfort. High-speed and air-tap hand dryers that incorporate heating elements commonly incorporate a heating control as well. Typically, this is an On/Off switch, accessible only to maintenance operatives, that enables the heating element to be switched off when the ambient temperature is warm and on when it is cold (see below for automatic ambient air temperature sensors). Hand dryers can also feature a thermostat, which is a safety control to prevent the overheating of the dryer.

[126] https://www.restroomdirect.com/american-dryer-part-dr218.aspx

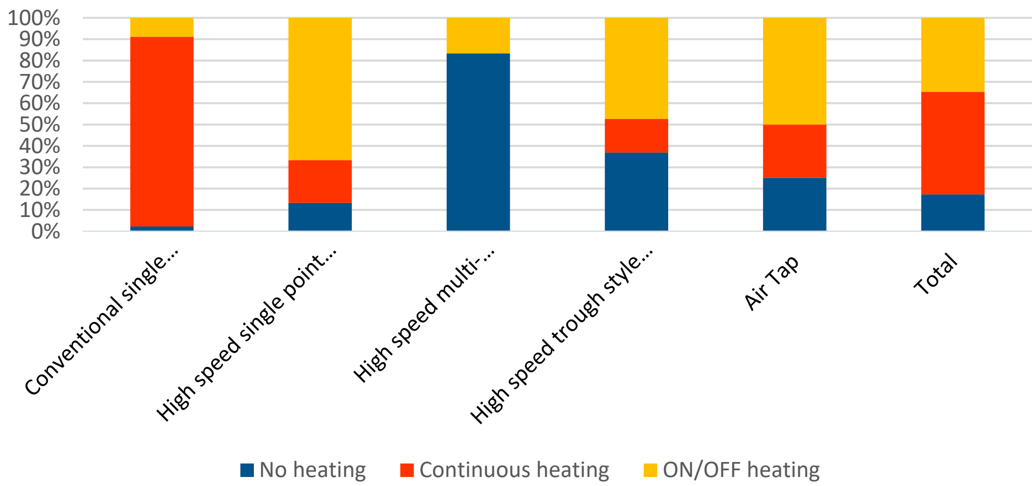
Table 4.6 and Figure 4.9 show the prevalence of heating technologies and (On/Off) controls among the hand dryers in the market research data received by ICF.

Table 4.6 Prevalence of heating features in hand dryers (in absolute numbers)

	Heating element	On/Off heating	Heat recovery from motor	Sample size
Conventional single point (hands under) dryer	44	4	1	46
High speed single point (hands under) dryer	26	20	0	30
High speed multi-point (hands under) dryer	1	1	0	6
High speed trough style (hands in) dryer	11	9	2	19
Air Tap	3	2	0	4
Total	85	36	3	105

Source: Manufacturer's Technical Specifications

Figure 4.9 Prevalence of heating features in hand dryers (as a % within each type)



Source: Manufacturer's Technical Specifications

Furthermore, at least two hand dryer models have been identified which feature an automatic ambient air temperature sensor. The temperature sensor detects when the ambient air temperature reaches a certain temperature and automatically switches off the warm air function within the dryer, ensuring that the model operates with no heat. The models featuring this sensor are the Kangarillo 2 from Handy Dryer[127] and the HD-1 from Ffuuss[128]. The ambient air temperature threshold for the HD-1 is 35C.

[127] Handy Dryer's Kangarillo 2, https://www.handydryers.co.uk/documents/Kangarillo%202%20Data%20Sheet.pdf

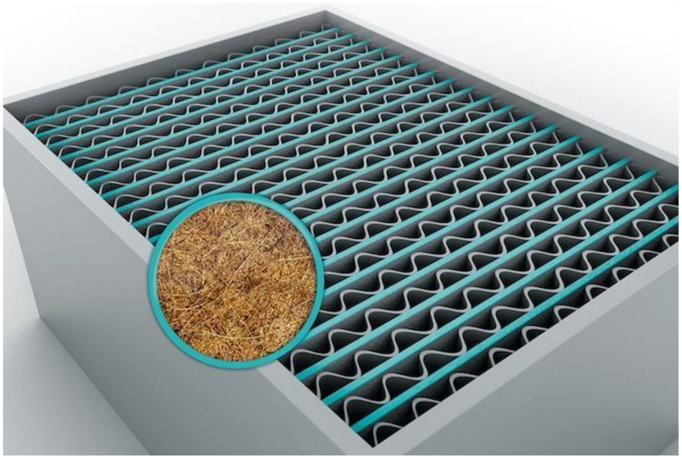
[128]

Filters and other air purifiers

Most hand dryers, except most models of the conventional single-point "hands under" type, are equipped with an air filter placed over the inlet to the hand dryer[129]. This filter removes particulates from the air as it enters the hand dryer. Trapping particulates is important for reducing wear and tear on the hand dryer, especially the fan motor, as well as for preventing it from expelling unhygienic particulates through the air outlet – which pre-existed in the restroom – such as microbes.

The filter consists of a plastic mounting that contains a very fine mesh made of fibreglass or other material. Most filters used in hand dryers are High Efficiency Particulate Air (HEPA) filters. To be classed as such according to the ISO 29463 family of standards, the filter must remove 99.7% of particles as small as 0.3 microns in diameter. Such particles include microbes (i.e., bacteria, viruses, mould and other fungi, yeasts, algae, etc.) as well as dust and other inanimate particles. Coarser filters are used in some hand dryers. These are capable of trapping particles larger than 0.5 microns, such as dust and other inanimate particles.

Figure 4.10 Example of a HEPA filter



Source: https://www.handdryerffuuss.com/en/filtro-hepa/

Table 4.7 shows the prevalence of filters among the hand dryers in the market research data received by ICF.

Table 4.7 Prevalence of air filters in hand dryers

Hand dryer category	HEPA filter	Non-HEPA filter	No filter	Sample Size
Conventional single point (hands under) dryer	0%	0%	100%	47
High speed single point (hands under) dryer	27%	33%	40%	30
High speed multi-point (hands under) dryer	63%	0%	38%	8
High speed trough style (hands in) dryer	86%	0%	14%	21
Air Tap	25%	75%	0%	4

Source: Manufacturer's Technical Specifications

[129] This is certainly not to say that those models without air filters are unhygienic. Filters can improve user confidence in the dryer.

Manufacturers were asked about energy loss through use of a filter and how often filters should be cleaned and replaced and whether the design of the dryer influences how often a filter could be replaced. Manufacturers noted that the filter itself will not impact on energy consumption, but if it is dirty, it will reduce the incoming air volume and reduce the drying efficiency of the dryer. The frequency of filter replacement is dependent on the environment (e.g. cleanliness) and usage. Estimates ranged from 6 to 18 months. Manufacturers noted that design could influence the frequency of filter replacement but that these considerations need to be balanced with designing an aesthetic and secure dryer. For instance, installing a filter outside of the cover, would make it easier to replace. However, this could affect the overall aesthetics of the dryer and without using secure screws could be removed, theoretically. Placing the filter inside of the cover improves aesthetics and security but adds a layer of complexity in its replacement.

Some hand dryers equipped with a filter may also be equipped with a sensor that detects (significant) clogging of the filter and sends a signal to the display panel or to an audio alarm. Separately, a hand dryer may incorporate an odour-neutralising technology based on adsorption within a carbon filter or on ionization. Manufacturers did not declare the electricity consumption of the filter sensor.

Antimicrobial technologies

Even if cleaned regularly, restrooms are places in which microbes (i.e., bacteria, viruses, mould and other fungi, yeasts, algae, etc.) can potentially flourish and be spread by hand dryers. Antimicrobial technologies are particularly important in hygiene-sensitive environments such as hospitals and clinics.

Antimicrobial coatings inhibit microbial growth on hand dryer surfaces. They are commonly based on silver ions, but not necessarily. UV lamps kill microbes in the air entering the hand dryer (when it is on standby). As discussed above, filters remove microbes from the air (when it is in use). Of these, only the UV lamp uses energy. The manufacturer of the hand dryer featuring the UVC lamp, the Sterillo by Handy Dryers[130], confirmed the electricity consumption of the lamp is 9W. The lamp typically requires replacement every 12-18 months.

Manufacturers noted that the effectiveness of silver ions has an expiration date. Once in contact with microbes, the silver ions begin to lose their effectiveness until such point as the ion’s effectiveness ceases.

Table 4.8 shows the prevalence of antimicrobial coatings among the hand dryers in the market research data received by ICF.

Table 4.8 Prevalence of antimicrobial coatings in hand dryers

	Share of Hand dryers with Antimicrobial coating	Sample size
Conventional single point (hands under) dryer	2%	45
High speed single point (hands under) dryer	33%	30
High speed multi-point (hands under) dryer	33%	6
High speed trough style (hands in) dryer	68%	19
Air Tap	0%	4
Total	25%	104

130 https://www.handydryers.co.uk/high-speed-dryers/sterillo-odour-control-hand-1175379.html

Source: Manufacturer's Technical Specifications

Lights, sound alarms and displays

Hand dryers may be equipped with an array of lights, an LCD display, and/or a sound alarm that are activated when a maintenance issue arises. Issues include a clogged filer needing to be cleaned, or a water tray needing to be emptied, or a malfunction.

Manufacturers confirmed the electricity consumption of the indicator lights ranged from 0.01W to 0.05W.

Less commonly, hand dryers may also be equipped with lights for non-maintenance purposes, such as aesthetics, or a display screen[131] for advertising or entertainment purposes[132]. Since this kind of screen exists to hold users' attention, it is reasonable to assume that it might cause users to linger for longer than the time required to dry their hands or even to reactivate the drying cycle unnecessarily. The electricity consumption of the screen has been declared by the manufacturer as 2W in on-mode, with the screen entering into a sleep mode when not in use (time to sleep mode was not declared).

Drip trays and associated evaporation devices

High-speed trough style "hands in" hand dryers may be equipped with a tray at the base of the dryer that collects (some of the) drips of water that fall from the user's hands. Unlike models that drain these drips to wastewater piping or that do not collect these drips at all, these hand dryers require their trays to be emptied regularly by a maintenance operative or, as is the case in one mode, a heater that evaporates the collected water away. The evaporator uses a 50W heater and consumes between 2.5 – 3.3Wh of energy[133] when the evaporator functions (activation begins after a pre-set number of uses). In normal circumstances, with the water tank partially filled, the evaporating process takes 3 to 4 minutes. When the tank is filled to the limit, the evaporation time is significantly longer. One manufacturer also reported the use of ceramic tiles which absorb the wastewater.

IoT connectivity

Hand dryers can be connected to the internet to deliver improved monitoring and maintenance. One manufacturer, Savortex, produces an IoT connected hand dryer, the adDryer[134]. Reviewing operation data remotely can allow for immediate engineer dispatch in case of a fault, along with internal diagnostics, determining the fault remotely and therefore limiting the number of engineer visits.

Bluetooth connectivity

Bluetooth connectivity allows for local data transfer. This could include the number of hand dryer uses, and hence indirectly the life expectancy of the asset. One manufacturer produces high-speed hand dryers that have Bluetooth connectivity. This enables performance data to be sent to facilities managers and alerts to maintenance operatives, concerning, for example, the condition of the filter or the fullness of the water tray. The

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[131] Note the pending revision to the Ecodesign regulation for televisions. DG ENER propose to rename and expand the scope of the revised regulation to focus on "displays". It remains to be seen whether the scope of the revised displays regulation includes displays of the size used in hand dryers.

[132] https://www.savortex.com/hand-dryers/the-addryer/

[133] Author's calculation: 50W*(3/60)h=2.5Wh 50W*(4/60)h=3.3Wh

[134] https://www.savortex.com/

energy consumption of the Bluetooth connectivity has not been declared but it would only draw electricity when the Bluetooth is activated.

4.1.1.5 Power Consumption in On mode

Most hand dryers have a power consumption which ranges between 500 and 2,000W (Table 4.9). Most of the conventional single point hands under dryers consume between 1,000 – 2,500W while most high-speed hand dryers consume between 500-2,000W. The average maximum power consumption of surveyed hand dryers is 1,430W. The most energy consuming are conventional single point hands under dryers with an average of 1,714W.

Table 4.9 Hand dryer power consumption

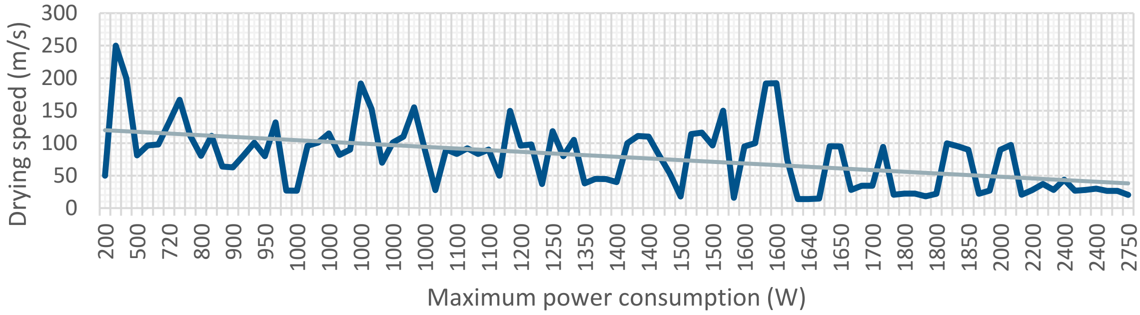
	Max. power consumption (W)						Sample Size
	≤500	501-1000	1001-1500	1501-2000	2001-2500	>2500	
Conventional single point (hands under) dryer	4%	7%	22%	31%	22%	13%	45
High speed single point (hands under) dryer	0%	30%	50%	20%	0%	0%	30
High speed multi-point (hands under) dryer	0%	33%	50%	0%	17%	0%	6
High speed trough style (hands in) dryer	0%	16%	32%	47%	5%	0%	19
Air Tap	0%	0%	80%	20%	0%	0%	5
Total	2%	16%	36%	29%	11%	6%	105

Source: Manufacturer's Technical Specifications

Power consumption is affected by multiple factors. One of them is air heating. Hand dryers with the lowest power consumption are those without the heating element. The largest energy consumers are hand dryers with a heating element which cannot be switched off.

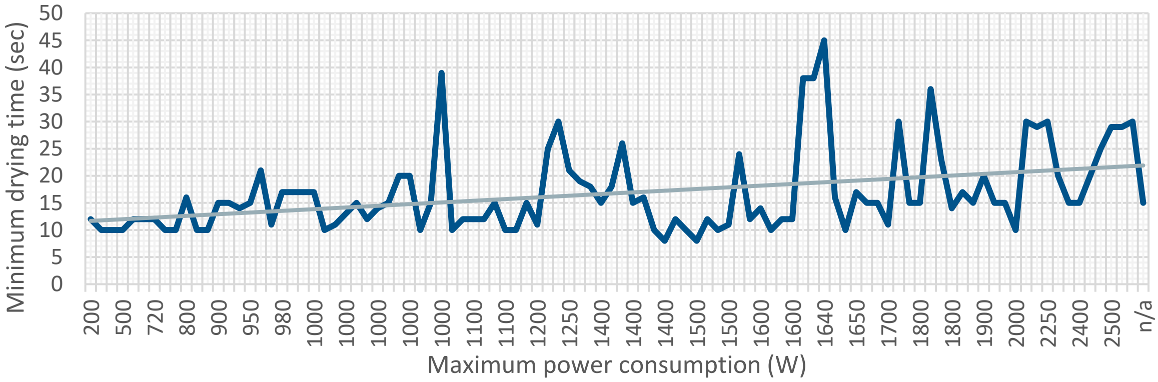
Power consumption shows a slight correlation with drying speed and minimum drying time. Faster drying speed (linear air flow rate) and shorter drying time, leads to lower power consumption (Figure 4.11 and Figure 4.12).

Figure 4.11 Drying speed to power consumption relationship



Source: Manufacturer's Technical Specifications

Figure 4.12 Drying time to power consumption relationship



Source: Manufacturer's Technical Specifications

Power consumption is not the only indicator of hand dryer efficiency, as a low consumption hand dryer may take much longer to dry hands. For this reason, it is advised to review these numbers in line with the energy consumption per cycle. Table 4.10 illustrates this point by presenting the average consumption per cycle for each hand dryer category. As Table 4.9 indicated, category 1 hand dryers generally consume more power than other hand dryers. Table 4.10 however shows that on average these use much longer cycle times to dry hands than other hand dryers, and therefore consume high energy consumption per cycle.

Table 4.10 Energy consumption per cycle in hand dryers

	Average Cycle duration (seconds)	Average energy consumption per cycle (Wh/cycle)	Sample size
Conventional single point (hands under) dryer	17.17	7.94	45
High speed single point (hands under) dryer	14.57	4.61	30
High speed multi-point (hands under) dryer	14.09	4.43	6
High speed trough style (hands in) dryer	12.78	4.99	19

Source: Manufacturer's Technical Specifications

4.1.1.6 *Power Consumption in Standby mode*

Standby power consumption in hand dryers varies from 0.3 to 3 watts[135]. The majority of surveyed hand dryers have a standby power consumption ranging from 1W to 2W (Table 4.11). However, there are many hand dryers with standby power consumption lower than 1W or lower than 0.5W. All surveyed air taps (four models) have a standby power consumption ranging from 0.4 or 0.5W.

[135] 6 watts for ffuuss HD-1 hand dryer when including operation of an air preheater

Table 4.11 Standby power consumption in hand dryers

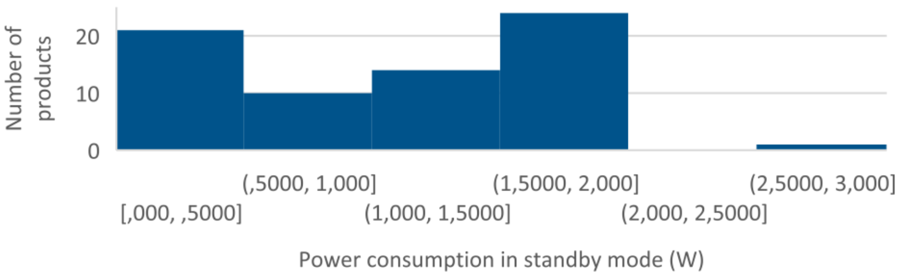
	Standby Power Consumption (W)			Sample Size
	≤0.5	>0.5 and ≤1	>1 and ≤2	
Conventional single point (hands under) dryer	19%	22%	59%	27
High speed single point (hands under) dryer	35%	4%	61%	23
High speed multi-point (hands under) dryer	60%	0%	40%	5
High speed trough style (hands in) dryer[136]	15%	23%	46%	13
Air Tap	100%	0%	0%	4
Total	31%	14%	56%	72

Source: Manufacturer's Technical Specifications

The average standby power consumption for high-speed hand dryers (1.26W) is lower than for conventional single point hands under dryers (1.36 W).

The lowest standby power consumption among the surveyed hand dryers is 0.3W. Figure 4.13 shows the range of standby power consumption values across the surveyed hand dryers. More than half of the hand dryers have standby power consumption lower than 1.3 W.

Figure 4.13 Standby rated power consumption in hand dryers (N = 71)



Source: Manufacturer's Technical Specifications

4.1.2 Standard Improvement Options & Best Available Technology

4.1.2.1 *Definitions*

This sub-task aims to categorise the components and features described above into those which represent Best Available Technology (BAT) or Standard Improvement Options (SIO). The BAT benchmark should be a robust benchmark for market pull measures. For example, the 'A' energy class and/or the level for public procurement, Eco-labels, etc. It represents the best commercially available product with the lowest resource use and/or emissions. As the name suggests, a Standard Improvement Option, or SIO, is an established measure, feature or component which improves the performance of the product.

[136] One model – standby power consumption 3W
One model – 6W for 2 hours after plugged-in, otherwise 1-1.5W standby power consumption

4.1.2.2 *Assessment*

The outputs from the authors' assessment are presented below in Table 4.12. The components and features highlighted in green are considered Best Available Technology. Note that the end buyer might specify a suite of components and features that best serves their intended application / location.

Table 4.12 Standard Improvement Options and Best Available Technology

Component/feature			**SIO**	**BAT**
Motor technologies	Brushless DC		☑	☑
	Induction AC		☑	☒
	Universal (brushed)		☒	☒
	Brushed DC		☒	☒
Motor control	VSD		☑	☑
	2-3 fixed speed settings		☑	☒
Heating	Waste heat recovery[137]		☑	☑
	Resistance		☒	☒
Heating control	Ambient Air Temperature Sensor		☑	☑
	ON/OFF (manual)		☑	☒
	Thermostat (included with heating element)		☑	☒
Activation control	Sensor only		☑	☑
	Sensor with timer		☑	☒
	Push button with timer		☒	☒
Air speed control	VSD or VR-dimmer		☑	☑
	3-speed setting (high, medium, low)		☑	☒
	2 speed setting (high, low)		☒	☒
Hygiene air flow	HEPA Filter		☑	☑
	Ioniser		☑	☑
	Standard filter		☑	☒
	Odour neutraliser		☒	☒
Hygiene (non-air flow)	Antimicrobial coating	Based on silver ions	☑	☑
		Not based on silver ions	☑	☑
	UV		☑	☒
	Wide cavity		☑	☒

[137] This may not be sufficient to provide the heat necessary for operation of a conventional dryer

Component/feature		SIO	BAT
Drying cavity (Hands-in) ii	Narrow cavity	☒	☒
Extra features	IoT connectivity	☑	☑
	Bluetooth connectivity	☑	☒
	(LED) Display	☑	☒
	Screen	☒	☒
Lights	Light alert (for filters and motors)	☑	☑
	Light indicator (guide where hands should be placed)	☑	☒
	Decorative lights	☒	☒
Water disposal methods iii	Sink connected	☑	☑
	Mains waste water connected	☑	☑
	Evaporating system	☑	☒
	Water tank	☑	☒

Notes

i. *A consideration for the fan motor technologies is the difference in reliability due to whether the motor is brushed or brushless. Changing the motor brushes extends the lifetime of the motor. Energy efficiency benefits may be less clear but in terms of the circular economy, improving lifetime has tangible benefits.*

ii. *Having a drying cavity that is wide is an SIO for hygiene reasons because the user's hands are less likely to touch the sides.*

iii. *For water disposal methods, an evaporating system could be considered an SIO if otherwise the water would drip on the restroom floor creating a maintenance issue.*

4.1.3 Best Available Technology – Performance

As well as considering Best Available Technology from a component and features perspective, BATs can be identified for hand dryer performance. Based upon the data set of 106 models, the BATs for standby, noise, dry time and energy consumption have been identified and presented below, representing each of the five hand dryer categories.

4.1.3.1 *Standby power consumption BAT*

The lowest standby power consumption among surveyed hand dryers is 0.3 W[138]. Over a third of these hand dryers achieve standby power consumption lower than 0.8W. The best performing hand dryers in terms of claimed standby power consumption are listed in Table 4.13.

[138] 71 surveyed hand dryers with claimed standby power consumption. Note - some manufacturers claim standby power of <0.5 W. These values in the analysis are assumed to be equal to 0.5 W.

Table 4.13 Specification of hand dryers with the lowest standby power consumption

		Conventional single point hands under dryer	High-speed single point hands under dryer	High-speed multi-point hands under dryer	High-speed trough style hands-in dryer	Air tap
Hand dryer type						
Model		Mediclinic Prima M96	Mediclinic Machflow	Starmix AirStar T-C1	Mediclinic Dualflow	Dryflow Dri-Tap (deck mounted)
Active Standby Power		**0.4 W**	**0.3 W**	**0.4 W**	**0.4 W**	**0.3-0.4 W**
Other properties	**Max. Power at 240V (W)**	1650	1100	1000	1500	1000
	ETL listed	No	Yes	No	No	No
	Operation	Automatic /Push Button	Automatic	Automatic	Automatic	Automatic
	Min. drying time (sec)	45	10	17	8	20
	Filters	None	HEPA	None	HEPA	General carbon filter
	Drying speed (m/s)	15	90	96	114	101
	Air speed control	No	Yes	No	Yes	Yes
	Heating	Yes	Yes	No	Yes	Yes
	Heating control	No	Yes	No	Yes	Yes
	Antimicrobial Technology	No	No	No	Yes	No
	Noise emission	57 dBA	74 dBA	69 dB	72 dBA	70.5 dB
	Quiet Mark	No	No	No	No	No
	Motor type	Induction motor	Universal brush motor	Universal brush motor	Universal brush motor	Universal brush motor
	Other		Odour neutralizer, ionizer		Ionizer	

Source: Manufacturer's Technical Specifications

4.1.3.2 *Noise emission BAT*

According to product technical specifications, most manufacturers refers to sound level expressed in dB or dB(A) measured either at 1m or 2m distance. In the database of 106 hand dryers compiled during this study, the sound level in dB is published for 59 hand dryers and in dB(A) for 23. For the remaining products technical documentation does not include sound level. The sound level is identified as a sound pressure level which is a measurable parameter and its value differs at different distance from the sound source. Values expressed in dB(A) refers to sound pressure level in dB adjusted to reflect the human ear perception of relative loudness.

For 58 hand dryers, in a database of 106 models, the distance of sound level measurement is identified. For 57% of them sound level was measured at 1m and for the remaining 43% at 2m.

The quietest hand dryers are those with sound level 57dBA at 2m, 59dB at 2m and 63dB at 1m. The best performing hand dryers in each hand dryers type category are listed in Table 4.14 to Table 4.16 below.

Table 4.14 Specification of the hand dryers with lowest sound level in dBA measured @2m

Hand dryer type		Conventional single point (hands under) dryer	High-speed single point	High-speed multi point	High speed trough style (hands in) dryer
Model		Mediclinic Prima M96	Mediclinic Speedflow Plus	Dyson Airblade V	Mediclinic Dualflow
Noise emission		**57dBA**	**65dBA**	**63dBA**	**72 dBA**
Other properties	**Max. Power at 240V (W)**	1650	850	1000	1500
	ETL listed	No	No	Yes	No
	Operation	Auto / Push Button	Auto	Auto	Auto
	Min. drying time (sec)	45	10	12	8
	Filters	None	HEPA	HEPA	HEPA
	Drying speed (m/s)	15	111	192	114
	Air speed control	No	Yes	No	No
	Heating	Yes	Yes	No	Yes
	Heating control	No	Yes	n/a	Yes
	Antimicrobial Technology	No	No	Yes	Yes
	Active Standby Power (W)	0.4	Unknown	<0.5	0.4
	Quiet Mark	No	No	Yes	No
	Motor type	Induction motor	High pressure motor	Digital brushless motor	Universal brush motor

	Other	Adjustable detection			Ionizer, carbon filtering to avoid odour

Source: Manufacturer's Technical Specifications

Table 4.15 Specification of the hand dryers with lowest sound level in dB measured @1m

	Hand dryer type	Conventional single point (hands under) dryer	High-speed single point	High speed multi-point (hands under) dryer	High speed trough style (hands in) dryer	Air Tap
	Model	Hokwang 1800W	Hokwang Dryflow EcoWave	Hokwang Dryflow Viper	Hokwang Dryflow Jet Force	HOKWANG EcoTap
	Noise emission	**64 dB**	**70 dB**	**75 dB**	**70 dB**	**63 dB**
Other properties	**Max. Power at 240V (W)**	1800	950	2000	1850	1000
	ETL listed	No	No	No	No	No
	Operation	Auto / Push Button	Auto	Auto	Auto	Auto
	Min. drying time (sec)	30	21	15	17	10
	Filters	None	General filter	HEPA	HEPA	Carbon filter
	Drying speed (m/s)	21	80	90	95	101
	Air speed control	No	No	Yes	No	No
	Heating	Yes	Yes	Yes	Yes	Yes
	Heating control	No	No	Yes	Yes	No
	Antimicrobial Technology	No	No	No	No	No
	Active Standby Power (W)	1.5	Unknown	Unknown	<3	0.5

Quiet Mark	No	No	Yes	Yes	No
Motor type	Brushless Motor	Universal brush motor	Universal brush motor	Digital Brushless Motor	Unknown

Source: Manufacturer's Technical Specifications

Table 4.16 Specification of the hand dryers with lowest sound level in dB measured @2m

	Hand dryer type	Conventional single point (hands under) dryer	High-speed single point	High speed trough style (hands in) dryer
	Model	Genwec WECFLOW	Mitsubishi Jet Towel Smart lite	Mitsubishi Jet Towel Unheated
	Noise emission	**60 dB**	**62 dB**	**59 dB**
Other properties	**Max. Power at 240V (W)**	1800	730	720
	ETL listed	No	No	No
	Operation	Auto	Auto	Auto
	Min. drying time (sec)	36	12	12
	Filters	None	Carbon filter	HEPA
	Drying speed (m/s)	18	132	98
	Air speed control	No	Yes	Yes
	Heating	Yes	No	No
	Heating control	No	n/a	n/a
	Antimicrobial Technology	No	Yes	Yes
	Active Standby Power (W)	Not known	Not known	1
	Quiet Mark	No	Yes	Yes
	Motor type	Universal brushless motor	Digital Brushless Motor	Brushless motor

Source: Manufacturer's Technical Specifications

4.1.3.3 *Dry time BAT*

From the data set of 106 models, the minimum dry time "claimed" by manufacturers, is 8 seconds. Table 4.17 shows the hand dryers with the shortest claimed drying time. For 25% of the surveyed models, the claimed drying time is ≤11 seconds.

Table 4.17 Hand dryers with the shortest "claimed" dry time

Hand dryer type		Conventional single point (hands under) dryer	High-speed single point	High speed multi-point (hands under) dryer	High speed trough style (hands in) dryer	Air Tap
Model		Bobrick B-38030 3 in 1 Hand Dryer	Excel XLERATOR	JVD COPT'AIR	Mediclinics Dualflow	HOKWANG EcoTap
Min. *claimed* drying time (sec)		**10**	**8**	**10**	**8**	**10**
Other properties	**Max. Power at 240V (W)**	900	1410	500	1500	1000
	ETL listed	No	Yes	No	No	No
	Operation	Auto	Auto	Auto	Auto	Auto
	Active Standby Power (W)	Not known	<1.5	2	0.4	0.5
	Filters	None	HEPA	HEPA	HEPA	Optional carbon filter
	Drying speed (m/s)	Not known	81	250	114	101
	Air speed control	No	Yes	No	No	No
	Heating	Yes	Yes	No	Yes	Yes
	Heating control	No	Yes	No	Yes	No
	Antimicrobial Technology	No	Yes	No	Yes	No

Noise emission	Not known	Not known	80 dB	72dBA	63 dB
Quiet Mark	No	No	No	No	No
Motor type	Universal brush motor	Thermally protected motor	Brush motor	Universal brush motor	Not known

Source: Manufacturer's Technical Specifications

Drying time should be associated with a level of remaining moisture content on the user's hands once the drying time is complete. Only a small number of hand dryer manufacturers declare the value of residual moisture within their product specifications. For example, Dyson hand dryers claim to achieve a residual moisture content of 0.1 g. For 43 of the 106 surveyed hand dryers, the level of residual moisture is known via independent standards and verifications.

It should be remembered that the 'claimed' drying times in Table 4.17 do not reference a commonly agreed test standard and therefore might not be comparable.

Certain certifications and/or standards such as Energy Technology List[139] (ETL), National Sanitation Foundation (NSF) mark[140] and UL's Product Category Rules[141] (PCR) set thresholds for drying time to a specified remaining moisture content level. Table 4.18 below details the respective remaining moisture content requirements and the number of conforming models against each standard.

Table 4.18 Conformity with residual moisture content thresholds

Standards	Remaining moisture content requirement (g)	Number of conforming models	Percentage of conforming models[142]
NSF mark	≤0.10	3	3%
ETL	≤0.15	7	7%
UL's PCR	≤0.25	33	31%

Sources: ETL, NSF P335 Protocol, UL's PCR, Products' Technical Specifications

All ETL listed high speed hand dryers (categories 2, 3 and 4) undergo an independent verification process, a requirement of which is the video recording of the user tests. Table 4.19 shows ETL listed hand dryers with the shortest measured drying time. Among ETL listed hand dryers the shortest measured drying time is 9.7 seconds for the Mitsubishi Jet Towel Smart Lite Hand Dryer.

Table 4.19 ETL listed hand dryers with the shortest measured dry time

Hand dryer type	High speed single-point (hands under) dryer	High speed multi-point (hands under) dryer	High speed trough style (hands in) dryer
Model	Mitsubishi Jet Towel Smart Lite	Dyson Airblade V	Cannon hygiene Cannon AirJet

[139] https://www.gov.uk/government/publications/energy-technology-list-etl-method-for-the-testing-of-high-speed-hand-air-dryers *(test method)*
https://www.gov.uk/government/publications/high-speed-hand-air-dryers-criteria-for-etl-inclusion *(criteria)*
https://etl.beis.gov.uk/engetl/fox/live/ETL_PUBLIC_PRODUCT_SEARCH *(listed hand dryers)*

[140] http://info.nsf.org/Certified/Protocols/Listings.asp?Company=3E300&Standard=P335

[141] https://www.shopulstandards.com/ProductDetail.aspx?UniqueKey=33229

[142] Data set of 106 models

	Min. drying time (sec)	9.7	10	10
Other properties	Max. Power at 240V (W)	980	1000	550
	ETL listed	Yes	Yes	Yes
	Operation	Auto	Auto	Auto
	Min. drying time (sec)	9.7	10	10
	Filters	General filter	HEPA	Not known
	Drying speed (m/s)	132	192	102
	Air speed control	Yes	No	Not known
	Heating	Yes	No	Not known
	Heating control	Yes	No	Not known
	Antimicrobial Technology	Yes	Yes	Yes
	Noise emission	62 dB	79 dB	61 dB
	Quiet Mark	Yes	Yes	Not known
	Motor type	Brushless Motor	Brushless motor	Not known

Source: Manufacturer's Technical Specifications

4.1.3.4 *Energy consumption per use BAT*

Hand dryer performance can be considered using an energy consumption/cycle statistic. These data are presented for certified Blue Angel hand dryers. However, only 3 models are certified against the Blue Angel criteria and just one model has a published declared energy consumption per cycle[143] - the Mediclinic MACHFLOW M09A-600W, M09AC-600W, M09ACS-600W, M09AB-600W. With a range of 8-12 seconds drying time, the consumption is 1.9Wh per cycle[144].

The retailer Intelligent Dryer also publishes energy consumption / cycle[145]. For the purposes of this report, energy consumption per drying cycle has been calculated for 104 of the 106 models in ICF's data set. The calculation is a result of multiplying values provided from manufacturers' technical specifications - namely rated power and minimum "claimed" drying time, per the equation below:

Rated power (W) x Minimum "claimed" drying time (s) / 360 = consumption per use (Wh).

The results have been validated against the data published by Intelligent Dryer and for 23 of the 28 values where the retailer published data for models included in ICF's data set, the results were the same. For the remaining 5, the results were different because the drying time varied. The results are presented below in Table 4.20.

[143] https://www.blauer-engel.de/en/products/business-municipality/haendetrockner

[144] https://www.blauer-engel.de/en/products/business-municipality/haendetrockner/machflow-m09a-600w-m09ac-600w-m09acs-600w-m09ab-60

[145] https://www.intelligenthanddryers.com/category/warm-air-hand-dryers

Table 4.20 Hand dryers with the lowest energy consumption per use

Hand dryer type		Conventional single point (hands under) dryer: NO HEAT	Conventional single point (hands under) dryer: HEAT	High speed single-point (hands under) dryer	High speed multi-point (hands under) dryer	High speed multi-point (hands under) dryer	High speed trough style (hands in) dryer	High speed trough style (hands in) dryer	Air Tap
Model		Bobrick B-7125	Bobrick B-38030	Excel XLERATORReco	JVD COPT'AIR	JVD SupAir	JVD Exp'Air	JVD Stell'Air	Hokwang EcoTap
Energy use per drying (Wh/use)		**0.71**	**2.50**	**1.47**	**1.39**	**1.39**	**2.22**	**2.22**	**2.78**
Other properties	**Max. Power at 240V (W)**	213	900	530	500	500	800	800	1000
	Active Standby Power (W)	Not known	Not known	0.6	2	2	2	2	0.5
	ETL listed	No	No	No	No	No	No	No	No
	Operation	Auto	Auto	Auto	Auto	Auto	Auto	Auto	Auto
	Min. drying time (sec)	12	10	10	10	10	10	10	10
	Filters	None	None	HEPA	HEPA	HEPA	HEPA	HEPA	Non-HEPA
	Drying speed (m/s)	50	Not known	81	250	200	167	111	101
	Air speed control	No	No	Yes	No	No	No	No	No
	Heating	No	Yes	No	No	No	No	No	Yes
	Heating control	No	No	No	No	No	No	No	No

	Antimicrobial Technology	No	No	Yes	No	No	Yes	Yes	No
	Noise emission	85dB	Not known	Not known	80dB	75dB	75dB	73dB	63dB
	Quiet Mark	No	No	No	No	No	No	No	No
	Motor type	Brushless motor	Brushed motor	Thermally protected motor	Brush motor	Brush motor	Brush motor	Brush motor	500W
	Other	Heat recovery			Rotating nozzle, LED lighting effect	Lighting of the drying zone	Water collection tank capacity sensing system, blue lighting on the drying zone	Patented circular air blowing system, blue lighting effect in drying zone	

Source: Manufacturer's Technical Specifications

4.1.3.5 *"Run On" time BAT*

As explained earlier under Activation controls, hand dryers are operated via one of four activation set-ups: *push button on/off*, *push button and timer*, *sensor and timer* or *sensor only*. Energy can be wasted when the user's hands are withdrawn from the dryer but its drying operation continues until either the timer counts down to zero or the sensor detects withdrawn hands. Under the sensor only activation control, the dryer should cease operation much quicker, once the user's hands are withdrawn. The amount of time the dryer operates once the user's hands are withdrawn from the dryer is referred to as "run on" time.

Some manufacturers self-declare run on time within their product specifications, the results of which are summarised in Table 4.21. Note only 3 of the 106 models in ICF's data set have published a declared "run on" time. Further responses from stakeholders via the consultation indicates that the average run-on time appears to be between 1 and 2 seconds, with one example being 0.650 seconds.

Table 4.21 "Run on" time

	Hand dryer type	High speed single-point (hands under) dryer	High speed single-point (hands under) dryer	High speed trough style (hands in) dryer
	Model	Mitsubishi Jet Towel Smart lite	Mitsubishi Jet Towel Smart	Mitsubishi Jet Towel Heated
	Sensor response time ("run on" time)	**0.1s**	**0.1s**	**0.1s**
Other properties	**Max. Power at 240V (W)**	730	980	1240
	ETL listed	No	Yes	No
	Operation	Auto	Auto	Auto
	Min. drying time (sec)	12	11	11
	Filters	Non-HEPA	Non-HEPA	HEPA
	Drying speed (m/s)	132	132	98
	Air speed control	Yes	Yes	Yes
	Heating	No	Yes	Yes
	Heating control	n/a	Yes	Yes
	Antimicrobial Technology	Yes	Yes	Yes
	Noise emission	62	62	59
	Quiet Mark	Yes	Yes	Yes
	Motor type	Digital Brushless Motor with thermal fuse	Digital Brushless Motor with thermal fuse	Brushless motor

Source: Manufacturer's Technical Specifications

In reality, users may not keep their hands under the dryer for the minimum drying time. Instead users might accept partially dry hands as a trade-off for less time under the dryer. The dryer therefore should switch off fast once it detects there are no hands present. The power consumption when running and the shortness of the run on time when hands are removed are important parameters determining energy use. It is a matter for debate if the comparison on energy use to achieve a certain level of dryness reflects real word user behaviour.

Manufacturers commented that in real world operation, users might not know where the sensor is located so a delay of 1-2 seconds is required to prevent the sensor switching the dryer off and on repeatedly (one manufacturer commented that this could reduce the lifetime of the relay switch). Users might also have a poor experience if the dryer is repeatedly turning off and on. In this respect, an indication light can be helpful in informing the user where to place their hands for optimal operation (e.g. detection by the sensor).

4.1.4 Best Not Yet Available Technology

The Best Not yet Available Technology (BNAT) point indicates the space for future innovation and product differentiation after the introduction of measures. BNAT represents an experimentally proven technology that is not yet brought to market. For example, it is still at the stage of field tests or official approval.

A number of BNAT ideas/concepts covering the key components and features of hand dryers (e.g. motors and heating, as per Table 4.12) have been drafted and are presented as discussion prompts below. The list also features ideas beyond these confines such as 3D printing and producer "take-back" schemes. Considering by its very nature, Best Not yet Available Technology is a particularly challenging area for elaboration by non-manufacturing parties. Therefore, manufacturer input and feedback on this list is welcomed.

1. **Heating** – heating represents a significant energy demand which even high-speed hand dryers rely upon. Is the heating element a subject of R&D / innovation? Waste heat recovery from the hand dryer motor is in its infancy (BAT); how much further could this be taken (e.g. in effectiveness and utilisation of other heat sources)? Are heating controls fully optimised to consider internal temperature and restroom humidity conditions?
2. **Motor controls and hard-coding** – innovations such as "soft start" already exist and might represent BAT, but what further can be done to prolong the lifetime/longevity of motors and ultimately the hand dryer itself? In this context, the motor is the single most significant component and most likely to break down.
3. **Hygiene** – how can air flow through filters be improved and what innovations are there for internal coatings (e.g. can the material sustainability characteristics be improved?).
4. **Activation sensors** – the operation of hand dryers whilst the hands are not underneath or within the cavity represents wastage. How can activation sensors be improved to reduce "run-on" time?
5. **Dust sensors** (air flow) – filters are currently in place in order to trap harmful particulates from entering the device. A detector could measure the air flow through the filter to identify if it is blocked. Coupled with an alarm signal / connectivity, this could allow the device to detect when the filter needs replacing.
6. **Filters** – currently single use and non-recyclable, how can filters be improved and made reusable to increase material efficiency?
7. **Digital twin** – for certain installations/applications, could a digital twin be created to foresee key maintenance milestones and prolong the lifetime of hand dryers? E.g. motor life, the dirtiness of the filter.
8. **3D Printing** – what role could 3D printing play to reduce smaller components and improve recycling and reuse of materials?

9. **Innovative materials** – Is there a role to play for innovative materials with higher strengths, improved longevity or other properties to allow for the reduction of materials used, increase recycling or reduce total carbon footprint?
10. **Producer responsibility** – In practice recycling and reuse rates for certain plastics (e.g. LDPE) are minimal due to their small size and incorporation into hand dryers. What role can producers play in improving these rates to ensure key materials and certain under-recycled materials, are recycled, via producer take back schemes?

4.2 PRODUCTION, DISTRIBUTION AND END-OF-LIFE

4.2.1 Bill of Materials

In general, hand dryers are composed of the following materials:

- Metals (steel, aluminium, copper)
- Plastics (LDPE, ABS, nylon)
- Electronics and printed wire boards (PWB)

The following tables provide an average category specific material/component composition of hand dryers based on a number of bill of materials (BoM) received from manufacturers. The BoMs are presented for the following hand dryer categories:

- Category 1, conventional single point "hands under" dryers
- Category 2/3, high speed "hands under" dryers
- Category 4, high speed trough style "hands in" dryers

Anonymous and averaged BoM component data is presented in order to protect the confidentiality of those manufacturers who provided data. Hand dryers' components and materials are classified according to the *Methodology for Ecodesign of Energy-related Products* (MEErP).

Table 4.23,Table 4.25 and Table 4.27 contain a list of extra components identified by manufacturers in their respective BoMs but not used in the category specific hand dryer BoM (Table 4.22, Table 4.24 and Table 4.26). This is because it could cause potential double counting of components or the component is specifically designed for a particular hand dryer and is not representative of a category specific hand dryer.

4.2.1.1 *Category 1, Conventional Single Point Hands Under Dryer*

Table 4.22 presents a category specific BoM for a conventional single point hands under dryer. The total weight is 5.3kg, rising to 6.2kg including packaging. The average volume of the product is 13.71litres, rising to 23.08litres with packaging. These values are calculated from a sample of 13 published technical specifications.

Table 4.22 Category specific BoM for a conventional single point hands under dryer

Hand dryer part	Share in total product weight	Component	Category	Material	Recyclable?	Assumptions
Nozzle	10%	Air outlet	4-Non-ferro	33 -ZnAl4 cast	Yes	Based on one BoM. This part is present only in one BoM
	≤0.5%	Air outlet fix ring	3-Ferro	23 -St tube/profile	Yes	Based on one BoM. This part is present only in one BoM
	≤0.5%	Air outlet packing	1-BlkPlastics	1 –LDPE	Yes	Based on one BoM. This part is present only in one BoM
External ring	≤0.5%	Air outlet rubber ring	1-BlkPlastics	1 –LDPE	Yes	Based on one BoM. This part is present only in one BoM
Casing	28%	Cover	3-Ferro	23 -St tube/profile	Yes	Average weight based on two BoMs from two manufacturers.
	≤0.5%	Controller Lid	2-TecPlastics	12 -PA 6	Yes	Based on one BoM. This part is present only in one BoM
	14%	Base plate	4-Non-ferro	28 -Al diecast	Yes	Average weight based on two BoMs from two manufacturers. Two different materials in both BoMs. Al diecast was chosen over steel because it has worse environmental impact.
Motor	18%	Motor (rotor, bearings, stator, windings,	3-Ferro 4-Non-ferro	24 -Cast iron 23 -St tube/profile	Yes	Average weight based on two BoMs from two manufacturers. Manufacturer feedback indicated that the motors was majority Steel and copper. Detailed ratios were not provided

Hand dryer part	Share in total product weight	Component	Category	Material	Recyclable?	Assumptions
		commutator, brushes)		31 -Cu tube/sheet		
eCircuit board	3%	Controller / Timer	6-Electronics	98 -controller board	Yes	Average weight based on two BoMs from two manufacturers. The assumption of "controller" and "timer" performing the same function.
Fan	1%	Fan blower	4-Non-ferro	27 -Al sheet/extrusion	Yes	Based on one BoM. This part is present only in one BoM. The assumption that fan blower is a separate part than fan wheel.
Fan housing	6%	Blower (fan) housing	2-TecPlastics	12 -PA 6	Yes	Average weight based on two BoMs from two manufacturers. Assumption that blower and fan are parts with the same purpose. Two different materials in both BoMs. PA6 chosen over Bulk Moulding Compound as it is available in the tool template and is larger by weight.
Sensor assembly	≤0.5%	Sensor	6-Electronics	50 -PWB 1/2 lay 3.75kg/m2	Yes	Based on one BoM. This part is present only in one BoM
	≤0.5%	Sensor rubber	2-TecPlastics	13 –PC	Yes	Average weight based on two BoMs from two manufacturers. Two different materials in both BoMs. PC chosen over LDPE because it has worse environmental impact.
Heating element	1%	Heating assembly	2-TecPlastics 5-Coating	19 – E-glass fibre (Mica)	No	Average weight based on two BoMs from two manufacturers. Assumption that a coil for one

Hand dryer part	Share in total product weight	Component	Category	Material	Recyclable?	Assumptions
				41 -Cu/Ni/Cr plating (Nickel)		manufacturer is nickel as well as for the other manufacturer who stated that it's nickel. Assumption for calculation that mica reflects E-glass fibre in terms of environmental impact and Nickel reflects Cu/Ni/Cr plating. Mica is not recyclable and Nickel is not likely to be recyclable in practice.
Accessories	≤0.5%	Thermostat	4-Non-ferro	27 -Al sheet/extrusion 31 -Cu tube/sheet	Yes	Average weight based on two BoMs from two manufacturers. Material based on one of them because. The other manufacturer stated that it is a regular thermostat.
	3%	Mounting brackets	3-Ferro	22 -St sheet galv.	Yes	Average weight based on two BoMs from two manufacturers.
	≤0.5%	Cable protector	2-TecPlastics	19 -E-glass fibre 12 -PA 6	Yes	Based on one BoM. This part is present only in one BoM. It's made of both PA6 and E-glass. Assumption made for each material to be half of the weight of this part.
	1%	Screws and nuts	3-Ferro	23 -St tube/profile	Yes	Based on one BoM. This part is present only in one BoM
	≤0.5%	L-Wrench	3-Ferro	23 -St tube/profile	Yes	Based on one BoM. This part is present only in one BoM

Hand dryer part	Share in total product weight	Component	Category	Material	Recyclable?	Assumptions
Packaging	11%	Cardboard box and packaging	7-Misc.	57 - Cardboard	Yes	Average weight of carboards based on two BoMs from two manufacturers.
	3%	Styrofoam	1-BlkPlastics	5 –PS	No	Based on one BoM. This part is present only in one BoM.

Table 4.23 Extra components from manufacturers' BoMs not featured in the category specific BoM

Component	Weight in g	Category	Material	Recyclable?	Assumption
Motor rubber	1.8	1-BlkPlastics	1 -LDPE	No	Based on one BoM. This part is present only in one BoM. It is likely that in other BoMs it is listed under "motor". It is added as extra to avoid double counting. Assumption that rubber is not commonly recyclable.
Fix shaft spring	2	3-Ferro	26 - Stainless 18/8 coil	Yes	Based on one BoM. This part is present only in one BoM. It is likely that in other BoMs it is listed under "motor". It is added as extra to avoid double counting.
Fix shaft	52.8	3-Ferro	23 -St tube/profile	Yes	Based on one BoM. This part is present only in one BoM. It is likely that in other BoMs it is listed under "motor". It is added as extra to avoid double counting.
Side ABS cover	278	1-BlkPlastics	11 –ABS	Yes	Based on one BoM. This part is present only in one BoM. This part is added as extra because it is an inclusive component for the particular hand dryer model.

Component	Weight in g	Category	Material	Recyclable?	Assumption
Outlet Shroud Moulding Quad GZ	53.5	2-TecPlastics	12 -PA 6	Yes	Based on one BoM. This part is present only in one BoM. It's an alternative to air outlet included in the BoM above. This part is added as extra because it is inclusively designed for the particular hand dryer model.
Air outlet NAME	322.2	4-Non-ferro	28 -Al diecast	Yes	Based on one BoM. This part is present only in one BoM. It is likely that in other BoMs it is listed under "Air outlet". It is added as extra to avoid double counting.

4.2.1.2 Category 2/3 High Speed Hands Under Dryer

The BoM presented in Table 4.24 refers to a high speed hands under dryer with heating element. The total weight is 4.4kg, rising to 5.1kg including packaging. The average volume of the product is 12.52litres, rising to 30.89litres with packaging. These values are calculated from a sample of 20 published technical specifications.

Table 4.24 Category specific BoM for a high-speed hands under dryer

Hand dryer part	Description of component	Share in total product weight	Category	Material	Recyclable?	Assumptions
Casing	Blower housing	5%	2-TecPlastics	12 -PA 6 19 -E-glass fibre	No	Average weight based on two BoMs from two manufacturers. Material E-glass fibre + PA6 chosen over ABS because of worse environmental impact. Because it is a single component made of two different materials, assumption was made that it is not recyclable as it might not be possible to separate them.
	Product casing	4%	1-BlkPlastics	11 -ABS	Yes	Two out of five BoMs included ABS casing, two glass reinforced resin (GRR) casing and one steel casing. The output is an average casing made of 2/5 ABS, 2/5 GRR and 1/5 steel.
		3%	3-Ferro	26 -Stainless 18/8 coil	Yes	
		17%	2-TecPlastics	Glass reinforced resin	No	
	Other casings	5%	1-BlkPlastics	11 -ABS	Yes	Average weight based on four BoMs from two manufacturers. Material ABS chosen over stainless 18/8 steel and glass reinforced resin as most of the cover parts (by quantity) are made from ABS within these BoMs. It includes external product cover, control assembly cover and filter cover.
Tamper Proof Bolt	Tamper Proof Bolt	≤0.5%	3-Ferro	23 -St tube/profile	Yes	Average weight based on three BoMs from one manufacturer.

Hand dryer part	Description of component	Share in total product weight	Category	Material	Recyclable?	Assumptions
Tamper Proof Wrench	Tamper Proof Bolt Wrench	≤0.5%	3-Ferro	23 -St tube/profile	Yes	Average weight based on three BoMs from one manufacturer.
Air outlet	Outlet nozzle	1%	1-BlkPlastics	11 -ABS	Yes	Based on one BoM. This part is present only in one BoM.
	Nozzle gasket	≤0.5%	2-TecPlastics	17 -Flex PUR	No	Average weight based on two BoMs from one manufacturer. Manufacturer uses neoprene foam. Assumption is made as it reflects unrecyclable Flex PUR.
Terminal block	Terminal block	≤0.5%	2-TecPlastics	15 -Epoxy	Yes	Average weight based on two BoMs from different manufacturers. Two different materials were listed. Epoxy is chosen over ABS because it has worse environmental impact.
Control assembly	Motor control module	≤0.5%	6-Electronics	48 -IC's avg., 1% Si	Yes	Average weight based on two BoMs from one manufacturer.
Sensor	Sensor	2%	6-Electronics	50 -PWB 1/2 lay 3.75kg/m2	Yes	Average weight based on four BoMs from two manufacturers. Two different materials were listed. PWB 1/2 lay 3.75kg/m2 chosen over controller board as it is in 3 out of 4 BoMs.
Heating element assembly	Heater assembly	1%	2-TecPlastics 3-Ferro	19 -E-glass fibre (Mica)	No/Yes	Average weight based on three BoMs from two manufacturers. Assumption that mica reflects E-glass fibre in terms of environmental impact. Different coil materials provided in BoMs. Stainless 18/8 steel coil chosen over nickel as it is in two out of three BoMs. Assumption that mica in not recyclable.

Hand dryer part	Description of component	Share in total product weight	Category	Material	Recyclable?	Assumptions
				26 - Stainless 18/8 coil		
	End plate	≤0.5%	1-BlkPlastics	12 -ABS	Yes	Based on one BoM. This part is present only in one BoM.
Motor[146]	Muffler foam (input and output)	≤0.5%	1-BlkPlastics	1 -LDPE	Yes	Based on one BoM. This part is present only in one BoM. Manufacturer uses polyurethane foam. Assumption is made as it reflects LDPE.
	Fan shroud	1%	3-Ferro	22 -St sheet galv.	Yes	Based on one BoM. This part is present only in one BoM.
	Fan	≤0.5%	4-Non-ferro	27 -Al sheet/extrusion	Yes	Based on one BoM. This part is present only in one BoM.
	Motor brushes	≤0.5%	3-Ferro	24 -Cast iron	Yes	Average weight of four BoMs. Material cast iron chosen over Cu/PA6 as it is dominant in 3 out of 4 BoMs.
	Rotor	4%	3-Ferro	24 -Cast iron	Yes	Average weight based on three BoMs from one manufacturer.

[146] An adjustment was made due to different approaches in the surveyed BoMs. Values, based on four BoMs (with 0.5-2.1kg motors), have been lowered by the percentage difference between the average weight of the four motors (0.5-2.1kg) and the average weight of five motors (0.17-2.1kg). The adjustment is a result of a high discrepancy in motors' weights in five different BoMs (0.17 to 2.1kg) and of differences in BoMs - some include a motor as a single component, others specify different elements within one motor.

Hand dryer part	Description of component	Share in total product weight	Category	Material	Recyclable?	Assumptions
	Rotor shaft	≤0.5%	3-Ferro	23 -St tube/profile	Yes	Based on one BoM. This part is present only in one BoM.
	Bearings	≤0.5%	3-Ferro	23 -St tube/profile	Yes	Based on one BoM. This part is present only in one BoM.
	Bearing housing	≤0.5%	2-TecPlastics	19 -E-glass fibre	No	Based on one BoM. This part is present only in one BoM. Glass reinforced resin - Assumption is made to use E-glass fibre for calculations. Glass reinforced resin is made of glass fibre and plastic form which E-glass fibre has worse environmental impact (compared to PET). Thermoset plastics are not recyclable.
	Stator	6%	3-Ferro	24 -Cast iron	Yes	Average weight based on three BoMs from one manufacturer.
	Block and Motor housing wiring harness	≤0.5%	1-BlkPlastics	11 -ABS	Yes	Based on two BoMs from the same manufacturer.
	Armature Stator Wiring	2%	4-Non-ferro	30 -Cu wire	Yes	Based on one BoM. This part is present only in one BoM.
	Motor housing	8%	1-BlkPlastics	11 -ABS	Yes	Based on two BoMs from the same manufacturer.

Hand dryer part	Description of component	Share in total product weight	Category	Material	Recyclable?	Assumptions
	Motor End plate	1%	1-BlkPlastics	11 -ABS	Yes	Average weight based on three BoMs from one manufacturer. Material ABS chosen over glass reinforced resin because it is dominant in 2 out of 3 BoMs.
	Motor Case	5%	2-TecPlastics	19 -E-glass fibre	No	Based on two BoMs from the same manufacturer. Assumption that E-glass fibre is an unrecyclable plastic.
	Plastic wiring holders	≤0.5%	2-TecPlastics	20 -E-glass fibre	No	Based on two BoMs from the same manufacturer. Assumption that E-glass fibre is an unrecyclable plastic.
Base plate assembly	Mounting metal plate	5%	4-Non-ferro	27 -Al sheet/extrusion	Yes	Average weight based on four BoMs from two manufacturers. Material Aluminium sheet chosen over steel sheet because it is listed in three out of four BoMs.
Brackets	Brackets	1%	4-Non-ferro	27 -Al sheet/extrusion	Yes	Average weight based on four BoMs from two manufacturers. Different materials listed in different BoMs. Aluminium sheet chosen (over steel sheet) as it has worse environmental impact.
Housing grommet	Motor rubber	1%	1-BlkPlastics	1 -LDPE	No	Average weight of four BoMs. Material LDPE chosen over Flex PUR as it is dominant in 3 out of 4 BoMs. Assumption that rubber is not commonly recycled.
Fuse holder	Fuse holder	≤0.5%	1-BlkPlastics	12 -ABS	Yes	Based on two BoMs from the same manufacturer.
HEPA filter	Filter paper	2%	7-Misc.	58 -Office paper	Yes	Based on two BoMs from the same manufacturer.

Hand dryer part	Description of component	Share in total product weight	Category	Material	Recyclable?	Assumptions
Pre-filter	Pre-filter	1%	3-Ferro	26 - Stainless 18/8 coil	Yes	Based on one BoM. This part is present only in one BoM. Assumption that it is stainless steel coil as in one manufacturers BoM which is the same as in case of a prefilter in BoMs from other hand dryer category manufacturer.
Electronics	Light	≤0.5%	6-Electronics	49 -SMD/ LED's avg.	Yes	Average weight based on three BoMs from one manufacturer.
	Capacitor	≤0.5%	6-Electronics	45 -big caps & coils	Yes	Average weight based on two BoMs from one manufacturer.
	Potentiometer	≤0.5%	6-Electronics	48 -IC's avg., 1% Si	Yes	Average weight based on two BoMs from one manufacturer.
Wiring	Other wiring	2%	4-Non-ferro	30 -Cu wire	Yes	Based on one BoM. This part is present only in one BoM.
	Wire winding	1%	4-Non-ferro	29 -Cu winding wire	Yes	Based on one BoM. This part is present only in one BoM.
Insulation	Plastic insulation	≤0.5%	1-BlkPlastics 7-Misc.	1 -LDPE 58 -Office paper	No	Average weight based on three BoMs from one manufacturer. Part made of both paper and plastic. Assumption made that paper is 80% and plastic remaining 20%. Because it is a single component made of two different materials, assumption was made that it is not recyclable as it might not be possible to separate them.

Hand dryer part	Description of component	Share in total product weight	Category	Material	Recyclable?	Assumptions
	Other insulators	≤0.5%	2-TecPlastics	17 -Flex PUR	No	Based on one BoM. This part is present only in one BoM. Assumption that rubber used in this part reflects Flex PUR and is difficult to collect because of few market outlets.
Accessories	Screws	2%	3-Ferro	23 -St tube/profile	Yes	Average weight based on four BoMs from two manufacturers.
	Plastic Bag for Wrench	≤0.5%	1-BlkPlastics	1 -LDPE	No	Average weight based on three BoMs from one manufacturer. Assumption that plastic packaging is unlikely to be recycled as local film collections vary widely.
	Nylon bushing	≤0.5%	2-TecPlastics	12 -PA 6 19 -E-glass fibre	No	Based on one BoM. This part is present only in one BoM. Because it is a single component made of two different materials, assumption was made that it is not recyclable as it might not be possible to separate them.
	Cable protector	≤0.5%	2-TecPlastics	12 -PA 6 19 -E-glass fibre	No	Based on one BoM. This part is present only in one BoM. Because it is a single component made of two different materials, assumption was made that it is not recyclable as it might not be possible to separate them.
Packaging	L-Wrench	≤0.5%	3-Ferro	23 -St tube/profile	Yes	Based on one BoM. This part is present only in one BoM.
	Cardboard box and packaging	13%	7-Misc.	57 -Cardboard	Yes	Based on one BoM. This part is present only in one BoM.

Hand dryer part	Description of component	Share in total product weight	Category	Material	Recyclable?	Assumptions
	Mounting Template	≤0.5%	7-Misc.	58 -Office paper	Yes	Based on one BoM. This part is present only in one BoM.
	Operating Instructions	≤0.5%	7-Misc.	58 -Office paper	Yes	Based on one BoM. This part is present only in one BoM.

Table 4.25 Extra components from manufacturers' BoMs not used in the category specific BoM

Component	Weight in g	Category	Material	Recyclable?	Assumption
Motor Gasket Ring and Prefilter screen plastic frame & Muffler housing	150.07	1-BlkPlastics	11 –ABS	Yes	Based on one BoM. This part is present only in one BoM. Assumption that it is included within other motor parts in the BoM above. Added as extra to avoid double counting.
Mylar shield with LNG marked	0.6	1-BlkPlastics	10 –PET	Yes	Based on one BoM. This part is present only in one BoM. Assumption that it is inclusive for the particular hand dryer model.
Knock out Gasket (EPDM)	6.4	1-BlkPlastics	1 - LDPE[147]	No	Based on one BoM. This part is present only in one BoM. Assumption that it is included within other motor parts in the BoM above and EPDM is not commonly recycled. Added as extra to avoid double counting.

[147] EPDM (or ethylene propylene diene monomer rubber) is a polymer which is not present in the MEERP EcoReport tool. It has been classified as LDPE in previous preparatory studies (such as lot 24: professional Washing Machines, Dryers and dishwashers Prep study, 2011 on page 5). LDPE has equivalent material properties to EPDM and is synthesized in a similar polymerization method. EPDM is usually made of around 60% LDPE which supports the equivalency being made. However, production would require more complicated input monomer chemicals (hence a higher energy footprint) and is not currently recycled. Future update of the EcoReport tool should look to include modelling figures for EPDM.

Component	Weight in g	Category	Material	Recyclable?	Assumption
Pressure tube	4.2	1-BlkPlastics	8 –PVC	No	Based on one BoM. This part is present only in one BoM. Assumption that it is inclusive for the particular hand dryer model and unlikely to be recycled or recovered as it typically is only ~1% of WEEE plastics.
Base plate / wall plate	414.60	1-BlkPlastics	11 –ABS	Yes	Average weight based on three BoMs from one manufacturer. Assumption that it is included under" mounting metal plate" in the BoM above. Added as extra to avoid double counting.
Motor Housing Bracket / Screws / Fan Shroud / Metal Disk / Terminal Connectors / Bolts / Washers / Screws / Brackets	205.20	3-Ferro	23 -St tube/profile	Yes	Average weight based on two BoMs from the same manufacturer. Assumption that it is included under "screws" and "brackets" in the BoM above. Added as extra to avoid double counting.

4.2.1.3 Category 4 High Speed Trough Style Hands In Dryer

The BoM presented in Table 4.26 refers to a high-speed trough-style hands in dryer. The total weight is 8.9kg, rising to 10kg including packaging. The average volume of the product is 43.9litres, rising to 74.22litres with packaging. These values are calculated from a sample of 13 published technical specifications.

Table 4.26 Category specific BoM for a high speed trough style hands in dryer

Hand dryer part	Description of component	Share in total product weight	Category	Material	Recyclable?	Assumptions
Housing/ casing	PCB cover	1%	1-BlkPlastics	4 -PP	Yes	Average weight of two BoMs from one manufacturer.
	Motor housing rubber	≤0.5%	1-BlkPlastics	1 -LDPE	No	Average weight of three BoMs from two manufacturers. Assumption that rubber is not commonly recycled.
	Cover/ hand dryer body /back cover	22%	1-BlkPlastics	11 -ABS	Yes	Average weight of three BoMs. It includes front cover, back cover and drying chamber. ABS chosen over PP as less than 5% by total weight of all cover parts in the three BoMs is PP only.
	Back plate / back panel	5%	3-Ferro	26 -Stainless 18/8 coil	Yes	Average weight of three BoMs. Stainless 18/8 coil chosen over ABS because of worse environmental impact.
	Power strip cover	≤0.5%	1-BlkPlastics	4 -PP	Yes	Average weight of two BoMs from one manufacturer.
	Wall support	14%	3-Ferro	26 -Stainless 18/8 coil	Yes	Average weight of three BoMs. Stainless 18/8 coil chosen over PP because of worse environmental impact.
	Steel bracket	3%	3-Ferro	26 -Stainless 18/8 coil	Yes	Average weight of three BoMs from two different manufacturers. Different materials in the BoMs. Stainless 18/8 coil is chosen (over St sheet galv) as it has worse environment impact.

Hand dryer part	Description of component	Share in total product weight	Category	Material	Recyclable?	Assumptions
Water tank	Water tank with float	2%	1-BlkPlastics	11- ABS	Yes	Average weight of three BoMs. ABS chosen over PP because of worse environmental impact.
	Drain tube	≤0.5%	1-BlkPlastics	8 -PVC	Yes	Average weight of two BoMs from one manufacturer.
Air flow ducting	Air outlet	4%	2-TecPlastics	13 -PC	Yes	Based on one manufacturer BoM. This part is present only in one BoM.
	Air inlet bracket	6%	1-BlkPlastics	11 -ABS	Yes	Based on one manufacturer BoM. This part is present only in one BoM.
Heating assembly	Heater assembly	1%	2-TecPlastics 5-Coating	19 – E-glass fibre (Mica) 41 - Cu/Ni/Cr plating (Nickel)	No	Based on one BoM. This part is present only in one BoM. Assumption for calculation that mica reflects E-glass fibre in terms of environmental impact and Nickel reflects Cu/Ni/Cr plating. Assumption that mica is not recyclable, and nickel is unlikely to be recycled in practice.
Motor	Motor shock absorber /gaskable gasket /motor rubber	1%	1-BlkPlastics	1 -LDPE	No	Average weight of three BoMs. Material LDPE chosen over TPE Plastic because of its availability in Eco-design BoM tool. Assumption that rubber is not commonly recycled.

Hand dryer part	Description of component	Share in total product weight	Category	Material	Recyclable?	Assumptions
	Blower housing	7%	2-TecPlastics	12 -PA 6 19 – E-glass fibre	No	Based on one BoM. This part is present only in one BoM. The part is made of both PA6 and E-glass fibre. Because it is a single component made of two different materials, assumption was made that it is not recyclable as it might not be possible to separate them.
	Motor	16%	3-Ferro	22 -St sheet galv.	Yes	Weight average of three BoMs. The component is a brush motor, with copper winding, metallic turbine with metal casing at the turbine zone, and plastic casing at the winding zone. Manufacturer state galvanized steel for most of the components (metallic turbine and metal casing). The weight share of each of the motor components is not known.
Filter	Prefilter	3%	3-Ferro	26 -Stainless 18/8 coil	Yes	Average weight of three BoMs. Stainless 18/8 coil chosen over PP because of worse environmental impact.
Electronics	Electronic circuit/PCB module	2%	6-Electronics	50 -PWB 1/2 lay 3.75kg/m2	Yes	Average weight of three BoMs. Material "PWB ½ lay…" chosen over controller board because of worse environmental impact.
	Sensor	≤0.5%	6-Electronics	98 -controller board	Yes	Based on one BoM. This part is present only in one BoM.
Accessories	Screws	1%	3-Ferro	23 -St tube/profile	Yes	Average weight of all screws/nuts and washers in three BoMs.

Hand dryer part	Description of component	Share in total product weight	Category	Material	Recyclable?	Assumptions
	Plastic parts of rawlplugs	≤0.5%	2-TecPlastics	12 -PA 6	Yes	Based on one BoM. This part is present only in one BoM.
	L-Wrench	≤0.5%	3-Ferro	22 -St sheet galv.	Yes	Based on one BoM. This part is present only in one BoM.
	C-Wrench	1%	3-Ferro	23 -St tube/profile	Yes	Based on one BoM. This part is present only in one BoM.
	Cleaning brush	≤0.5%	2-TecPlastics 3-Ferro	12 -PA 6 23 -St tube/profile	Yes	Average weight of two BoMs from one manufacturer. Assumed recyclable because it is likely that the metal and the nylon parts can be easily separated.
	Laser pointer protector	≤0.5%	1-BlkPlastics	4 -PP	Yes	Average weight of two BoMs from one manufacturer.
	Fastening	≤0.5%	3-Ferro	22 -St sheet galv.	Yes	Average weight of two BoMs from one manufacturer.
	Nylon holder	≤0.5%	2-TecPlastics	12 -PA 6	Yes	Average weight of two BoMs from one manufacturer.
	Terminal block	≤0.5%	1-BlkPlastics	11 -ABS	Yes	Based on one BoM. This part is present only in one BoM.

Hand dryer part	Description of component	Share in total product weight	Category	Material	Recyclable?	Assumptions
	Cable gland	≤0.5%	1-BlkPlastics	11 -ABS	Yes	Based on one BoM. This part is present only in one BoM.
Packaging	Packing box	10%	7-Misc.	57 -Cardboard	Yes	Average weight of three BoMs from two manufacturers.
	User Manual	≤0.5%	7-Misc.	58 -Office paper	Yes	Average weight of three BoMs from two manufacturers.
	Installation template	1%	7-Misc.	58 -Office paper	Yes	Average weight of three BoMs from two manufacturers.
	Labels	≤0.5%	1-BlkPlastics	2 -HDPE	Yes	Average weight of two BoMs from one manufacturer.
	Plastic bags	1%	1-BlkPlastics	1 -LDPE	Yes	Average weight of two BoMs from one manufacturer.

Table 4.27 Extra compounds from manufacturers' BoMs not included in the category specific BoM

Component	Weight in g	Category	Material	Recyclable?	Assumption
Main PCB module bracket	357.52	3-Ferro	26 -Stainless 18/8 coil	Yes	Based on one BoM. This part is present only in one BoM. Added as extra to avoid double counting with other brackets
Paper boards	502.95	7-Misc.	57 -Cardboard	Yes	Based on one BoM. This part is present only in one BoM. The packaging box is already included in

Component	Weight in g	Category	Material	Recyclable?	Assumption
					the BoM above. Paper boards added as extra to avoid double counting.
Motor brushes	15.7	2-TecPlastics 4-Non-ferro	12 -PA 6 31 -Cu tube/sheet	Yes	Based on one BoM. This part is present only in one BoM. This part is made of both nylon and copper. Motor brushes are included under "motor" in the BoM above and are added as extra to avoid double counting.
Frontal viewer	15	2-TecPlastics	13 –PC	Yes	Average weight of two BoMs from one manufacturer. This part is added as extra because only one manufacturer listed it and it is possible that it's an inclusive part only for its products.
Foam	227	1-BlkPlastics	6 –EPS	Yes	Average weight of two BoMs from one manufacturer. This part is added as extra because only one manufacturer listed it and it is possible that it's an inclusive part only for its products.
Inferior body foam	2	8-Extra	PE/Flex PUR	Yes	Average weight of two BoMs from one manufacturer. This part is added as extra because only one manufacturer listed it and it is possible that it's an inclusive part only for its products.
Motor casing	455	1-BlkPlastics	4 –PP	Yes	Average weight of two BoMs from one manufacturer. The BoM above includes motor casing under "motor". This part is added as extra to avoid double counting.
Deflector and deflector cover	391	1-BlkPlastics	5 –PP	Yes	Average weight of two BoMs from one manufacturer. This part is added as extra because only one manufacturer listed it and it is possible that it's an inclusive part only for its products.

Component	Weight in g	Category	Material	Recyclable?	Assumption
Drying chamber	252.5	1-BlkPlastics	11 –ABS	Yes	Based on one BoM. This part is present only in one BoM. This part is added as extra because only one manufacturer listed it and it is possible that it's an inclusive part only for its products.
Corrugated paper pad	23.94	7-Misc.	57 – Cardboard	Yes	Based on one BoM. This part is present only in one BoM. This part is added as extra because only one manufacturer listed it and it is possible that it's an inclusive part only for its products.
Ceramic absorber	332.3	3-Ferro	25 – Ferrite	No	Based on one BoM. This part is present only in one BoM. Manufacturer feedback suggests this is not a common feature.

4.2.2 Primary scrap production during sheet metal manufacturing

Primary scrap production during sheet metal manufacturing for hand dryers is approximately 22%. It is an average value based on responses from three hand dryer manufacturers. The highest scrap among these three figures is slightly above 28% and the lowest is 18%.

4.2.3 Means of Transport Employed

Based on the MEErP Methodology Report (2011) and EcoReport calculations, the distribution and retail phases consume between 75-127MJ of energy and produces 6-9kg eCO_2,17-27kg of eSO_2 and 79-254g of particulate matter (PM), depending on the hand dryer category. This includes shop and warehouse gas heating (shop - 0.5GJ per m^2, warehouse - 0.3GJ/m^2) and lighting (shop - 90kWh_e per m^2, warehouse – 0.54kWh_e/m^2), transport from the retailer central warehouse to the shop (200km, medium-sized truck) and transport from shop to the customer (20km, delivery van or customer's car, diesel, city-traffic). The size of shop and warehouse depends on product dimensions.

The energy consumption during distribution and retail phase is insignificant (0.16-0.61% of energy consumption during product lifetime). The significant environmental effect of this phase is PM emission, which makes up to 60% of total PM emission during the product lifetime.

For the purpose of repairing hand dryers, the assumption is made that technical visits require on average 20km of travel. The EcoReport tool calculates the energy consumption and environmental impacts created by assuming the distance is travelled using a diesel fuelled mini-van that consumes 2.41 MJ of fuel per km. Maintenance does not require travelling since it is assumed that staff responsible for maintenance of the hand dryer are based on site.

4.2.4 Material Flows

Table 4.28 presents the flow of materials from hand dryer components at the End of Life (EoL) phase.

The EoL values are estimated according to the MEErP EcoReport tool and consultation with distributors and recycling experts. Metals, cardboards and papers have the highest recycling rate. Most of the plastic components are landfilled or incinerated based on the assumption that most hand dryers go to informal recycling routes where there is likely little significant recovery of plastics. For ABS (Acrylonitrile Butadiene Styrene), PP (Polypropylene) and HIPS (High-Impact Polystyrene), a 30% recycling rate is assumed while for other plastics a 0% recycling is assumed. The recycling rate for plastics was calculated based on the weight fraction of ABS, PP and HIPS plastics in each type of dryer.

Table 4.28 Material flow for hand dryer components at the End of Life phase

EoL	Plastics	Ferro and Non-Ferro	Electronics	Miscellaneous (including cardboard and office paper)	Filter
Re-use	2.5%	2.5%	2.5%	2.5%	0%
Recycling	0-19%	93%	10%	84%	0%
Recovery	21-17%	0%	0%	0%	15%
Incineration	31-25%	0%	54%	2%	15%
Landfill	46-37%	5%	34%	11%	69%

Source: ICF

From discussions with distributors, a 2.5% fraction for re-use of hand dryer units is proposed. There is little evidence of direct reuse of hand dryers between installations (e.g. removal from one installation and redeployment to another). Most reuse or repair activity is in-situ and therefore deemed lifetime extension rather than a reuse. Some distributors recondition and resell items, but this is trivial volume.

Filters are assumed as not reusable or recyclable. The percentages for heat recovery (15%), incineration (15%) and landfill (69%) are adjusted values based on the default EcoReport values for auxiliaries.

Discussions with compliance schemes, recyclers and industry experts from across UK, DE & IT indicate hand dryers are rarely captured in formal WEEE recovery routes and typically end up in the informal (scrap metal) recycling system.

A European Commission event on "All WEEE Flows[148]" in 2017 reiterated the challenge in accurately identifying B2B WEEE collection and treatment figures and recommended engaging with the scrap metal recycling sector. There is no detail on category split in The Global E-waste Statistics Partnership[149] but this report puts the EU formal WEEE collection rate at 32% of the amount placed on the market. However, this reference does not account for informal recycling.

Based on the Table 9.6 from the Europa Study on collection rates of WEEE (2014 reference[150]) it is reasonable to assume there is good recovery & recycling of major metals in the informal recycling sector. This includes: steels, copper, aluminium, zinc and brass. Allowing for losses, wastage and mis-sorting reflects proposed 93% recycling rate to key metals that enter the recycling process with 5% losses due to shredding and sortation inefficiencies. Metals have the same EoL values as designed in EcoReport.

Based on the assumption that most hand dryers go to informal recycling routes there is no likely significant recovery of plastics and of precious and critical raw materials.

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148 http://ec.europa.eu/environment/waste/weee/events_weee_en.htm

149 Baldé, C.P., Forti V., Gray, V., Kuehr, R., Stegmann,P. : The Global E-waste Monitor – 2017, United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Vienna. https://globalewaste.org/countrystatistics/europe-2016/

150 http://ec.europa.eu/environment/waste/weee/pdf/Final_Report_Art7_publication.pdf

There is no reliable information on circuit board recovery from the scrap metal recycling sector. Where there are significant copper and aluminium parts on circuit boards, they may be recovered along with core metals. Therefore, a 10% recycling rate is proposed on Electronics components to account for this.

Eurostat provides data on municipal waste and packaging recycling[151]. The data for the EU28 countries shows that paper and card recycling rates are 84% as shown in the Table 4.28 above.

The percentages for heat recovery, incineration and landfill for plastics, electronics and miscellaneous are adjusted values based on the default EcoReport values.

[151] https://ec.europa.eu/eurostat/web/products-datasets/product?code=ten00063

5 INTRODUCTION TO TASK 5 ENVIRONMENT AND ECONOMICS

In Task 5, the data collected from Tasks 1-4 is used to provide an environmental and economic assessment of electric hand dryers. In Task 5, representative Base Cases (BCs) are defined to denote the average of a range of similar products. The Task 5 report serves as an important link between the work to date in the preparatory study and Tasks 6 (design options) and 7 (scenarios and sensitivity analysis).

The procedure used for this assessment follows the Methodology for the Ecodesign of Energy related Products (MEErP, 2011 and MEErP, 2014) as required by the European Commission for developing all preparatory studies under the Ecodesign Directive. Specifically, the EcoReport tool is used to perform a simplified Life Cycle Analysis (LCA) that considers all stages of a product's lifetime (i.e. production, distribution, use and end-of-life) to calculate the economic Life Cycle Costs (LCC) and the Societal Life Cycle Costs (SLCC) for each of the Base Cases.

While the real-life performance of these products might differ from the assumed performance, this study is based on the most reliable data available. These data have been provided by stakeholders (e.g. electric Hand dryer Association – eHA and individual hand dryer manufacturers) or extrapolated from the available literature.

5.1 OVERVIEW OF BASE CASES

The BCs were selected according to the MEErP guidelines, which consider products' market share, environmental impacts, and improvement potential. According to this methodology, products that have similar performance, functionality and Bill of Materials (BoM) can be represented by a single BC.

Based on the specifications provided and the methodology, Table 5.1 presents an overview of the BCs selected for the economic and environmental assessment. It includes information on the sales and stock and shows the percentage of each BC as a fraction of total EU28 in 2020. Sales were calculated based on Prodcom data and stock was calculated based on sales and the lifespan of the products.

Table 5.1 Overview of Hand Dryer Base Cases

	Overlay			
Technology Category	1	2, 3	4	5
Associated Base Case	BC1	BC2	BC3	No BC – negligible sales re. overall stock

Base Case	Product Category	EU28 Sales (2020) Units	%	EU28 Stock (2020) Units	%
BC1	Conventional single point hands under dryer	409,000	40%	5,179,000	62%
BC2	High speed single/multi point hands under dryer	431,000	42%	1,988,000	24%
BC3	High speed trough style hands in dryer	178,000	18%	1,120,000	14%

In chapter 1 five product categories are presented: conventional single point (category 1), high speed single point (category 2), high speed multi point (category 3), high speed trough style (category 4) and air taps (category 5). For the purpose of modelling the environmental and economic impacts, the selection of base cases takes into account technical and market aspects of these products. A base case can be a virtual product, and not represent an actual product type available on the market.

The three Base Cases presented in Table 5.1 cover category 1, 2, 3 and 4 products, which make up 99% of the stock of hand dryers in the EU. Category 1 is covered within BC1, Categories 2 & 3 are amalgamated into BC2 as the similarities between them outweigh the differences (principally the single vs. dual air stream), Category 4 is covered within BC3, and air taps are not covered within the modelling as their share of the market is not significant.

5.2 PRODUCT SPECIFIC CASES

This section presents all the inputs and assumptions used for the assessment of each BC as well as the corresponding references and justifications. Section 5.2.1 lists the assumptions that are not specific to each BC and that were used to model the impacts of all three. Sections 5.2.1, 5.2.3 and 5.2.4 present the inputs and assumptions that are specific to BC1, BC2 and BC3, respectively.

5.2.1 Inputs and Assumptions common to all BCs

5.2.1.1 *Discount Rate and Escalation Rate*

The discount and escalation rates used for all BCs were provided in the MEErP and are presented in Table 5.2.

Table 5.2 Discount Rate & Escalation Rate Inputs

Input / Assumption	Value	Source
Escalation rate (annual growth of running costs)	4% per year	MEErP, 2011
Discount Rate	4% per year	MEErP, 2011

5.2.1.2 *Electricity Rate*

The electricity rate used for all BCs was calculated based on the values and methodology provided in the MEErP[152] and are presented in Table 5.3. Electricity prices for the Industry in 2010 were adjusted using the annual escalation rate (4% annual growth of running costs) to estimate the electricity prices for the industry in 2020. The prices were sense checked against Eurostat EU28 electricity prices for non-household consumers on the second half of 2018.

Table 5.3 Electricity Prices

Input / Assumption	Value	Source
Electricity prices for the Industry EU28, 2020	0.15 € / kWh	Calculated based on MEErP, 2011
Electricity prices for the Industry EU27, 2010	0.10 € / kWh	MEErP, 2011
Price for non-household consumers, second half 2018 (for sense checking purposes only)	0.1149 € / kWh	Eurostat Electricity Price Statistics for EU28[153]

5.2.1.3 *Production Phase – Sheetmetal Scrap*

The EcoReport tool sets a default value of 25% (in % of mass metal input) for the primary scrap production during sheet metal manufacturing. This percentage was

[152]Section 2.3 of the *MEErP 2011 Methodology Part 1 - Final* provides guidance for estimating the electricity prices. Because hand dryers are not a household appliance, the electricity prices used were those presented in Section 2.4 for the Industry.

[153] Available at https://ec.europa.eu/eurostat/statistics-explained/images/4/44/Electricity_prices%2C_second_semester_of_2016-2018_%28EUR_per_kWh%29.png

adjusted to 21.64% (Table 5.4) based on an average of four values provided by the manufacturers.

Table 5.4 Primary scrap production during sheet metal manufacturing

Input / Assumption	Value	Source
Sheetmetal Scrap	21.64%	Manufacturers feedback

5.2.1.4 *End of Life (EoL) Phase*

Table 5.5 presents the assumptions for the End of Life section of the EcoReport tool. While most inputs are common to all BCs, different disposal figures were calculated for plastics depending on the composition of each BC. This section provides further information on how these values have been calculated.

Table 5.5 End of Life Assumptions

Per fraction (post-consumer)	1 & 2			3	4	5	6	7a	7b	7c	8	9
	Bulk Plastics & Tec Plastics			Ferro	Non-ferro	Coating	Electronics	Miscellaneous (cardboard and office paper)	Refrigerant	Hg (mercury), in mg/unit	Extra	Auxiliaries (filters)
	BC1	BC2	BC3	All BCs								
EoL mass fraction to re-use, in %	2.5%											0.0%
EoL mass fraction to (materials) recycling, in %	0%	11%	19%	93%			10%	84%	30%	38%	59%	0%
EoL mass fraction to (heat) recovery, in %	21%	19%	17%	0%			0%	0%	0%	0%	0%	15%
EoL mass fraction to non-recov. incineration, in %	31%	27%	25%	0%			54%	2%	5%	5%	10%	15%
EoL mass fraction to landfill/missing/fugitive, in %	46%	41%	37%	5%			34%	11%	63%	54%	29%	69%
TOTAL	100%	100%	100%	100%			100%	100%	100%	100%	100%	100%

Reuse

From earlier tasks and discussions with distributors, there is little evidence of direct reuse of hand dryers between installations (e.g. removal from one installation and redeployment to another). Most reuse or repair activity is in-situ and therefore deemed lifetime extension rather than a reuse proportion to include in the impact calculations. According to manufacturers, the percentage of products that are reconditioned and resold ranges between 0% and 5%. An average 2.5% fraction for reuse is used in the calculations. For auxiliaries (i.e. filters) the reuse is assumed to be 0%.

Recycling

Discussions with compliance schemes, recyclers and industry experts from across UK, DE & IT indicate that hand dryers are rarely captured in formal WEEE recovery routes and typically end up in the informal (scrap metal) recycling system. Therefore, the working assumption is that hand dryer recycling is modelled on scrap metal recovery systems rather than WEEE Approved Authorised Treatment Facility (AAFT) recovery systems.

Recycling – Metals at informal recyclers

Based on Table 9.6 from the Europa Study on collection rates of WEEE[154], it is reasonable to assume high recovery and recycling rates for major metals in the informal recycling sector. This includes steel, copper, aluminium, zinc and brass. Allowing for losses, wastage and mis-sorting, a 93% recycling rate is applied to key metals that enter the recycling process with 5% losses due to shredding and sortation inefficiencies.

Recycling – Plastics at informal recyclers

Based on the assumption that most hand dryers go to informal recycling routes there is likely little significant recovery of plastics. For ABS (Acrylonitrile Butadiene Styrene), PP (Polypropylene) and HIPS (High-Impact Polystyrene), a 30% recycling rate is assumed while for other plastics a 0% recycling is assumed. For each of the BCs, the recycling rate for plastics was calculated based on the weight fraction of ABS, PP and HIPS plastics in the BoM.

Table 5.6 Recycling rate for plastics at informal recyclers

Base Case	Plastics Recycling Rate	Source
BC1	0%	Calculated based on the weight fraction of ABS, PP and HIPS plastics in the BoM
BC2	11%	
BC3	19%	

Recycling – Electronics

There is no reliable information on circuit board recovery from the scrap metal recycling sector. In the absence of evidence to demonstrate circuit boards are recovered, a 0% allowance for recovery of circuit boards and the precious and critical metals in them is used for the modelling. Where there are significant copper and aluminium parts on circuit boards, they may be recovered along with core metals. A 10% recycling rate on Electronics components is allowed to account for this.

Recycling – Miscellaneous (i.e. Cardboard and paper)

The only materials categorised as miscellaneous in the BoM were cardboard and paper, mostly used in the packaging and the user manual. Thus, the input values are specific for these materials. Eurostat provides data on municipal waste and packaging recycling[155]. The data for the EU28 countries shows that paper and card recycling rates are 85%. The value used in the model has been adjusted to 84% when accounting for the 2.5% reuse fraction (versus the 1% default figure).

Heat Recovery, Incineration and Landfill / Missing / Fugitive

For plastics, metals, electronics, miscellaneous and auxiliaries the weight fractions that are disposed in heat recovery, incineration and landfill / missing / fugitive have been adjusted based on the aforementioned assumed recycling rates and the default percentages of the EcoReport tool. In other words, after the recyclability percentage was defined, the percentages for other EoL destinations was adjusted through keeping the

[154] Available at http://ec.europa.eu/environment/waste/weee/pdf/Final_Report_Art7_publication.pdf.

[155] Available at https://ec.europa.eu/eurostat/web/products-datasets/product?code=ten00063.

heat recovery : incineration : landfill / missing / fugitive ratios as per the EcoReport default and the totals adding up to 100%.

Refrigerant, Mercury and Extra

None of the materials in the BoMs of all three Base Cases fits into any of these categories. Thus, no assumptions have been made regarding them and the EcoReport tool default values have been kept unchanged with the percentages adjusted proportionally to account for the 2.5% reuse assumption (versus the 1% default figure).

Recyclability Benefit Rate

The EcoReport tool was last revised in 2014. The revisions incorporated into the tool allow the calculation of a recyclability benefit rate (RBR) for plastics, intended to compare different EoL scenarios under different design options. However, in the present Hand Dryers study, no assumptions have been made regarding RBR in modelling the BCs; this is solely due to lack of adequate evidence.

Fraction of Materials – Historic Inputs

The final input required in the EoL section of the EcoReport tool is the weight fraction of the different materials in units produced L years ago, where L is the product stock life. As per the default values in the tool and due to the lack of evidence (historic BoMs) these were assumed to be equal to the weight fractions of the different materials in current units. In other words, if a BC unit sold today is made out of 30% metal and 60% plastic, it is assumed that the same applied to one sold around 10 years ago. This assumption has been validated by manufacturers.

5.2.1.5 *Critical Raw Materials and Hazardous Materials*

CRM as per the EcoReport tool are: Germanium (Ge), Beryllium (Be), Tantalum (Ta), Indium (In), Platinum Group metals (PGM), Gallium (Ga), Antimony (Sb), Tungsten, Niobium (Nb), Rare earth elements (Sc, Y, Nd), Cobalt (Co), Graphite (C), Fluorspar (CaF_2), and Magnesium (Mg).

Hazardous materials as per the RoHS Directive are: Cadmium (Cd), Lead (Pb), Mercury (Hg), Hexavalent Chromium (Cr VI), Polybrominated Biphenyls (PBB), Polybrominated Diphenyl Ethers (PBDE), Bis(2-Ethylhexyl) phthalate (DEHP), Benzyl butyl phthalate (BBP), Dibutyl phthalate (DBP) and Diisobutyl phthalate (DIBP).

Since 2017, the EU has added neodymium to its official list of 27 critical raw materials. Within the list, neodymium is one of four Light Rare Earth Elements (LREE) [156]. According to EU research, neodymium is commonly used in permanent magnet motors [157]. Neodymium is not regulated in the revised Ecodesign regulation for motors, due to be formally published at the end of 2019[158]. However, within the new Ecodesign servers regulation, neodymium is included as an Information Requirement. Namely, from the 1 March 2020 suppliers shall provide an indicative weight range of Neodymium (<5g; between 5 and 25g and >25g). Hand dryer manufacturers are invited to confirm whether or not their motors contain neodymium.

[156] Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52017DC0490

[157] Available at https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/substitution-critical-raw-materials-low-carbon-technologies-lighting-wind-turbines-and

[158] Available at https://ec.europa.eu/energy/en/regulation-laying-down-ecodesign-requirements-1-october-2019

The Environmental Product Declarations published by UL[159] do not report on hazardous or critical materials used in the production of hand dryers.

5.2.1.6 *Test and Measurement Standard(s)*

As detailed in the Task 1 report, there is no single test and measurement standard which covers all aspects of performance and consumption data for hand dryers. There are no EN or ISO standards covering the product performance parameters for hand dryers. There are however at least two test standards specific to hand dryers which cover the product performance parameters. Namely, a national Member State independent verification scheme with associated test standard – the UK's Energy Technology List – and a global set of Product Category Rules for Environmental Product Declarations, produced by UL. To cover the range of hand dryer performance and consumption date, these standards would need to be supported by the Ecodesign regulation on standby (801/2013), the new suite of material efficiency standards under development (EN 45500-59), EN 60704-1 for measuring sound power and the BS EN ISO 29463 suite of filter standards.

5.2.2 BC1 – Conventional single point hands under dryer

This section presents all the inputs and assumptions used for the assessment of BC1 as well as the corresponding references and justifications.

5.2.2.1 *Production Phase*

Bill of Materials (BoM)

Table 5.7 shows the BoM for BC1, presenting aggregated data from manufacturer BoM submissions for conventional single point hands under dryers which are on the market.

Table 5.7 Bill of Materials of BC1 (Conventional single point hands under dryer)

Component	Material	Weight (g)
Casing	Metal	2,581
	Plastic	24
Motor	Metal	1,111
Packaging	Cardboard	667
	Plastic	174
Nozzle	Metal	612
	Plastic	4
Fan housing	Plastic	400
Accessories	Metal	272
	Plastic	3
Circuit board	Electronics	191
Fan	Metal	46
Heating element	Metal	25
	Plastic	25
Sensor assembly	Electronics	30
	Plastic	5
External ring	Plastic	11
	TOTAL	6,179

The total weight of an average BC1 equipment is 6.18 kg. The casing and the motor are the heaviest components, representing 42% and 18% of the total weight, respectively. Also, the packaging (14%) and the nozzle (10%) account for a significant share of the total weight.

Most of the materials in the BoM (61% in weight) were directly categorised into one of the default categories provided in the EcoReport tool. Exceptions and corresponding assumptions are listed in Table 5.8.

[159] Available at https://www.ul.com/resources/environmental-product-declarations-program.

Table 5.8 Assumptions related to the BoM of BC1

Component	Material	Weight (g)	Assumption
Motor Rotor, bearings, stator, windings, commutator and brushes	Stainless steel profile	1111	In different models, different materials were used. Manufacturers did not provide enough information to determine the weight fraction of the different materials. 100% of the weight was assumed to be steel profile - the dominant motor component in the high speed single and multi point hands under dryers (BC2) indicated during manufcturer consultation.
Casing Base plate	Diecast aluminium	878	In different models, different materials were used (Aluminium sheet or Aluminium diecast). Manufacturers provided feedback after consultation confirming the more common material used is diecast aluminium.
Fan housing Blower (fan) housing	PA 6	400	In different models, different materials were used (PA6 and Bulk Molding Compound). Conservatively, this component has been categorised PA6 as the weight fraction is larger for this material and as this is available in the EcoReport tool.
Heating element Heating assembly	Nickel plating	25	In different models, different materials were used (Coil or Nickel). Conservatively, it has been categorised as Nickel Plating as this is the closer material available in the EcoReport too and it has the worse environmental impact.
Sensor assembly Sensor rubber	PC	5	In different models, different materials were used (PC or LDPE). Conservatively, it has been categorised as PC as it has the worse environmental impacts, as per the EcoReport tool.
Accessories Cable protector	PA 6	1	The component is made out of PA6 and E-glass fiber with a weight ratio assumed to be 50/50.
Accessories Cable protector	E-glass fiber	1	

According to manufacturers, 25% of BC1 units are repaired throughout their lifetime. This repair consists of:

- Replacing the sensor unit, 75% of the times
- Replacing the carbon brush, 15% of the times
- Replacing the motor, 10% of the times

The BoM used in the modelling accounts for the weight of these additional components (i.e. a second sensor unit, a second carbon brush or a second motor) considering the probability of them being replaced. Further implications of this assumption are mentioned throughout the report.

5.2.2.2 *Distribution Phase*

Table 5.9 presents the inputs required for assessing the life cycle impacts in the distribution phase. The volume of a BC1 unit was estimated through averaging the actual volume of six conventional single point hands under dryers that are on the market.

Table 5.9 Inputs for the distribution phase of BC1

Input / Assumption	Value	Source
Is it an ICT or Consumer Electronics product <15kg?	No	Manufacturers' questionnaire
Is it an installed appliance?	Yes	Manufacturers' questionnaire
Volume of packaged final product	0.023 m^3	Calculated through averaging the actual packaged volume

		of 6 products currently on the market

5.2.2.3 *Use Phase*

As per Task 3, hand dryers only generate a direct impact, and no indirect impact.

Electricity Consumption

Table 5.10 presents the inputs considered to estimate the electricity consumption of a BC1 product. The units are assumed to always operate on standby in between the cycles.

Table 5.10 Electricity consumption inputs for BC1

Input / Assumption	Value	Source
Average number of cycles in a day	150 cycles / day	Manufacturers' questionnaire
Duration of cycles	17.17 seconds / cycle	From Task 3
Electricity consumption per cycle	7.94 Wh / cycle	Estimated through averaging the actual electricity consumption of products currently on the market
On-mode duration	0.72 hours / day 261 hours / year	Calculated
Standby-mode duration	23.28 hours / day 8,499 hours / year	Calculated
On-mode electricity consumption	1,665 Wh / hour	Calculated
Standby-mode electricity consumption	1.36 W	Estimated from averaging product datasheets

Water & Heat

Stakeholder consultation indicated that the operation of BC1 units does not consume any water or heat.

Consumables

BC1 units can operate with or without a filter. In the model, BC1 units are assumed to operate without filters.

Table 5.11 Filter usage for BC1

Input / Assumption	Value	Source
Percentage of BC1 units that operate with a filter	0 %	ICF
Filter usage per BC1 unit	0 filters / year 0 kg / year	ICF
Filter weight	80.15 g / filter	Calculated based on the weight of two different filters available on the market as provided by the manufacturers in the BoMs. The filters are assumed to not be category specific, i.e. the same consumable filter can be used in BC1, BC2 and BC3 units.

Product Life

The EcoReport tool requires inputs for the product service life – i.e. the period that the product is in use and operational – and the product stock life – which accounts for the time consumers keep the product stocked before they throw it away. The assumptions and inputs for estimating product service and stock life are presented in Table 5.12.

Table 5.12 Product life of BC1

Input / Assumption	Value	Source
Product service life (baseline)	10.9 years	Manufacturer questionnaires
Product service life (with repair)	13.63 years	Calculated
Stock time after service life (time that consumers keep the product stocked before throwing it away)	0.5 years	ICF
Percentage of products that are repaired	25%	Manufacturer feedback
Average product service life	11.6 years	Calculated based on the baseline service life, the service life with repair and the percentage of units that are repaired
Average product stock life	12.1 years	Calculated using the sum of the average product service life and the stock time after service life

BC1 units have a baseline service life of 10.9 years. The most common repairs for BC1 units are replacing the sensor (75% of times), replacing the carbon brushes (15% of times), or replacing the motor (10% of times). Replacing the motor or the carbon brushes is assumed to double a unit's service life and replacing the sensor is assumed to not affect the lifespan. The average product service life with repair was calculated based on the probabilities of each type of repair and how it affects the lifespan. To estimate the average service life of a unit, the percentage of units that are repaired was estimated at 25%, as mentioned in Section 5.2.2.1. Average service life has been estimated at 11.6 years and average stock life at 12.1 years, assuming consumers keep the product in stock (i.e. not in service but not disposed of) for 6 months before disposing of it.

Maintenance

The maintenance cost used in the model is the cost of labour for replacing the filters. Because BC1 units are assumed to operate without a filter, the total maintenance cost over the lifetime of a unit is was calculated at 0€. The distance travelled for maintenance per BC1 unit has also been estimated to zero km over its lifetime.

Table 5.13 Maintenance of BC1

Input / Assumption	Value	Source
Average maintenance cost over a BC1 unit lifetime	€ 0	Manufacturer questionnaires
Average km travelled for maintenance of a BC1 unit over its lifetime	0 km	ICF

Repair

According to manufacturers, 25% of BC1 units are repaired throughout their lifetime. This repair, as mentioned in Section 5.2.2.1, consists of:

- Replacing the sensor unit, 75% of the time
- Replacing the carbon brush, 15% of the time
- Replacing the motor, 10% of the time

The repair assumptions used in the modelling are presented below in Table 5.14.

Table 5.14 Repair of BC1

Input / Assumption	Value	Source
Percentage of products that are repaired	25%	Manufacturer feedback
Cost of material for repairing a BC1 unit	€ 27	Calculated based on the probability and cost of the different types of repairs (sensor, motor and carbon brushes)
Cost of labour for repairing a BC1 unit	€ 129	ICF
Total cost of repairing a BC1 unit	€ 156	Calculated based on the costs of labour and material
Average cost of repair per BC1 unit	€ 39	Calculated based on the total cost of repairing a BC1 unit and the percentage of products that are repaired
Number of technical visits per repair	2	ICF
Average km travelled per technical visit	20 km	ICF
Average km travelled per repair	40 km	Calculated based on the average km travelled per technical visit and the number of technical visits
Average km travelled for repair of a BC1 unit over its lifetime	10 km	Calculated based on the average km travelled per repair and the percentage of products that are repaired

5.2.2.4 *Economic Inputs*

The EcoReport tool requires inputs for sales and stock in the EU28. In Task 2, figures were estimated for both sales and stock in 2020 based on Prodcom historic sales data and product lifespan. The approach of using the most recent data has been taken to increase the relevance of this analysis and ensure it reflects the current scenario. The tool also requires the annual sales L years ago, where L is the product stock life. Stock and sales assumptions for BC1 are presented below in Table 5.15.

Table 5.15 Stock and Sales of BC1

Input / Assumption	Value	Source
BC1 EU28 Stock in 2020	5,179,000 units	Calculated
BC1 EU28 Annual Sales in 2020	409,000 units	Calculated
BC1 EU28 Annual Sales in 2008 (L is 12.1 and 2020 – 12.1 = 2008)	575,000 units	Calculated

Table 5.16 lists the price and cost assumptions inputs and assumptions. All values are in current prices.

Table 5.16 Price and cost assumptions for BC1

Input / Assumption	Value	Source
BC1 unit price	€ 188	Manufacturer questionnaires
Cost of installation of a BC1 unit	€ 100	Manufacturer questionnaires

Average Repair & Maintenance cost per unit over its lifetime	€ 39	Calculated based on the average maintenance cost over a BC1 unit lifetime and the average cost of repair per BC1 unit
Average filter price	€ 20 per unit	Manufacturer feedback
Cost of consumables – Filters	€ 250 per kg	Calculated based on the average filter price

Manufacturer feedback indicates that a new BC1 unit has the same efficiency as an average unit in the current stock. Thus, the ratio that compares the efficiency of the stock to the efficiency of a new unit has been set at 1.

Table 5.17 Efficiency Ratio for BC1

Input / Assumption	Value	Source
Efficiency Ratio	1	Manufacturer feedback

5.2.3 BC2 – High speed single/multi-point hands under dryer

This section presents all the inputs and assumptions used for the assessment of BC2 as well as the corresponding references and justifications. The MEErP states that when the BC is a virtual (non-existing) product, its characteristics should be an average sales-weighted of the characteristics of the individual products. All of the inputs listed in this section have been calculated as per the methodology, using the EU28 2020 sales of high-speed single point and high speed multi point hand dryers to weight individual characteristics for an average virtual BC2 unit.

5.2.3.1 *Production Phase*

Bill of Materials (BoM)

Table 5.18 shows the BoM for BC2, presenting aggregated data from manufacturer BoM submissions for high speed single point hands under dryers which are on the market.

Table 5.18 Bill of Materials of BC2 (High speed single/multi point hands under dryer)

Component	Material	Weight (g)
Casing	Plastic	1,821
	Metal	164
Motor	Plastic	764
	Metal	718
Packaging	Cardboard/paper	668
	Metal	9
Base plate assembly	Metal	237
Wiring	Metal	126
Accessories	Plastic	3
	Metal	79
Sensor	Electronics	79
Filter	Metal	62
Housing grommet	Plastic	43
Heating element assembly	Plastic	31
	Metal	14
Brackets	Metal	45
Air outlet	Plastic	36
Terminal block	Plastic	18
Control assembly	Electronics	16
Tamper Proof Bolt	Metal	12
Electronics	Electronics	11
Tamper Proof Wrench	Metal	9
Insulations	Paper	2
	Plastic	4
Fuse holder	Plastic	2
TOTAL		4,973

The total weight of an average BC2 equipment is 4.97 kg. The casing and the motor are the heaviest components, representing 40% and 30% of the total weight, respectively. Also, the packaging (14%) accounts for a significant share of the total weight.

Most of the materials in the BoM (64% in weight) were directly categorised into one of the default categories provided in the EcoReport tool. Exceptions and corresponding assumptions are listed in Table 5.19.

Table 5.19 Assumptions related to the BoM of BC2

Component	Material	Weight (g)	Assumption
Casing Product Casing	ABS	208	In different models, different materials were used (ABS/ Steel/ reinforced glass resin). The material used for the product casing heavily influences the weight of the final product. This is accounted for by considering a cover made of a mix of materilas with a weighted average composition proportional to BoMs provided.
Casing Product Casing	Steel	164	
Casing Product Casing	Glass reinforced resin	845	
Casing Blower housing	PA 6	245	In different models, different materials were used (PA 6 + E-glass fiber or ABS). Conservatively, this component has been categorised as PA 6 + E-glass fiber (50/50 weight fraction) as it has the worse environmental impacts, as per the EcoReport tool.
Casing Blower housing	E-glass fibre	245	
Motor Bearing housing	E-glass fibre	21	Glass reinforced resin is assumed to be made out of E-glass fiber and PET. Conservatively, this component has been categorised as E-glass fiber as it has the worse environmental impacts, as per the EcoReport tool.
Terminal block	Epoxy	18	In different models, different materials were used (Epoxy or ABS). Conservatively, this component has been categorised as Epoxy as it has the worse environmental impacts, as per the EcoReport tool.
Heating element assembly	E-glass fibre	14	The mica insulation has been categorised as E-glass fiber as this is the closer material available in the EcoReport tool.
Motor Muffler foam (input)	LDPE	5	Polyurethane foam has been assumed as LDPE.
Motor Muffler foam (output)	LDPE	3	Polyurethane foam has been assumed as LDPE.
Insulations Plastic insulation	Office paper	2	The component is made out of office paper and LDPE. The weight fractions have been assumed at 80/20.
Insulations Plastic insulation	LDPE	0	The component is made out of office paper and LDPE. The weight fractions have been assumed at 80/20.
Air outlet Nozzle gasket	Flex PUR	0.3	Neoprene foam has been assumes as Flex PUR.

According to manufacturers, 30% of BC2 units are repaired throughout their lifetime. This repair consists of:

- Replacing the PCB, 66.6% of the time
- Replacing the motor, 33.6% of the time

The BoM used in the modelling accounts for the weight of these additional components (i.e. a second PCB or a second motor) considering the probability of them being replaced. Further implications of this assumption are mentioned throughout the report.

5.2.3.2 *Distribution Phase*

Table 5.20 presents the inputs required for assessing the life cycle impacts in the distribution phase. The volume of a BC2 unit was estimated through averaging the actual volume of eight high speed single point hands under dryers and three high speed multi point hands under dryers that are on the market.

Table 5.20 Inputs for the distribution phase of BC2

Input / Assumption	Value	Source
Is it an ICT or Consumer Electronics product <15kg?	No	Manufacturers' questionnaire
Is it an installed appliance?	Yes	Manufacturers' questionnaire
Volume of packaged final product	0.032 m^3	Calculated through averaging the actual packaged volume of 11 products currently on the market

5.2.3.3 *Use Phase*

As per Task 3, hand dryers only generate a direct impact, and no indirect impact.

Electricity Consumption

Table 5.21 presents the inputs considered to estimate the electricity consumption of a BC2 product. The units are assumed to always operate on standby in between the cycles.

Table 5.21 Electricity consumption inputs for BC2

Input / Assumption	Value	Source
Average number of cycles in a day	150 cycles / day	Manufacturers' questionnaire
Duration of cycles	14.51 seconds / cycle	From Task 3
Electricity consumption per cycle	4.59 Wh / cycle	Estimated through averaging the actual electricity consumption of products currently on the market
On-mode duration	0.6 hours / day 220 hours / year	Calculated
Standby-mode duration	23.4 hours / day 8,539 hours / year	Calculated
On-mode electricity consumption	1,138 Wh / hour	Calculated
Standby-mode electricity consumption	1.11 W	Estimated from averaging product datasheets

Water & Heat

Stakeholder consultation indicated that the operation of BC2 units does not consume any water or heat.

Consumables

BC2 units should operate with disposable filters but this is not a requirement (i.e. they can operate without one). These filters should be replaced frequently. The consumable part of these filters is assumed to be made out of office paper.[160] Table 5.22 presents the inputs and assumptions for estimating yearly filter consumption per BC2 unit.

Table 5.22 Filter usage for BC2

Input / Assumption	Value	Source
Percentage of BC2 units that operate with a filter	30 %	Manufacturer feedback
Filter usage per BC2 unit	1 filter / year 0.02 kg / year	Manufacturer feedback
Filter weight	80.15 g / filter	Calculated based on the weight of two different filters available on the market as provided by the manufacturers in the BoMs. The filters are assumed to not be category specific, i.e. the same consumable filter can be used in BC1, BC2 and BC3 units.

[160] This approach is consistent to that taken in previous EcoDesign Prep Studies. Source: Work on Preparatory Studies for Eco-Design Requirements of EuPs - Lot 17 Vacuum Cleaners. Available at: https://www.eup-network.de/fileadmin/user_upload/Produktgruppen/Arbeitsplan/eup_lot17_final_report_issue_1.pdf Section 5.3 page 56.

Product Life

The EcoReport tool requires inputs for the product service life – i.e. the period that the product is in use and operational – and the product stock life – which accounts for the time consumers keep the product stocked before they throw it away. The assumptions and inputs for estimating product service and stock life are presented in Table 5.23.

Table 5.23 Product life of BC2

Input / Assumption	Value	Source
Product service life (baseline)	6.0 years	Manufacturer questionnaires
Product service life (with repair)	7.98 years	Calculated
Stock time after service life (time that consumers keep the product stocked before throwing it away)	0.5 years	ICF assumption due to lack of evidence
Percentage of products that are repaired	30%	Manufacturer feedback
Average product service life	6.59 years	Calculated based on the baseline service life, the service life with repair and the percentage of units that are repaired
Average product stock life	7.09 years	Calculated using the sum of the average product service life and the stock time after service life

BC2 units have a baseline service life of 6.0 years. The most common repairs for BC2 units are replacing PCB (66.6% of times) or replacing the motor (33.3% of times). Replacing the motor is assumed to double a unit's service life and replacing the PCB is assumed to not affect the lifespan. The average product service life with repair was calculated based on the probabilities of each type of repair and how it affects the lifespan. To estimate the average service life of a unit, the percentage of units that are repaired was estimated at 30%, as mentioned in Section 5.2.3.1. Average service life has been calculated at 6.6 years and average stock life at 7.1 years, assuming consumers keep the product in stock (i.e. not in service but not disposed of) for 6 months before disposing of it.

Maintenance

The maintenance cost used in the model is the cost of labour for replacing the filters which has been calculated at an average € 2.13 over a BC2 unit's lifetime in Task 2. The distance travelled for maintenance per BC2 unit has been estimated to zero km as it can be delivered by the building's facilities staff and does not require specific training or expertise.

Table 5.24 Maintenance of BC2

Input / Assumption	Value	Source
Average maintenance cost over a BC2 unit lifetime	€ 2.13	Manufacturer questionnaires
Average km travelled for maintenance of a BC2 unit over its lifetime	0 km	ICF assumption due to lack of evidence

Repair

According to manufacturers, 30% of BC2 units are repaired throughout their lifetime. This repair, as mentioned in Section 5.2.3.1, consists of:

- Replacing the PCB, 66.6% of the times
- Replacing the motor, 33.3% of the times

The repair assumptions used in the modelling are presented below in Table 5.25.

Table 5.25 Repair of BC2

Input / Assumption	Value	Source
Percentage of products that are repaired	30%	Manufacturer feedback
Cost of material for repairing a BC2 unit	€ 53	Calculated based on the probability and cost of the different types of repairs (PCB and motor)
Cost of labour for repairing a BC2 unit	€ 129	ICF
Total cost of repairing a BC2 unit	€ 182	Calculated based on the costs of labour and material
Average cost of repair per BC2 unit	€ 55	Calculated based on the total cost of repairing a BC2 unit and the percentage of products that are repaired
Number of technical visits per repair	2	ICF assumption due to lack of evidence
Average km travelled per technical visit	20 km	ICF assumption due to lack of evidence
Average km travelled per repair	40 km	Calculated based on the average km travelled per technical visit and the number of technical visits
Average km travelled for repair of a BC2 unit over its lifetime	12 km	Calculated based on the average km travelled per repair and the percentage of products that are repaired

5.2.3.4 *Economic Inputs*

The EcoReport tool requires inputs for sales and stock in the EU28. In Task 2, figures were estimated for both sales and stock in 2020 based on Prodcom historic sales data and product lifespan. The approach of using the most recent data has been taken to increase the relevance of this analysis and ensure it reflects the current scenario. The tool also requires the annual sales L years ago, where L is the product stock life. Stock and sales assumptions for BC2 are presented below in Table 5.26 and are the sum of the values for high speed single and multi point hands under dryers.

Table 5.26 Stock and Sales of BC2

Input / Assumption	Value	Source
BC2 EU28 Stock in 2020	1,988,000 units	Calculated
BC2 EU28 Annual Sales in 2020	431,000 units	Calculated
BC2 EU28 Annual Sales in 2013 (L is 7.09 and 2020 – 7.09 = 2013)	251,000 units	Calculated

Table 5.27 lists the price and cost assumptions inputs and assumptions. All values are in current prices.

Table 5.27 Price and cost assumptions for BC2

Input / Assumption	Value	Source
BC2 unit price	€ 351	Manufacturer questionnaires
Cost of installation of a BC2 unit	€ 100	Manufacturer questionnaires
Average Repair & Maintenance cost per unit over its lifetime	€ 57	Calculated based on the average maintenance cost over a BC2 unit lifetime and the average cost of repair per BC2 unit
Average filter price	€ 20 per unit	Manufacturer feedback
Cost of consumables – Filters	€ 250 per kg	Calculated based on the average filter price

The ratio that compares the efficiency of the stock to the efficiency of a new unit has been estimated using the sales per year calculated based on Prodcom data in Task 2, the average service life of a unit, and the yearly average efficiency of a unit sold. The model assumes that the decrease of the stock of units sold in a given year follows a normal distribution over time.

For BC2 units, historic average efficiency information was extracted from manufacturers data submitted for the Energy Technology List (ETL)[161] in 2013 (single point) and 2016 (multi point). For all other years, the average efficiency was estimated using a linear trend.

Data for the efficiency of new products (2019) has been extracted from product specifications available online. Because ETL is expected to include the most efficient products on the market, the 50% best values were used for estimating 2019 efficiency. Because sales and stock data used in the model are for 2020, the ratio was estimated considering the estimated efficiency of the stock and that of a new product in 2020. Manufacturers have validated the estimated efficiency ratio.

Table 5.28 Efficiency Ratio for BC2

Input / Assumption	Value	Source
Efficiency Ratio	0.93	Calculated based on yearly sales, yearly average efficiencies and product life

5.2.4 BC3 – High speed trough style hands in dryer

This section presents all the inputs and assumptions used for the assessment of BC3 as well as the corresponding references and justifications.

5.2.4.1 *Production Phase*

Bill of Materials (BoM)

Table 5.29 shows the BoM for BC3, presenting aggregated data from manufacturer BoM submissions for high speed trough style hands in dryers which are on the market.

[161] Available at: https://www.gov.uk/guidance/energy-technology-list.

Table 5.29 Bill of Materials of BC3 (High speed trough style hands in dryer)

Component	Material	Weight (g)
Housing/casing	Plastic	2,241
	Metal	2,165
Motor	Plastic	786
	Metal	1,566
Packaging	Paper/Cardboard	1,057
	Plastic	55
Air flow ducting	Plastic	952
Water tank	Plastic	247
Accessories	Plastic	51
	Metal	225
Filter	Metal	266
Electronic components	Eletronics	324
Heating assembly	Plastic	38
	Metal	38
TOTAL		10,011

The total weight of an average BC3 equipment is 10.01 kg. The housing/casing and the motor are the heaviest components, representing 44% and 23% of the total weight, respectively. Also, the packaging (11%) and the air flow (10%) account for a significant share of the total weight.

Most of the materials in the BoM (66% in weight) were directly categorised into one of the default categories provided in the EcoReport tool. Exceptions and corresponding assumptions are listed in Table 5.30.

Table 5.30 Assumptions related to the BoM of BC3

Component	Material	Weight (g)	Assumption
Housing/casing Wall Support	Stainless 18/8 coil	1407	In different models, different materials were used (PP or Steel). Conservatively, this component has been categorised as Stainless 18/8 Steel as it has the worse environmental impacts, as per the EcoReport tool.
Housing/casing Back plate / back panel	Stainless 18/8 coil	503	In different models, different materials were used (ABS or Steel). Conservatively, this component has been categorised as Stainless 18/8 Steel as it has the worse environmental impacts, as per the EcoReport tool.
Motor Blower housing	PA 6	348	The component is made out of PA6 and E-glass fiber with a weight ratio assumed to be 50/50.
Motor Blower housing	E-glass fibre	348	The component is made out of PA6 and E-glass fiber with a weight ratio assumed to be 50/50.
Filter Prefilter	Stainless 18/8 coil	266	In different models, different materials were used (PP or Steel). Conservatively, this component has been categorised as Stainless 18/8 Steel as it has the worse environmental impacts, as per the EcoReport tool.
Housing/casing Steel bracket	Stainless 18/8 coil	256	In different models, different materials were used (Stainless 18/8 Steel or Galvanised Steel Sheet). Conservatively, this component has been categorised as Stainless 18/8 Steel as it has the worse environmental impacts, as per the EcoReport tool.
Water tank Water tank with float	ABS	207	In different models, different materials were used (ABS or PP). Conservatively, this component has been categorised as ABS as it has the worse environmental impacts, as per the EcoReport tool.
Heating assembly Heater assembly nickel wire	Nickel plating	38	The nickel wire has been categorised as Nickel Plating as this is the closer material available in the EcoReport tool.
Heating assembly Heater assembly mica insulation	E-glass fibre	38	The mica insulation has been categorised as E-glass fiber as this is the closer material available in the EcoReport tool.

According to manufacturers, 30% of BC3 units are repaired throughout their lifetime. This repair consists of:

- Replacing the PCB, 66.6% of the times
- Replacing the motor, 33.6% of the times

The BoM used in the modelling accounts for the weight of these additional components (i.e. a second PCB or a second motor) considering the probability of them being replaced. Further implications of this assumption are mentioned throughout the report.

5.2.4.2 *Distribution Phase*

Table 5.31 presents the inputs required for assessing the life cycle impacts in the distribution phase. The volume of a BC3 unit was estimated through averaging the actual volume of 11 high speed trough style hands in dryers that are on the market.

Table 5.31 Inputs for the distribution phase of BC3

Input / Assumption	Value	Source
Is it an ICT or Consumer Electronics product <15kg?	No	Manufacturers questionnaire
Is it an installed appliance?	Yes	Manufacturers questionnaire
Volume of packaged final product	0.074 m^3	Calculated through averaging the actual packaged volume of 11 products currently on the market

5.2.4.3 *Use Phase*

As per Task 3, hand dryers only generate a direct impact, and no indirect impact.

Electricity Consumption

Table 5.32 presents the inputs considered to estimate the electricity consumption of a BC3 product. The units are assumed to always operate on standby in between the cycles.

Table 5.32 Electricity consumption inputs for BC3

Input / Assumption	Value	Source
Average number of cycles in a day	150 cycles / day	Manufacturers questionnaire
Duration of cycles	12.78 seconds / cycle	From Task 3
Electricity consumption per cycle	4.99 Wh / cycle	Estimated through averaging the actual electricity consumption of products currently on the market
On-mode duration	0.5 hours / day 194 hours / year	Calculated
Standby-mode duration	23.5 hours / day 8,566 hours / year	Calculated
On-mode electricity consumption	1,406 Wh / hour	Calculated
Standby-mode electricity consumption	1.51 W	Estimated from averaging product datasheets

Water & Heat

Stakeholder consultation indicated that the operation of BC3 units does not consume any water or heat.

Consumables

BC3 units should operate with disposable filters but this is not a requirement (i.e. they can operate without one). These filters should be replaced frequently. The consumable part of these filters is assumed to be made out of office paper.[162] Table 5.33 presents the inputs and assumptions for estimating yearly filter consumption per BC3 unit.

Table 5.33 Filter usage for BC3

Input / Assumption	Value	Source
Percentage of BC3 units that operate with a filter	100 %	Manufacturer feedback
Filter usage per BC3 unit	1 filter / year 0.08 kg / year	Manufacturer feedback
Filter weight	80.15 g / filter	Calculated based on the weight of two different filters available on the market as provided by the manufacturers in the BoMs. The filters are assumed to not be category specific, i.e. the same consumable filter can be used in BC1, BC2 and BC3 units.

Product Life

The EcoReport tool requires inputs for the product service life – i.e. the period that the product is in use and operational – and the product stock life – which accounts for the time consumers keep the product stocked before they throw it away. The assumptions and inputs for estimating product service and stock life are presented in Table 5.34.

Table 5.34 Product life of BC3

Input / Assumption	Value	Source
Product service life (baseline)	7.83 years	Manufacturer questionnaires
Product service life (with repair)	10.41 years	Manufacturer questionnaires
Stock time after service life (time that consumers keep the product stocked before throwing it away)	0.5 years	ICF assumption due to lack of evidence
Percentage of products that are repaired	30%	Manufacturer feedback
Average product service life	8.6 years	Calculated based on the baseline service life, the service life with motor replacing and the percentage of units that have its motor replaced
Average product stock life	9.1 years	Calculated using the sum of the average product service life and the stock time after service life

[162] This approach is consistent to that taken in previous EcoDesign Prep Studies. Source: Work on Preparatory Studies for Eco-Design Requirements of EuPs - Lot 17 Vacuum Cleaners. Available at: https://www.eup-network.de/fileadmin/user_upload/Produktgruppen/Arbeitsplan/eup_lot17_final_report_issue_1.pdf Section 5.3 page 56.

BC3 units have a baseline service life of 7.8 years. The most common repairs for BC2 units are replacing PCB (66.6% of times) or replacing the motor (33.3% of times). Replacing the motor is assumed to double a unit's service life and replacing the PCB is assumed to not affect the lifespan. The average product service life with repair was calculated based on the probabilities of each type of repair and how it affects the lifespan. To estimate the average service life of a unit, the percentage of units that are repaired was estimated at 30%, as mentioned in Section 5.2.4.1. Average service life has been calculated at 8.6 years and average stock life at 9.1 years, assuming consumers keep the product in stock (i.e. not in service but not disposed of) for 6 months before throwing it away.

Maintenance

The maintenance cost used in the model is the cost of labour for replacing the filters and emptying the water tray which has been calculated at an average € 178.36 over a BC3 unit's lifetime in Task 2. The distance travelled for maintenance per BC3 unit has been estimated to zero km as it can be delivered by the building's facilities staff and does not require specific training or expertise.

Table 5.35 Maintenance of BC3

Input / Assumption	Value	Source
Average maintenance cost over a BC3 unit lifetime	€ 178.36	Manufacturer questionnaires
Average km travelled for maintenance of a BC3 unit over its lifetime	0 km	ICF

Repair

According to manufacturers, 30% of BC3 units are repaired throughout their lifetime. This repair, as mentioned in Section 5.2.4.1, consists of:

- Replacing the PCB, 66.6% of the times
- Replacing the motor, 33.3% of the times

The repair assumptions used in the modelling are presented below in Table 5.36.

Table 5.36 Repair of BC3

Input / Assumption	Value	Source
Percentage of products that are repaired	30%	Manufacturer feedback
Cost of material for repairing a BC3 unit	€ 65	Calculated based on the probability and cost of the different types of repairs (PCB and motor)
Cost of labour for repairing a BC3 unit	€ 129	ICF assumption due to lack of evidence
Total cost of replacing a BC3 unit's motor	€ 194	Calculated based on the costs of labour and material
Average cost of repair per BC3 unit	€ 58	Calculated based on the total cost of repairing a BC3 unit and the percentage of products that are repaired
Number of technical visits per repair	2	ICF assumption due to lack of evidence
Average km travelled per technical visit	20 km	ICF assumption due to lack of evidence

Input / Assumption	Value	Source
Average km travelled per repair	40 km	Calculated based on the average km travelled per technical visit and the number of technical visits
Average km travelled for repair of a BC3 unit over its lifetime	12 km	Calculated based on the average km travelled per repair and the percentage of products that are repaired

5.2.4.4 *Economic Inputs*

The EcoReport tool requires inputs for sales and stock in the EU28. In Task 2, figures were estimated for both sales and stock in 2020 based on Prodcom historic sales data and product lifespan. The approach of using the most recent data has been taken to increase the relevance of this analysis and ensure it reflects the current scenario. The tool also requires the annual sales L years ago, where L is the product stock life. Stock and sales assumptions for BC3 are presented below in Table 5.37.

Table 5.37 Stock and Sales of BC3

Input / Assumption	Value	Source
BC3 EU28 Stock in 2020	1,120,000 units	Calculated
BC3 EU28 Annual Sales in 2020	178,000 units	Calculated
BC3 EU28 Annual Sales in 2011 (L is 9.1 and 2020 – 9.1 = 2011)	60,000 units	Calculated

Table 5.38 lists the price and cost assumptions inputs and assumptions. All values are in current prices.

Table 5.38 Price and cost assumptions for BC3

Input / Assumption	Value	Source
BC3 unit price	€ 715	Manufacturer questionnaires
Cost of installation of a BC3 unit	€ 100	Manufacturer questionnaires
Average Repair & Maintenance cost per unit over its lifetime	€ 237	Calculated based on the average maintenance cost over a BC3 unit lifetime and the average cost of repair per BC3 unit
Average filter price	€ 20 per unit	Manufacturer feedback
Cost of consumables – Filters (per kg)	€ 250 per kg	Calculated based on the average filter price

The ratio that compares the efficiency of the stock to the efficiency of a new unit has been estimated using the sales per year inputs provided by the manufacturers, the average service life of a unit, and the yearly average efficiency of a unit sold. The model assumes that the decrease of the stock of units sold each year follows a normal distribution over time.

For BC3 units, historic average efficiency information was extracted from manufacturers data submitted for ETL listing in 2012 and 2016. For all other years, the average efficiency was estimated using a linear trend.

Data for the efficiency of new products (2019) has been extracted from product specifications available online. Because ETL is expected to include the most efficient products on the market, the 50% best values were used for estimating 2019 efficiency. Because sales and stock data used in the model are for 2020, the ratio was estimated considering the estimated efficiency of the stock and that of a new product in 2020. Manufacturers have validated the estimated efficiency ratio.

Table 5.39 Efficiency Ratio for BC3

Input / Assumption	Value	Source
Efficiency Ratio	0.88	Calculated based on yearly sales, yearly average efficiencies and product life

5.3 BASE CASE ENVIRONMENTAL IMPACT

Within this sub-task the EcoReport 2014 tool has been used to calculate the outputs per environmental indicator and "cradle-to-grave" stages of product life for the hand dryers' base cases.

Table 5.40, Table 5.41 and Table 5.42 present the environmental impacts for BC1, BC2 and BC3, respectively. While the right column presents total values, the tables disaggregate impacts per life cycle phase. For production, impacts are estimated separately for the materials used and for the manufacturing process. For the EoL phase, impacts are estimated separately for the disposal (incineration, landfill, fugitive and missing) and the recycling (reuse, recycle and heat recovery).

Table 5.40 Life Cycle Impact per unit of BC1 (conventional single point)

Life Cycle Impact per conventional single point hands under dryer (BC1) unit over its lifetime

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Stock	
	Materials	**unit**									
1	Bulk Plastics	g			**189**		**2**	205	63	-77	**0**
2	TecPlastics	g			**457**		**5**	497	152	-187	**0**
3	Ferro	g			**3,114**		**31**	221	4,199	-1,275	**0**
4	Non-ferro	g			**1,540**		**15**	109	2,077	-631	**0**
5	Coating	g			**0**		**0**	0	0	0	**0**
6	Electronics	g			**227**		**2**	282	40	-93	**0**
7	Misc.	g			**667**		**7**	127	819	-273	**0**
8	Extra	g			**25**		**0**	13	22	-10	**0**
9	Auxiliaries	g			**0**		**0**	0	0	0	**0**
10	Refrigerant	g			**0**		**0**	0	0	0	**0**
	Total weight	g			**6,217**		**62**	1,454	7,371	-2,545	**0**
									see note!		
	Other Resources & Waste							debet	credit		
11	Total Energy (GER)	MJ	724	42	**767**	**75**	**46,523**	45	-146		**47,263**
12	of which, electricity (in primary MJ)	MJ	439	23	**461**	**0**	**46,520**	0	-61		**46,921**
13	Water (process)	ltr	102	1	**103**	**0**	**1**	0	-10		**93**
14	Water (cooling)	ltr	185	12	196	0	2,069	0	-26		2,240
15	Waste, non-haz./ landfill	g	3,933	128	**4,062**	**62**	**24,010**	157	-1,787		**26,504**
16	Waste, hazardous/ incinerated	g	91	0	**91**	**1**	**735**	0	-8		**819**
	Emissions (Air)										
17	Greenhouse Gases in GWP100	kg CO2 eq.	41	2	**43**	**6**	**1,986**	0	-9		**2,027**
18	Acidification, emissions	g SO2 eq.	294	11	**304**	**17**	**8,789**	3	-51		**9,062**
19	Volatile Organic Compounds (VOC)	g	1	0	**2**	**1**	**1,039**	0	0		**1,041**
20	Persistent Organic Pollutants (POP)	ng i-Teq	118	1	**118**	**0**	**110**	0	-61		**167**
21	Heavy Metals	mg Ni eq.	141	1	**143**	**3**	**472**	2	-30		**590**
22	PAHs	mg Ni eq.	53	0	**53**	**4**	**109**	0	-11		**154**
23	Particulate Matter (PM, dust)	g	170	2	**172**	**79**	**188**	17	-18		**437**
	Emissions (Water)										
24	Heavy Metals	mg Hg/20	62	0	**62**	**0**	**201**	0	-13		**251**
25	Eutrophication	g PO4	4	0	**4**	**0**	**9**	1	-1		**13**

Table 5.41 Life Cycle Impact per unit of BC2 (high speed single/multi point)

Life Cycle Impact per high speed single/multi point hands under dryer (BC2) unit over its lifetime

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Stock	
	Materials	**unit**									
1	Bulk Plastics	g			**1,079**		**11**	432	203	455	**0**
2	TecPlastics	g			**1,647**		**16**	660	310	694	**0**
3	Ferro	g			**989**		**10**	29	553	417	**0**
4	Non-ferro	g			**555**		**6**	16	310	234	**0**
5	Coating	g			**0**		**0**	0	0	0	**0**
6	Electronics	g			**111**		**1**	57	8	47	**0**
7	Misc.	g			**670**		**7**	53	342	282	**0**
8	Extra	g			**0**		**0**	0	0	0	**0**
9	Auxiliaries	g			**0**		**159**	78	14	66	**0**
10	Refrigerant	g			**0**		**0**	0	0	0	**0**
	Total weight	g			**5,052**		**209**	1,326	1,741	2,195	**0**
									see note!		
	Other Resources & Waste							debet	credit		
11	Total Energy (GER)	MJ	442	137	**579**	**84**	**15,471**	9	-42		**16,102**
12	of which, electricity (in primary MJ)	MJ	116	74	**190**	**0**	**15,463**	0	-6		**15,647**
13	Water (process)	ltr	125	2	**127**	**0**	**1**	0	-10		**118**
14	Water (cooling)	ltr	632	38	671	0	693	0	-33		1,331
15	Waste, non-haz./ landfill	g	1,595	415	**2,009**	**66**	**7,994**	50	-209		**9,910**
16	Waste, hazardous/ incinerated	g	164	0	**165**	**1**	**246**	0	-6		**406**
	Emissions (Air)										
17	Greenhouse Gases in GWP100	kg CO2 eq.	23	8	**31**	**7**	**660**	0	-2		**695**
18	Acidification, emissions	g SO2 eq.	225	35	**260**	**19**	**2,923**	1	-30		**3,173**
19	Volatile Organic Compounds (VOC)	g	1	0	**1**	**1**	**345**	0	0		**347**
20	Persistent Organic Pollutants (POP)	ng i-Teq	11	1	**12**	**0**	**36**	0	-2		**46**
21	Heavy Metals	mg Ni eq.	61	3	**64**	**3**	**157**	0	-12		**213**
22	PAHs	mg Ni eq.	34	0	**34**	**4**	**36**	0	-7		**67**
23	Particulate Matter (PM, dust)	g	34	6	**40**	**111**	**62**	1	-5		**209**
	Emissions (Water)										
24	Heavy Metals	mg Hg/20	141	0	**141**	**0**	**68**	0	-17		**192**
25	Eutrophication	g PO4	7	0	**7**	**0**	**4**	1	-1		**11**

Table 5.42 Life Cycle Impact per unit of BC3 (high speed trough style)

Life Cycle Impact per high speed trough style hands in dryer (BC3) unit over its lifetime

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Stock	
	Materials	**unit**									
1	Bulk Plastics	g			**3,305**		**33**	700	437	2,202	**0**
2	TecPlastics	g			**1,140**		**11**	241	151	759	**0**
3	Ferro	g			**4,377**		**44**	75	1,430	2,916	**0**
4	Non-ferro	g			**0**		**0**	0	0	0	**0**
5	Coating	g			**38**		**0**	1	12	25	**0**
6	Electronics	g			**306**		**3**	92	13	204	**0**
7	Misc.	g			**1,057**		**11**	49	315	704	**0**
8	Extra	g			**0**		**0**	0	0	0	**0**
9	Auxiliaries	g			**0**		**690**	199	36	455	**0**
10	Refrigerant	g			**0**		**0**	0	0	0	**0**
	Total weight	g			**10,223**		**792**	1,356	2,394	7,265	**0**
									see note!		
	Other Resources & Waste							debet	credit		
11	Total Energy (GER)	MJ	928	290	**1,218**	**127**	**22,197**	10	-60		**23,492**
12	of which, electricity (in primary MJ)	MJ	279	152	**432**	**0**	**22,168**	0	-20		**22,579**
13	Water (process)	ltr	314	5	**320**	**0**	**3**	0	-29		**294**
14	Water (cooling)	ltr	849	79	928	0	993	0	-31		1,890
15	Waste, non-haz./ landfill	g	7,721	957	**8,679**	**85**	**11,544**	63	-879		**19,492**
16	Waste, hazardous/ incinerated	g	517	1	**518**	**2**	**355**	0	-11		**864**
	Emissions (Air)										
17	Greenhouse Gases in GWP100	kg CO2 eq.	50	17	**67**	**9**	**947**	0	-4		**1,019**
18	Acidification, emissions	g SO2 eq.	400	75	**475**	**27**	**4,193**	1	-33		**4,663**
19	Volatile Organic Compounds (VOC)	g	2	1	**2**	**2**	**495**	0	0		**499**
20	Persistent Organic Pollutants (POP)	ng i-Teq	82	10	**92**	**0**	**53**	0	-11		**134**
21	Heavy Metals	mg Ni eq.	466	23	**488**	**4**	**229**	0	-59		**663**
22	PAHs	mg Ni eq.	9	1	**10**	**6**	**52**	0	0		**67**
23	Particulate Matter (PM, dust)	g	75	14	**88**	**254**	**91**	1	-5		**429**
	Emissions (Water)										
24	Heavy Metals	mg Hg/20	291	1	**292**	**0**	**98**	0	-32		**359**
25	Eutrophication	g PO4	15	0	**15**	**0**	**8**	1	-2		**23**

For all three Base Cases, the Production and Use phases account for most of the environmental impacts created. Table 5.43 compares the impacts in these two life cycle phases between the different BCs. Figure 5.1 compares energy consumption in the production and use phases between the different BCs. Figure 5.2 compares GHG emissions in the use phase between the different BCs. Figure 5.3 compares acidification emissions in the production and use phases between the different BCs.

Table 5.43 Impacts in the Production and Use phase for all Base Cases

		BC1		BC2		BC3	
		PRODUCTION	USE	PRODUCTION	USE	PRODUCTION	USE
Other Resources & Waste							
Total Energy (GER)	MJ	767	46,523	579	15,471	1,218	22,197
of which, electricity (in primary MJ)	MJ	461	46,520	190	15,463	432	22,168
Water (process)	ltr	103	1	127	1	320	3
Water (cooling)	ltr	196	2,069	671	693	928	993
Waste, non-haz./ landfill	g	4,062	24,010	2,009	7,994	8,679	11,544
Waste, hazardous/ incinerated	g	91	735	165	246	518	355
Emissions (Air)							
Greenhouse Gases in GWP100	kg CO2 eq.	43	1,986	31	660	67	947
Acidification, emissions	g SO2 eq.	304	8,789	260	2,923	475	4,193
Volatile Organic Compounds (VOC)	g	2	1,039	1	345	2	495
Persistent Organic Pollutants (POP)	ng i-Teq	118	110	12	36	92	53
Heavy Metals	mg Ni eq.	143	472	64	157	488	229
PAHs	mg Ni eq.	53	109	34	36	10	52
Particulate Matter (PM, dust)	g	172	188	40	62	88	91
Emissions (Water)							
Heavy Metals	mg Hg/20	62	201	141	68	292	98
Eutrophication	g PO4	4	9	7	4	15	8

Figure 5.1 Total Energy Consumption in the Production and Use phases for all Base Cases

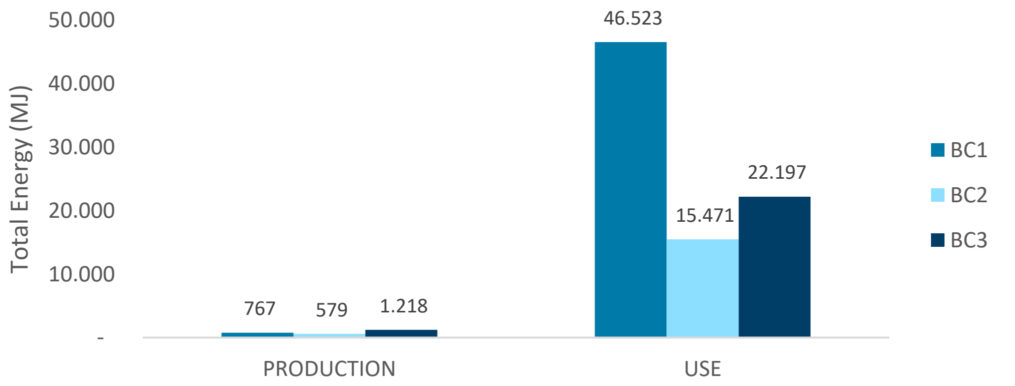


Figure 5.2 GHG Emissions in GWP100 in the Use phase for all Base Cases

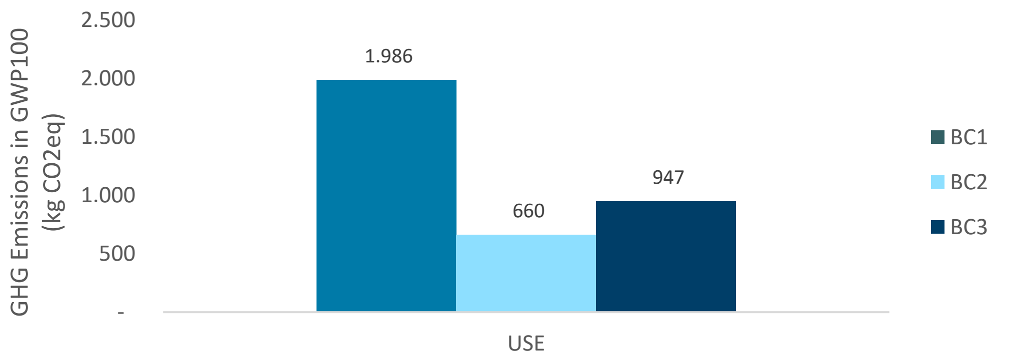
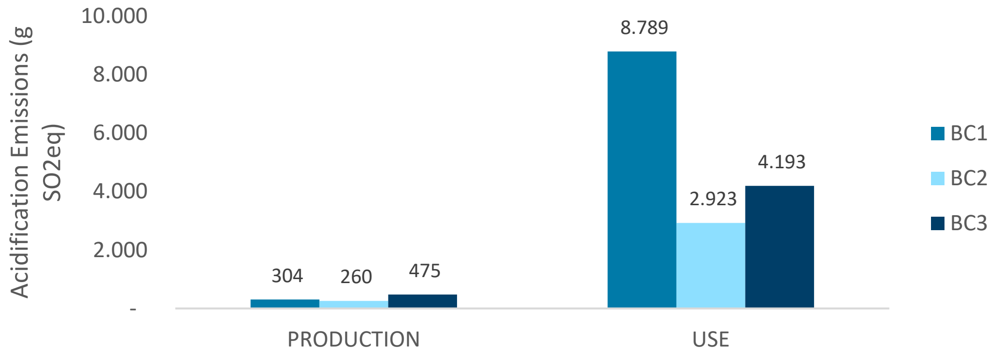


Figure 5.3 Acidification Emissions in the Production and Use phases for all Base Cases



While Figure 5.1, Figure 5.2 and Figure 5.3 compare the total energy consumption and total GHG and acidification emissions over a product's lifetime, the figures presented are affected by the length of a product's lifespan. Figure 5.4, Figure 5.5 and Figure 5.6 present the average impacts on a per year basis of the total impacts (i.e. sum of the impacts in the production, distribution, use and end of life phases) allowing for a fairer comparison between the different BCs.

Figure 5.4 Average Yearly Energy Consumption for all Base Cases

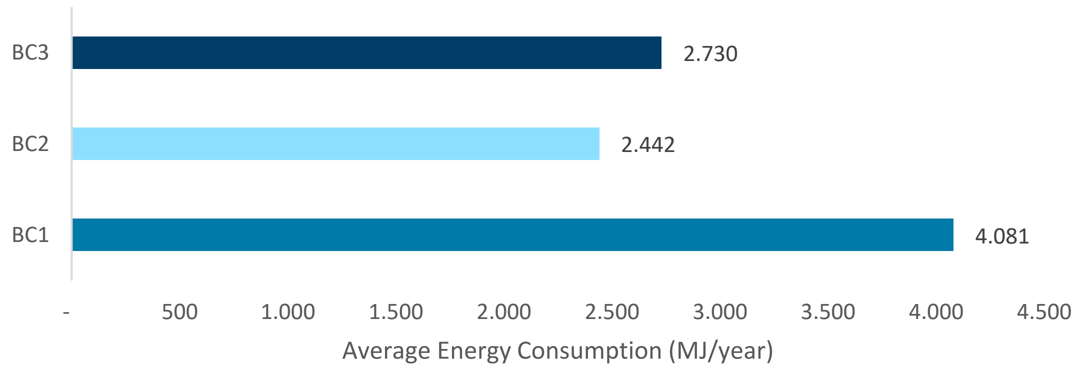


Figure 5.5 Average Yearly GHG Emissions for all Base Cases

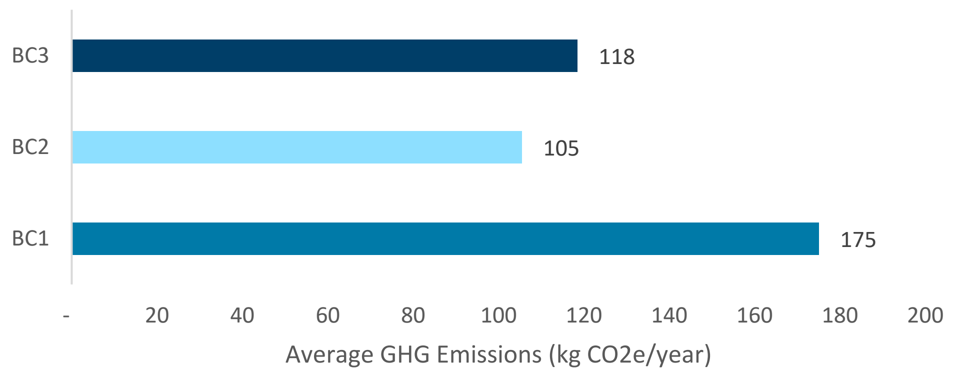
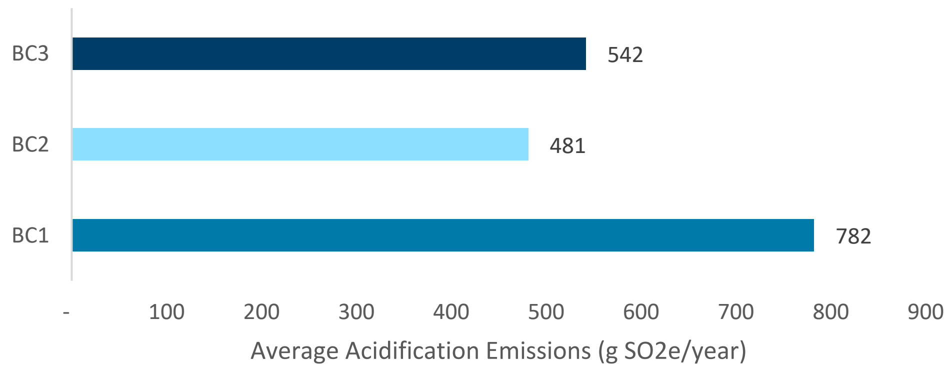


Figure 5.6 Average Yearly Acidification Emissions for all Base Cases



5.4 BASE CASE LIFE CYCLE COST FOR CONSUMERS

This section presents the life cycle costs for hand dryer consumers. Table 5.44 shows the estimated averages for the product price, the installation cost, the cost of electricity, the cost of replacing a unit's filters and the total repair and maintenance costs throughout the whole lifespan of a unit.

Table 5.44 Life Cycle Costs for all Base Cases

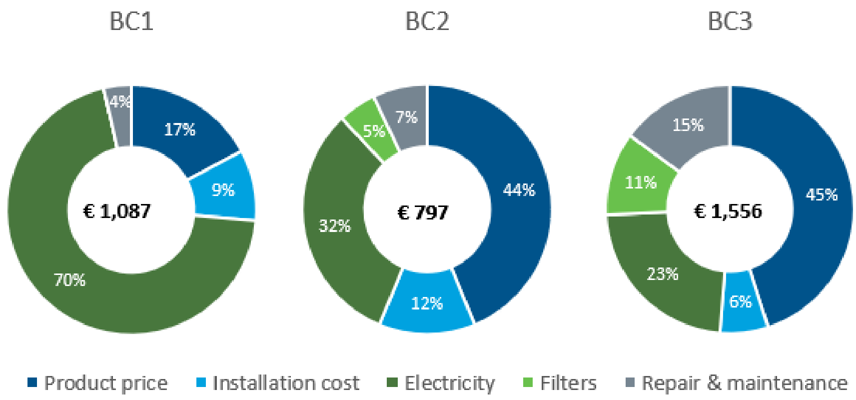
	BC1 Conventional Single Point	BC2 High speed single/multi point	BC3 High speed trough style
Product price (€)	188	351	715
Installation cost (€)	100	100	100
Electricity (€)	765	254	364
Filters (€)	0	40	172
Repair & maintenance (€)	39	57	237
TOTAL (€)	1,092	802	1,588

While installation cost is the same for all BCs, the average price of a trough style hand dryer is much higher than of a conventional or high speed unit. The different costs of electricity reflect the difference in electricity consumption of each Base Case.

Maintenance and repair costs for BC3 products are higher because these units require more filter changes and also emptying of the water tray. Furthermore, these figures reflect the assumptions on the percentage of units that are repaired, the types and costs of repair, which are specific to each Base Case. The cost of filters is estimated based on filter price and filter consumption inputs.

Figure 5.7 shows the fraction of each of the costs inferred by the consumer for each of the BCs.

Figure 5.7 Fraction of the different costs over the product life cycle



While for BC1 units the electricity cost is the most significant cost to consumers, for BC2 and BC3 units the product price is the largest fraction of the total cost.

5.5 BASE CASE LIFE CYCLE COSTS FOR SOCIETY

On top of the life cycle costs that consumers pay, the EcoReport tool calculates the societal costs, i.e. the cost of externalities that occur as a consequence of production, distribution, use and end of life of hand dryer units. These outputs are calculated based on the environmental impacts created and the respective rates for each of these impacts (e.g. € per kgCO_2eq, € per kgSO_2eq).

Table 5.45 presents the EcoReport tool outputs for the societal life cycle costs of all BCs per phase and Table 5.46 presents the total life cycle costs calculated in the tool (consumer expenditure plus societal costs).

Table 5.45 Life Cycle Costs for Society per phase for all BCs

	BC1	BC2	BC3
	Conventional Single Point	High speed single/multi point	High speed trough style
Production and Distribution (€)	7	5	11
Use (€)	106	35	51
End of Life (€)	1	0	0
TOTAL (€)	115	41	62

Table 5.46 Total Life Cycle Costs for all BCs

	BC1	BC2	BC3
	Conventional Single Point	High speed single/multi point	High speed trough style
Life Cycle Cost (€)	1,092	802	1,588
Life Cycle Cost to Society (€)	115	41	62
TOTAL (€)	1,207	843	1,650

5.6 EU TOTALS

This section presents the EcoReport tool outputs at EU-28 level.

5.6.1 *Lifecycle Environmental Impact at EU-28 Level*

Table 5.47 EU28 Total Impact of New BC1 units sold in 2020 over their lifetime

EU28 Total Impact of New BC1 units sold in 2020 over their lifetime

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Stock	
	Materials	**unit**									
1	Bulk Plastics	kt			**0.077**		**0.001**	0.084	0.026	-0.032	**0.000**
2	TecPlastics	kt			**0.187**		**0.002**	0.203	0.062	-0.076	**0.000**
3	Ferro	kt			**1.274**		**0.013**	0.090	1.717	-0.521	**0.000**
4	Non-ferro	kt			**0.630**		**0.006**	0.045	0.849	-0.258	**0.000**
5	Coating	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
6	Electronics	kt			**0.093**		**0.001**	0.115	0.016	-0.038	**0.000**
7	Misc.	kt			**0.273**		**0.003**	0.052	0.335	-0.112	**0.000**
8	Extra	kt			**0.010**		**0.000**	0.006	0.009	-0.004	**0.000**
9	Auxiliaries	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
10	Refrigerant	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
	Total weight	kt			**2.543**		**0.025**	0.595	3.015	-1.041	**0.000**
									see note!		
	Other Resources & Waste							debet	credit		
11	Total Energy (GER)	PJ	0.296	0.017	**0.314**	**0.031**	**19.028**	0.018	-0.060	0.000	**19.331**
12	of which, electricity (in primary PJ)	PJ	0.179	0.009	**0.189**	**0.000**	**19.027**	0.000	-0.025	0.000	**19.191**
13	Water (process)	mln. m3	0.042	0.000	**0.042**	**0.000**	**0.000**	0.000	-0.004	0.000	**0.038**
14	Water (cooling)	mln. m3	0.076	0.005	**0.080**	**0.000**	**0.846**	0.000	-0.011	0.000	**0.916**
15	Waste, non-haz./ landfill	kt	1.609	0.053	**1.661**	**0.025**	**9.820**	0.064	-0.731	0.000	**10.840**
16	Waste, hazardous/ incinerated	kt	0.037	0.000	**0.037**	**0.001**	**0.301**	0.000	-0.003	0.000	**0.335**
	Emissions (Air)										
17	Greenhouse Gases in GWP100	mt CO2 eq.	0.017	0.001	**0.018**	**0.002**	**0.812**	0.000	-0.004	0.000	**0.829**
18	Acidification, emissions	kt SO2 eq.	0.120	0.004	**0.124**	**0.007**	**3.595**	0.001	-0.021	0.000	**3.706**
19	Volatile Organic Compounds (VOC)	kt	0.001	0.000	**0.001**	**0.000**	**0.425**	0.000	0.000	0.000	**0.426**
20	Persistent Organic Pollutants (POP)	g i-Teq	0.048	0.000	**0.048**	**0.000**	**0.045**	0.000	-0.025	0.000	**0.068**
21	Heavy Metals	ton Ni eq.	0.058	0.001	**0.058**	**0.001**	**0.193**	0.001	-0.012	0.000	**0.241**
22	PAHs	ton Ni eq.	0.021	0.000	**0.022**	**0.001**	**0.045**	0.000	-0.005	0.000	**0.063**
23	Particulate Matter (PM, dust)	kt	0.069	0.001	**0.070**	**0.032**	**0.077**	0.007	-0.007	0.000	**0.179**
	Emissions (Water)										
24	Heavy Metals	ton Hg/20	0.026	0.000	**0.026**	**0.000**	**0.082**	0.000	-0.005	0.000	**0.103**
25	Eutrophication	kt PO4	0.002	0.000	**0.002**	**0.000**	**0.004**	0.000	0.000	0.000	**0.005**

Table 5.48 EU28 Total Impact in 2020 of BC1 units in Stock (produced, in use, discarded)

EU28 Total Impact in 2020 of BC1 units in Stock (produced, in use, discarded)

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Stock	
	Materials	**unit**									
1	Bulk Plastics	kt			**0.077**		**0.001**	0.084	0.026	-0.032	**0.000**
2	TecPlastics	kt			**0.187**		**0.002**	0.203	0.062	-0.076	**0.000**
3	Ferro	kt			**1.274**		**0.013**	0.090	1.717	-0.521	**0.000**
4	Non-ferro	kt			**0.630**		**0.006**	0.045	0.849	-0.258	**0.000**
5	Coating	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
6	Electronics	kt			**0.093**		**0.001**	0.115	0.016	-0.038	**0.000**
7	Misc.	kt			**0.273**		**0.003**	0.052	0.335	-0.112	**0.000**
8	Extra	kt			**0.010**		**0.000**	0.006	0.009	-0.004	**0.000**
9	Auxiliaries	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
10	Refrigerants	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
	Total weight	kt			**2.543**		**0.025**	0.595	3.015	-1.041	**0.000**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0.296	0.017	**0.314**	**0.031**	**20.804**	0.018	-0.060	0.000	**21.149**
9	of which, electricity (in primary PJ)	PJ	0.179	0.009	**0.189**	**0.000**	**20.803**	0.000	-0.025	0.000	**20.992**
10	Water (process)	mln. m3	0.042	0.000	**0.042**	**0.000**	**0.000**	0.000	-0.004	0.000	**0.042**
11	Water (cooling)	mln. m3	0.076	0.005	**0.080**	**0.000**	**0.925**	0.000	-0.011	0.000	**1.006**
12	Waste, non-haz./ landfill	kt	1.609	0.053	**1.661**	**0.025**	**10.737**	0.064	-0.731	0.000	**12.424**
13	Waste, hazardous/ incinerated	kt	0.037	0.000	**0.037**	**0.001**	**0.329**	0.000	-0.003	0.000	**0.366**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	Mt CO2 eq.	0.017	0.001	**0.018**	**0.002**	**0.888**	0.000	-0.004	0.000	**0.908**
16	Acidification, emissions	kt SO2 eq.	0.120	0.004	**0.124**	**0.007**	**3.930**	0.001	-0.021	0.000	**4.062**
17	Volatile Organic Compounds (VOC)	kt	0.001	0.000	**0.001**	**0.000**	**0.465**	0.000	0.000	0.000	**0.465**
18	Persistent Organic Pollutants (POP)	g i-Teq	0.048	0.000	**0.048**	**0.000**	**0.049**	0.000	-0.025	0.000	**0.098**
19	Heavy Metals	ton Ni eq.	0.058	0.001	**0.058**	**0.001**	**0.211**	0.001	-0.012	0.000	**0.271**
	PAHs	ton Ni eq.	0.021	0.000	**0.022**	**0.001**	**0.049**	0.000	-0.005	0.000	**0.072**
20	Particulate Matter (PM, dust)	kt	0.069	0.001	**0.070**	**0.032**	**0.084**	0.007	-0.007	0.000	**0.187**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**0**	**0**	**0**	0	0	0	**0**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	0	**0**

Table 5.49 EU28 Total Impact of New BC2 units sold in 2020 over their lifetime

	EU28 Total Impact of New BC2 units sold in 2020 over their lifetime										
	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Stock	
	Materials	**unit**									
1	Bulk Plastics	kt			**0.465**		**0.005**	0.186	0.088	0.196	**0.000**
2	TecPlastics	kt			**0.710**		**0.007**	0.284	0.134	0.299	**0.000**
3	Ferro	kt			**0.426**		**0.004**	0.013	0.238	0.180	**0.000**
4	Non-ferro	kt			**0.239**		**0.002**	0.007	0.134	0.101	**0.000**
5	Coating	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
6	Electronics	kt			**0.048**		**0.000**	0.025	0.003	0.020	**0.000**
7	Misc.	kt			**0.289**		**0.003**	0.023	0.147	0.122	**0.000**
8	Extra	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
9	Auxiliaries	kt			**0.000**		**0.068**	0.034	0.006	0.029	**0.000**
10	Refrigerant	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
	Total weight	kt			**2.177**		**0.090**	0.571	0.750	0.946	**0.000**
									see note!		
	Other Resources & Waste							debet	credit		
11	Total Energy (GER)	PJ	0.190	0.059	**0.250**	**0.036**	**6.668**	0.004	-0.018	0.000	**6.940**
12	of which, electricity (in primary PJ)	PJ	0.050	0.032	**0.082**	**0.000**	**6.664**	0.000	-0.002	0.000	**6.744**
13	Water (process)	mln. m3	0.054	0.001	**0.055**	**0.000**	**0.001**	0.000	-0.005	0.000	**0.051**
14	Water (cooling)	mln. m3	0.273	0.017	**0.289**	**0.000**	**0.299**	0.000	-0.014	0.000	**0.574**
15	Waste, non-haz./ landfill	kt	0.687	0.179	**0.866**	**0.028**	**3.445**	0.022	-0.090	0.000	**4.271**
16	Waste, hazardous/ incinerated	kt	0.071	0.000	**0.071**	**0.001**	**0.106**	0.000	-0.003	0.000	**0.175**
	Emissions (Air)										
17	Greenhouse Gases in GWP100	mt CO2 eq.	0.010	0.003	**0.013**	**0.003**	**0.285**	0.000	-0.001	0.000	**0.300**
18	Acidification, emissions	kt SO2 eq.	0.097	0.015	**0.112**	**0.008**	**1.260**	0.000	-0.013	0.000	**1.367**
19	Volatile Organic Compounds (VOC)	kt	0.000	0.000	**0.000**	**0.000**	**0.149**	0.000	0.000	0.000	**0.150**
20	Persistent Organic Pollutants (POP)	g i-Teq	0.005	0.001	**0.005**	**0.000**	**0.016**	0.000	-0.001	0.000	**0.020**
21	Heavy Metals	ton Ni eq.	0.026	0.001	**0.028**	**0.001**	**0.068**	0.000	-0.005	0.000	**0.092**
22	PAHs	ton Ni eq.	0.015	0.000	**0.015**	**0.002**	**0.016**	0.000	-0.003	0.000	**0.029**
23	Particulate Matter (PM, dust)	kt	0.015	0.003	**0.017**	**0.048**	**0.027**	0.000	-0.002	0.000	**0.090**
	Emissions (Water)										
24	Heavy Metals	ton Hg/20	0.061	0.000	**0.061**	**0.000**	**0.029**	0.000	-0.008	0.000	**0.083**
25	Eutrophication	kt PO4	0.003	0.000	**0.003**	**0.000**	**0.002**	0.000	0.000	0.000	**0.005**

Table 5.50 EU28 Total Impact in 2020 of BC2 units in Stock (produced, in use, discarded)

	EU28 Total Impact in 2020 of BC2 units in Stock (produced, in use, discarded)										
	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Stock	
	Materials	**unit**									
1	Bulk Plastics	kt			**0.465**		**0.005**	0.186	0.088	0.196	**0.000**
2	TecPlastics	kt			**0.710**		**0.007**	0.284	0.134	0.299	**0.000**
3	Ferro	kt			**0.426**		**0.004**	0.013	0.238	0.180	**0.000**
4	Non-ferro	kt			**0.239**		**0.002**	0.007	0.134	0.101	**0.000**
5	Coating	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
6	Electronics	kt			**0.048**		**0.000**	0.025	0.003	0.020	**0.000**
7	Misc.	kt			**0.289**		**0.003**	0.023	0.147	0.122	**0.000**
8	Extra	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
9	Auxiliaries	kt			**0.000**		**0.068**	0.034	0.006	0.029	**0.000**
10	Refrigerants	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
	Total weight	kt			**2.177**		**0.090**	0.571	0.750	0.946	**0.000**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0.190	0.059	**0.250**	**0.036**	**5.011**	0.004	-0.018	0.000	**5.297**
9	of which, electricity (in primary PJ)	PJ	0.050	0.032	**0.082**	**0.000**	**5.008**	0.000	-0.002	0.000	**5.090**
10	Water (process)	mln. m3	0.054	0.001	**0.055**	**0.000**	**0.000**	0.000	-0.005	0.000	**0.055**
11	Water (cooling)	mln. m3	0.273	0.017	**0.289**	**0.000**	**0.225**	0.000	-0.014	0.000	**0.514**
12	Waste, non-haz./ landfill	kt	0.687	0.179	**0.866**	**0.028**	**2.589**	0.022	-0.090	0.000	**3.484**
13	Waste, hazardous/ incinerated	kt	0.071	0.000	**0.071**	**0.001**	**0.080**	0.000	-0.003	0.000	**0.151**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	Mt CO2 eq.	0.010	0.003	**0.013**	**0.003**	**0.214**	0.000	-0.001	0.000	**0.230**
16	Acidification, emissions	kt SO2 eq.	0.097	0.015	**0.112**	**0.008**	**0.947**	0.000	-0.013	0.000	**1.067**
17	Volatile Organic Compounds (VOC)	kt	0.000	0.000	**0.000**	**0.000**	**0.112**	0.000	0.000	0.000	**0.113**
18	Persistent Organic Pollutants (POP)	g i-Teq	0.005	0.001	**0.005**	**0.000**	**0.012**	0.000	-0.001	0.000	**0.017**
19	Heavy Metals	ton Ni eq.	0.026	0.001	**0.028**	**0.001**	**0.051**	0.000	-0.005	0.000	**0.080**
	PAHs	ton Ni eq.	0.015	0.000	**0.015**	**0.002**	**0.012**	0.000	-0.003	0.000	**0.028**
20	Particulate Matter (PM, dust)	kt	0.015	0.003	**0.017**	**0.048**	**0.020**	0.000	-0.002	0.000	**0.085**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0.061	0.000	**0.061**	**0.000**	**0.022**	0.000	-0.008	0.000	**0.083**
22	Eutrophication	kt PO4	0.003	0.000	**0.003**	**0.000**	**0.001**	0.000	0.000	0.000	**0.004**

Table 5.51 EU28 Total Impact of New BC3 units sold in 2020 over their lifetime

	EU28 Total Impact of New BC3 units sold in 2020 over their lifetime										
	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Stock	
	Materials	**unit**									
1	Bulk Plastics	kt			**0.588**		**0.006**	0.125	0.078	0.392	**0.000**
2	TecPlastics	kt			**0.203**		**0.002**	0.043	0.027	0.135	**0.000**
3	Ferro	kt			**0.779**		**0.008**	0.013	0.255	0.519	**0.000**
4	Non-ferro	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
5	Coating	kt			**0.007**		**0.000**	0.000	0.002	0.004	**0.000**
6	Electronics	kt			**0.054**		**0.001**	0.016	0.002	0.036	**0.000**
7	Misc.	kt			**0.188**		**0.002**	0.009	0.056	0.125	**0.000**
8	Extra	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
9	Auxiliaries	kt			**0.000**		**0.123**	0.035	0.006	0.081	**0.000**
10	Refrigerant	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
	Total weight	kt			**1.820**		**0.141**	0.241	0.426	1.293	**0.000**
									see note!		
	Other Resources & Waste							debet	credit		
11	Total Energy (GER)	PJ	0.165	0.052	**0.217**	**0.023**	**3.951**	0.002	-0.011	0.000	**4.182**
12	of which, electricity (in primary PJ)	PJ	0.050	0.027	**0.077**	**0.000**	**3.946**	0.000	-0.004	0.000	**4.019**
13	Water (process)	mln. m3	0.056	0.001	**0.057**	**0.000**	**0.001**	0.000	-0.005	0.000	**0.052**
14	Water (cooling)	mln. m3	0.151	0.014	**0.165**	**0.000**	**0.177**	0.000	-0.006	0.000	**0.336**
15	Waste, non-haz./ landfill	kt	1.374	0.170	**1.545**	**0.015**	**2.055**	0.011	-0.156	0.000	**3.470**
16	Waste, hazardous/ incinerated	kt	0.092	0.000	**0.092**	**0.000**	**0.063**	0.000	-0.002	0.000	**0.154**
	Emissions (Air)										
17	Greenhouse Gases in GWP100	mt CO2 eq.	0.009	0.003	**0.012**	**0.002**	**0.169**	0.000	-0.001	0.000	**0.181**
18	Acidification, emissions	kt SO2 eq.	0.071	0.013	**0.085**	**0.005**	**0.746**	0.000	-0.006	0.000	**0.830**
19	Volatile Organic Compounds (VOC)	kt	0.000	0.000	**0.000**	**0.000**	**0.088**	0.000	0.000	0.000	**0.089**
20	Persistent Organic Pollutants (POP)	g i-Teq	0.015	0.002	**0.016**	**0.000**	**0.009**	0.000	-0.002	0.000	**0.024**
21	Heavy Metals	ton Ni eq.	0.083	0.004	**0.087**	**0.001**	**0.041**	0.000	-0.010	0.000	**0.118**
22	PAHs	ton Ni eq.	0.002	0.000	**0.002**	**0.001**	**0.009**	0.000	0.000	0.000	**0.012**
23	Particulate Matter (PM, dust)	kt	0.013	0.002	**0.016**	**0.045**	**0.016**	0.000	-0.001	0.000	**0.076**
	Emissions (Water)										
24	Heavy Metals	ton Hg/20	0.052	0.000	**0.052**	**0.000**	**0.018**	0.000	-0.006	0.000	**0.064**
25	Eutrophication	kt PO4	0.003	0.000	**0.003**	**0.000**	**0.001**	0.000	0.000	0.000	**0.004**

Table 5.52 EU28 Total Impact in 2020 of BC3 units in Stock (produced, in use, discarded)

	EU28 Total Impact in 2020 of BC3 units in Stock (produced, in use, discarded)										
	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Stock	
	Materials	**unit**									
1	Bulk Plastics	kt			**0.588**		**0.006**	0.125	0.078	0.392	**0.000**
2	TecPlastics	kt			**0.203**		**0.002**	0.043	0.027	0.135	**0.000**
3	Ferro	kt			**0.779**		**0.008**	0.013	0.255	0.519	**0.000**
4	Non-ferro	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
5	Coating	kt			**0.007**		**0.000**	0.000	0.002	0.004	**0.000**
6	Electronics	kt			**0.054**		**0.001**	0.016	0.002	0.036	**0.000**
7	Misc.	kt			**0.188**		**0.002**	0.009	0.056	0.125	**0.000**
8	Extra	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
9	Auxiliaries	kt			**0.000**		**0.123**	0.035	0.006	0.081	**0.000**
10	Refrigerants	kt			**0.000**		**0.000**	0.000	0.000	0.000	**0.000**
	Total weight	kt			**1.820**		**0.141**	0.241	0.426	1.293	**0.000**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0.165	0.052	**0.217**	**0.023**	**3.247**	0.002	-0.011	0.000	**3.486**
9	of which, electricity (in primary PJ)	PJ	0.050	0.027	**0.077**	**0.000**	**3.243**	0.000	-0.004	0.000	**3.320**
10	Water (process)	mln. m3	0.056	0.001	**0.057**	**0.000**	**0.000**	0.000	-0.005	0.000	**0.057**
11	Water (cooling)	mln. m3	0.151	0.014	**0.165**	**0.000**	**0.145**	0.000	-0.006	0.000	**0.310**
12	Waste, non-haz./ landfill	kt	1.374	0.170	**1.545**	**0.015**	**1.689**	0.011	-0.156	0.000	**3.249**
13	Waste, hazardous/ incinerated	kt	0.092	0.000	**0.092**	**0.000**	**0.052**	0.000	-0.002	0.000	**0.144**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	Mt CO2 eq.	0.009	0.003	**0.012**	**0.002**	**0.139**	0.000	-0.001	0.000	**0.152**
16	Acidification, emissions	kt SO2 eq.	0.071	0.013	**0.085**	**0.005**	**0.613**	0.000	-0.006	0.000	**0.703**
17	Volatile Organic Compounds (VOC)	kt	0.000	0.000	**0.000**	**0.000**	**0.072**	0.000	0.000	0.000	**0.073**
18	Persistent Organic Pollutants (POP)	g i-Teq	0.015	0.002	**0.016**	**0.000**	**0.008**	0.000	-0.002	0.000	**0.024**
19	Heavy Metals	ton Ni eq.	0.083	0.004	**0.087**	**0.001**	**0.033**	0.000	-0.010	0.000	**0.121**
	PAHs	ton Ni eq.	0.002	0.000	**0.002**	**0.001**	**0.008**	0.000	0.000	0.000	**0.010**
20	Particulate Matter (PM, dust)	kt	0.013	0.002	**0.016**	**0.045**	**0.013**	0.000	-0.001	0.000	**0.074**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0.052	0.000	**0.052**	**0.000**	**0.014**	0.000	-0.006	0.000	**0.066**
22	Eutrophication	kt PO4	0.003	0.000	**0.003**	**0.000**	**0.001**	0.000	0.000	0.000	**0.004**

5.6.2 Life Cycle Costs for Consumers at EU-28 Level

Table 5.53 Total annual consumer expenditure in the EU28

	BC1	BC2	BC3	All Hand Dryers
Product price (million €)	77	151	127	355
Installation cost (million €)	41	43	18	102
Electricity (million €)	342	77	47	466
Filters (million €)	0	12	22	34
Repair & maintenance (million €)	17	17	31	65
TOTAL (million €)	477	288	223	989

5.6.3 Life Cycle Costs for Society at EU-28 Level

Table 5.54 Total annual societal costs in the EU28

	BC1	BC2	BC3	All Hand Dryers
Production and Distribution (million €)	3	2	2	7
Use (million €)	48	11	7	65
End of Life (million €)	0	0	0	1
TOTAL (million €)	51	13	9	73

Table 5.55 Total annual costs in the EU28 (consumer expenditure + societal costs)

	BC1	BC2	BC3	All Hand Dryers
Annual consumer expenditure (million €)	477	288	223	989
Annual societal cost (million €)	51	13	9	73
TOTAL (million €)	528	301	232	1,062

5.7 SENSITIVITY ANALYSIS

In Task 5, manufacturers' inputs and data were used to provide an environmental and economic assessment of hand dryers. While these inputs represent the characteristics of an average product, unit specific features can significantly affect the results.

Specifically, the 150 cycles per day figure is likely too low for hand dryers installed in certain high-volume public facilities (e.g. airports, shopping malls and hospitals). Also, for sensor activated hand dryers – where the motor stops when the user's hands are removed – the average duration of a drying cycle might be lower. For instance, users may not keep their hands under the dryer for the minimum drying time and might accept partially dry hands as a trade-off for less time under the dryer instead.

Furthermore, discussions with DG GROW, technical experts and manufacturers indicate a few of the default values in the EcoReport tool are likely outdated. In particular, the primary energy factor (PEF), the marginal societal cost of externalities and the electricity price calculated using the MEErP default approach and figures.

In this section, the sensitivity of the key results of the assessment to these inputs is tested through modelling the environmental and economic impacts of a BC2 unit (which currently represent the highest fraction of sales) in the following scenarios:

- High usage – increased number of cycles per day
- Low usage – reduced number of cycles per day
- Low cycle duration – reduced seconds per cycle
- Primary Energy Factor – updated primary energy factor figure
- Externalities cost – updated prices for environmental externalities
- Electricity price – updated price of electricity from Eurostat and PRIMES

5.7.1 High Usage

In public facilities such as airports, shopping malls, train stations and hospitals, hand dryers are used with a much higher frequency than the average 150 cycles per day used to model the Base Cases.

To understand what the effect of an increased number of cycles in the environmental and economic impacts would be, a BC2 High Usage scenario was modelled using the EcoReport tool. All inputs and assumptions used in this scenario were identical to those used in the BC2 model, with the exception of the number of cycles per day, which increased from 150 to 2,500 – an average high usage figure according to manufacturer feedback.

Figure 5.8, Figure 5.9, Figure 5.10 and Figure 5.11 show how the key outputs of the assessment change in this scenario. The total energy consumption of a unit over its lifetime increases fourteenfold, as do total GHG and acidification emissions. The life cycle cost of electricity is fifteen times higher than that of an average BC2 unit and the societal life cycle cost of externalities thirteen times higher. The total life cycle cost increases fivefold. Table 5.56 and Table 5.57 present the difference in the EU total figures.

Figure 5.8 Total Energy per unit over lifecycle - BC2 vs. BC2 High Usage

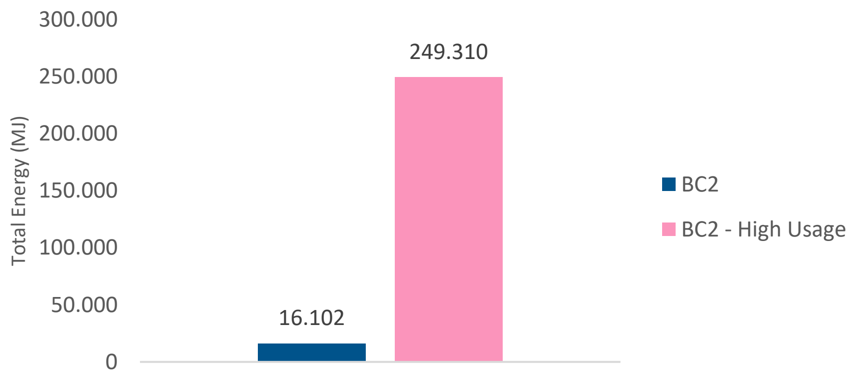


Figure 5.9 GHG Emissions per unit over lifecycle - BC2 vs. BC2 High Usage

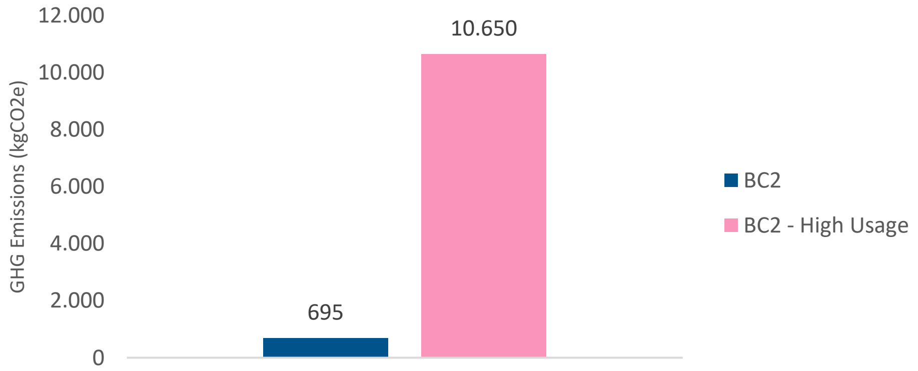


Figure 5.10 Acidification Emissions per unit over lifecycle - BC2 vs. BC2 High Usage

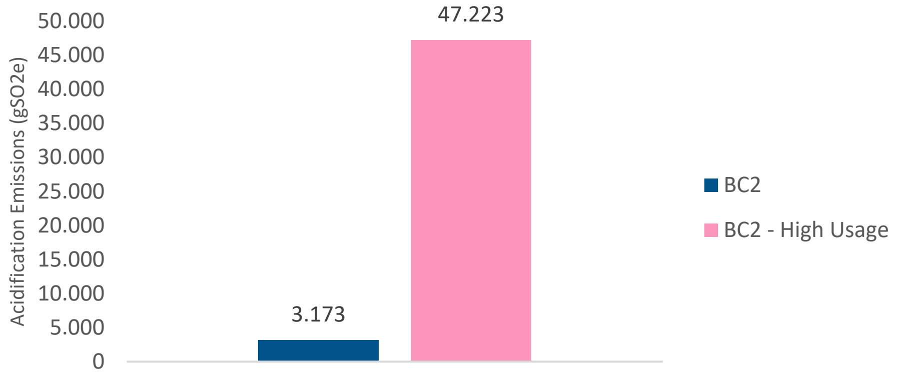


Figure 5.11 Life Cycle Costs - BC2 vs. BC2 High Usage

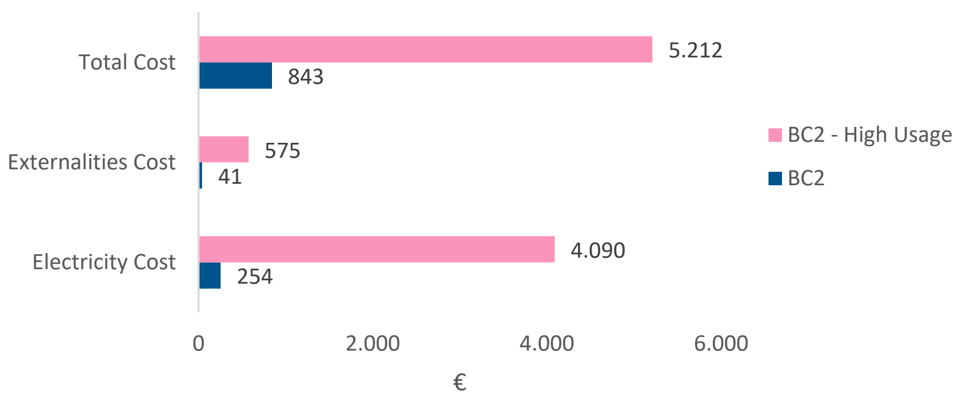


Table 5.56 Environmental impacts EU28 Total – BC2 vs. BC2 High Usage

	Units sold in 2020 over their lifetime		Impact in 2020 of all units in stock	
	BC2	BC2 High Usage	BC2	BC2 High Usage
Total Energy (PJ)	6.94	107.45	5.30	80.83
GHG Emissions (mtCO2e)	0.30	4.59	0.23	3.45
Acidification Emissions (ktSO2e)	1.37	20.35	1.07	15.33

Table 5.57 Economic impacts EU28 Total – BC2 vs. BC2 High Usage

	Annual Expenditure	
	BC2	BC2 High Usage
Electricity Cost (€ million)	77	1,233
Externalities Cost (€ million)	13	174
Total Cost (€ million)	313	1,630

5.7.2 Low Usage

In specific facilities such as small offices, hand dryers can be used with a lower frequency than the average 150 cycles per day used to model the Base Cases.

To understand what the effect of a decreased number of cycles in the environmental and economic impacts would be, a BC2 Low Usage scenario was modelled using the EcoReport tool. All inputs and assumptions used in this scenario were identical to those used in the BC2 model, with the exception of the number of cycles per day, which decreased from 150 to 50 – an average low usage figure according to manufacturer feedback.

Figure 5.12, Figure 5.13, Figure 5.14 and Figure 5.15 show how the key outputs of the assessment change in this scenario. The total energy consumption of a unit over its lifetime decrease by 62%, total GHG by 61% and acidification emissions by 59%. The life cycle cost of electricity 64% lower than that of an average BC2 unit and the societal life cycle cost of externalities 55% lower. The total life cycle cost decreases by 22%. Table 5.58 and Table 5.59 present the difference in the EU total figures.

Figure 5.12 Total Energy per unit over lifecycle - BC2 vs. BC2 Low Usage

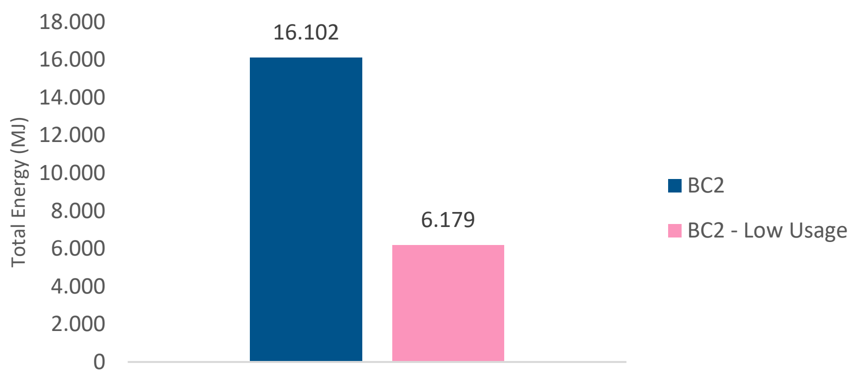


Figure 5.13 GHG Emissions per unit over lifecycle - BC2 vs. BC2 Low Usage

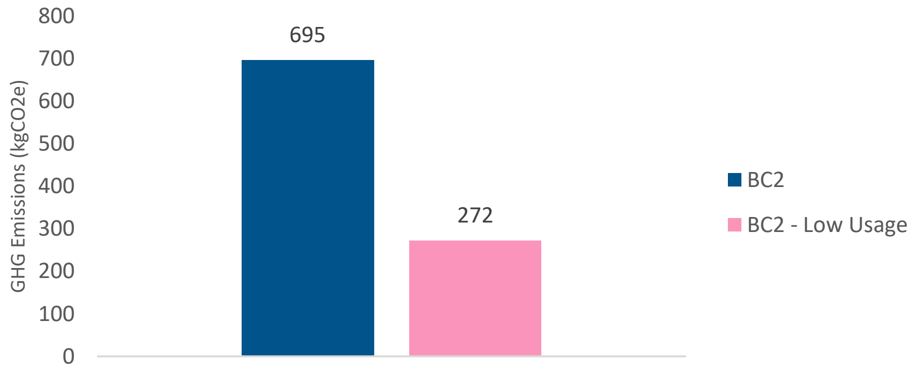


Figure 5.14 Acidification Emissions per unit over lifecycle - BC2 vs. BC2 Low Usage

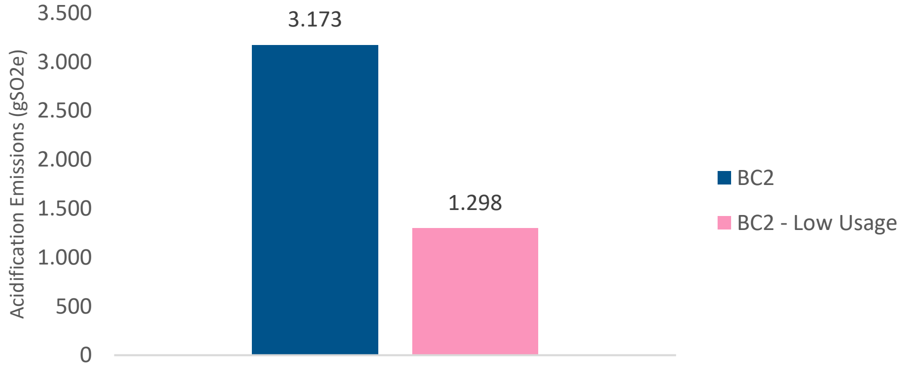


Figure 5.15 Life Cycle Costs - BC2 vs. BC2 Low Usage

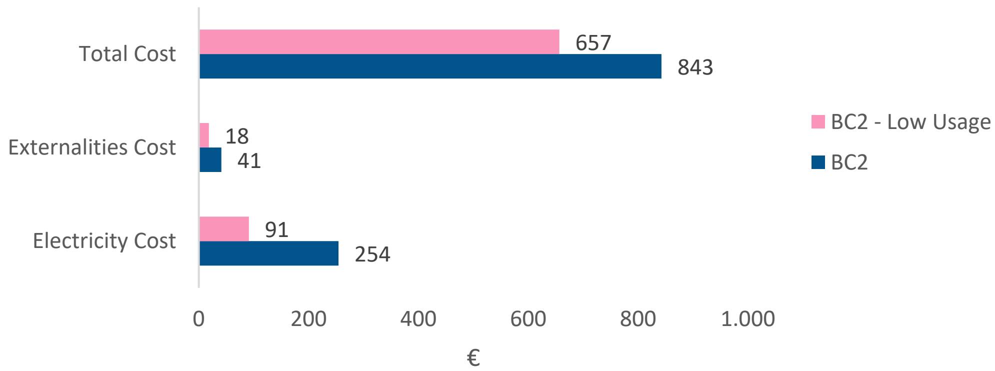


Table 5.58 Environmental impacts EU28 Total – BC2 vs. BC2 Low Usage

	Units sold in 2020 over their lifetime		Impact in 2020 of all units in stock	
	BC2	BC2 Low Usage	BC2	BC2 Low Usage
Total Energy (PJ)	6.94	2.66	5.30	2.08
GHG Emissions (mtCO2e)	0.30	0.12	0.23	0.09
Acidification Emissions (ktSO2e)	1.37	0.56	1.07	0.46

Table 5.59 Economic impacts EU28 Total – BC2 vs. BC2 Low Usage

	Annual Expenditure	
	BC2	BC2 Low Usage
Electricity Cost (€ million)	77	27
Externalities Cost (€ million)	13	6
Total Cost (€ million)	313	257

5.7.3 *Low Cycle Duration*

User behaviour can significantly affect the operation of hand dryers and consequently the environmental and economic impact created in the use phase. Specifically, users may not keep their hands under the dryer for the minimum drying time and might accept partially dry hands as a trade-off for less time under the dryer instead.

To understand what the effect of a decreased cycle duration in the environmental and economic impacts would be, a BC2 Low Cycle scenario was modelled using the EcoReport tool. All inputs and assumptions used in this scenario were identical to those used in the BC2 model, with the exception of the duration of cycles – which decreased by 50% from 14.13 to 7.07 seconds per cycle – and the electricity consumption per cycle which reduced proportionally from 0.00448 to 0.00224 kWh per cycle.

Figure 5.16, Figure 5.17, Figure 5.18 and Figure 5.19 show how the key outputs of the assessment change in this scenario. The total energy consumption of a unit over its lifetime decrease by 46%, total GHG by 46% and acidification emissions by 44%. The life cycle cost of electricity is 48% lower than that of an average BC2 unit and the societal life cycle cost of externalities 41% lower. The total life cycle cost decreases by 17%. Table 5.60 and Table 5.61 present the difference in the EU total figures.

Figure 5.16 Total Energy per unit over lifecycle - BC2 vs. BC2 Low Cycle

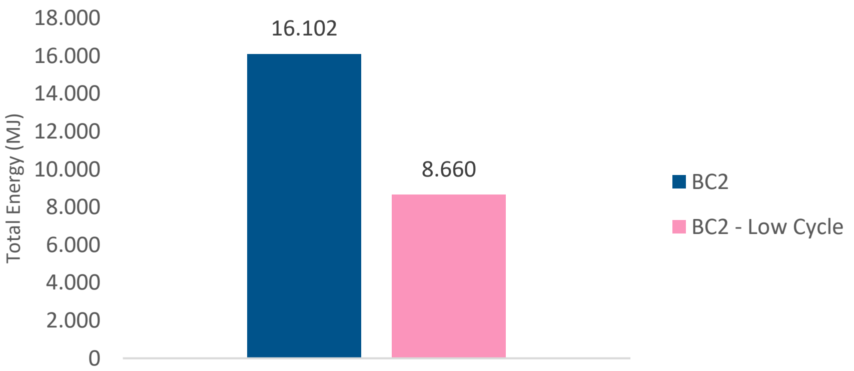


Figure 5.17 GHG Emissions per unit over lifecycle - BC2 vs. BC2 Low Cycle

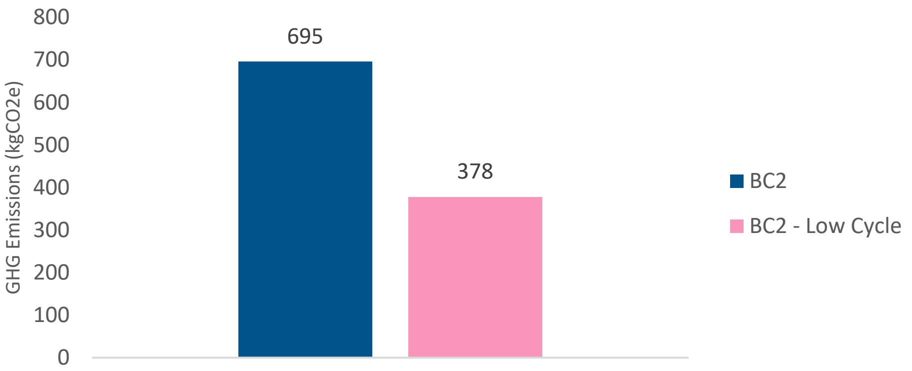


Figure 5.18 Acidification Emissions per unit over lifecycle - BC2 vs. BC2 Low Cycle

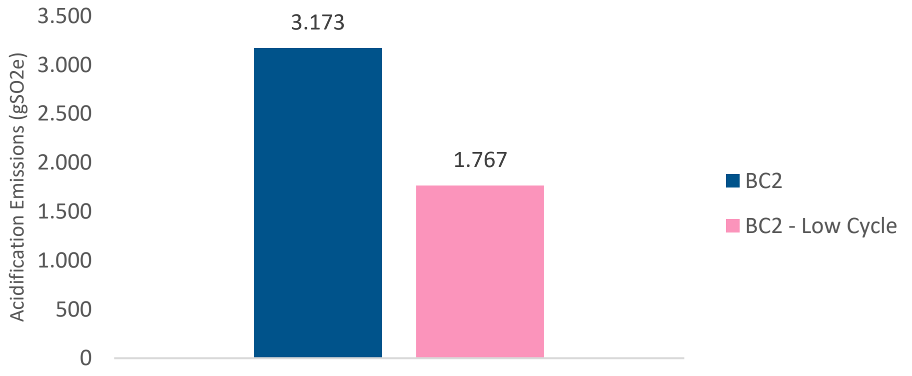


Figure 5.19 Life Cycle Costs - BC2 vs. BC2 Low Cycle

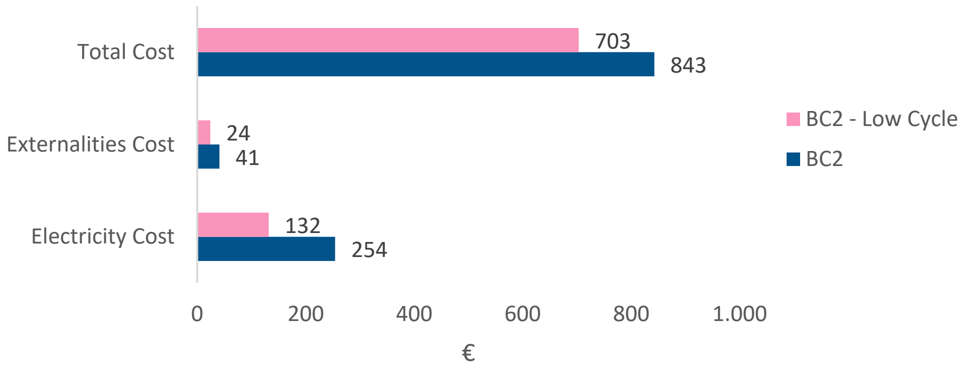


Table 5.60 Environmental impacts EU28 Total – BC2 vs. BC2 Low Cycle

	Units sold in 2020 over their lifetime		Impact in 2020 of all units in stock	
	BC2	BC2 Low Cycle	BC2	BC2 Low Cycle
Total Energy (PJ)	6.94	3.73	5.30	2.89
GHG Emissions (mtCO2e)	0.30	0.16	0.23	0.13
Acidification Emissions (ktSO2e)	1.37	0.76	1.07	0.61

Table 5.61 Economic impacts EU28 Total – BC2 vs. BC2 Low Cycle

	Annual Expenditure	
	BC2	BC2 Low Cycle
Electricity Cost (€ million)	77	40
Externalities Cost (€ million)	13	8
Total Cost (€ million)	313	271

5.7.4 Primary Energy Factor

The Primary Energy Factor (PEF) indicates how much primary energy is used to generate a unit of electricity. In the EcoReport tool, the default PEF is 2.5, meaning that 2.5 MWh of primary energy are used to generate each 1 MWh of electricity used.

Recent studies suggest that the default EcoReport figure might be outdated and overestimating the primary energy used to generate the electricity consumed by hand dryers. For the sensitivity analysis, a 2.1 PEF was in line with latest analyses undertaken by the European Commission and the Ecodesign Impact Accounting Status Report 2017.

To understand what the effect of a decreased PEF in the environmental and economic impacts would be, a BC2 PEF scenario was modelled using the EcoReport tool. All inputs and assumptions used in this scenario were identical to those used in the BC2 model, with the exception of the default PEF which was adjusted from 2.5 to 2.1.

The only effect that this change had in the outputs was a 15% reduction in total energy consumed over the life cycle of a product, as pictured in Figure 5.20. Reductions in the EU28 totals are presented in Table 5.62.

Figure 5.20 Total Energy per unit over lifecycle - BC2 vs. BC2 PEF

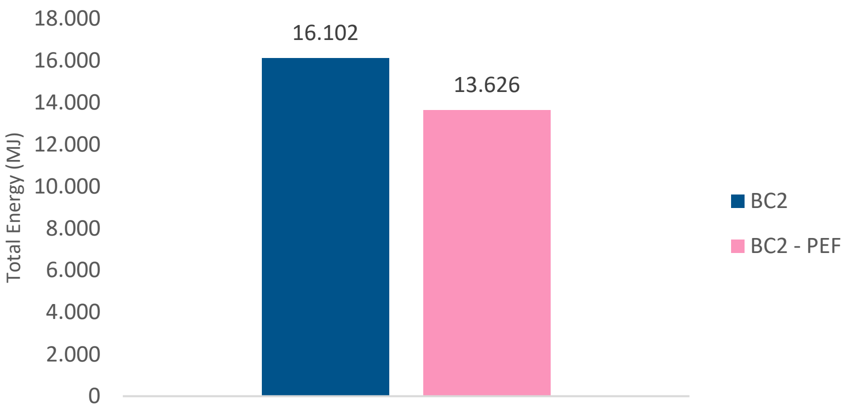


Table 5.62 Environmental impacts EU28 Total – BC2 vs. BC2 PEF

	Units sold in 2020 over their lifetime		Impact in 2020 of all units in stock	
	BC2	BC2 PEF	BC2	BC2 PEF
Total Energy (PJ)	6.94	5.87	5.30	4.49

5.7.5 Externalities Cost

The EcoReport tool calculates societal costs, i.e. the cost of externalities that occur as a consequence of production, distribution, use and end of life of hand dryer units. These outputs are calculated based on the environmental impacts created and the respective rates for each of these impacts (e.g. € per kgCO2eq, € per kgSO2eq).

Recent research suggests that the default rates in the EcoReport template might be outdated and underestimated. Specifically, the Environmental Prices Handbook published in 2017 by CE Delft proposes environmental prices as external costs to be used in Life Cycle Assessments.

To understand what the effect of more recent rates for externalities on the economic impacts would be, a BC2 Externalities scenario was modelled using the EcoReport tool. All inputs and assumptions used in this scenario were identical to those used in the BC2 model, except for the marginal societal costs of environmental impacts which were adjusted based on the Environmental Prices Handbook and are presented in Table 5.63.

Table 5.63 External marginal cost to society rates – EcoReport Default vs. Environmental Prices Handbook

Environmental Impact	Rate external marginal costs to society (€) EcoReport Default	Environmental Prices Handbook	Unit
GHG	0.014	0.057	€/kg CO2 eq.
Acidification	0.0085	0.0054	€/g SO2 eq.
Volatile Organic Compounds	0.00076	0.0021	€/g
Particulate Matter	0.01546	0.069	€/g

The only effect that this change had in the outputs was a 78% increase in the externalities costs over the life cycle of a product and a consequent 4% increase in total costs, as pictured in Figure 5.21. Increased costs in the EU28 are presented in Table 5.64.

Figure 5.21 Life Cycle Costs - BC2 vs. BC2 Externalities

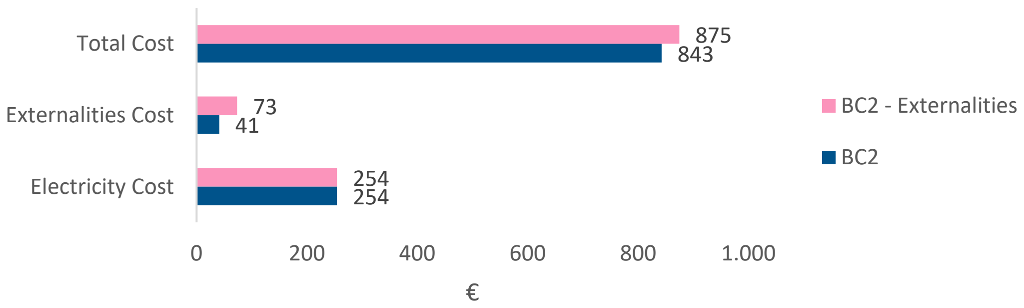


Table 5.64 Economic impacts EU28 Total – BC2 vs. BC2 Externalities

	Annual Expenditure BC2	BC2 Externalities
Electricity Cost (€ million)	77	77
Externalities Cost (€ million)	13	24
Total Cost (€ million)	313	324

5.7.6 *Electricity Price*

The MEErP determines that the electricity price used in the EcoReport tool should be escalated from the 0.10 €/kWh 2010 rate using a 4% default escalation rate. When sense checking the calculated rate of 0.15 €/kWh for 2020 against the Eurostat[163] 0.1149 €/kWh rate for the second half of 2018 or the PRIMES[164] 0.171€/kWh rate, it seems the

[163] Available at https://ec.europa.eu/eurostat/statistics-explained/images/4/44/Electricity_prices%2C_second_semester_of_2016-2018_%28EUR_per_kWh%29.png.

[164] The PRIMES model is an EU energy system model which simulates energy consumption and the energy supply system. It is a partial equilibrium modelling system that simulates an energy market equilibrium in the European Union and each of its Member States. This includes consistent EU

escalation rate and consequently the electricity price used in the modelling might be over or underestimated.

To understand what the effect of a lower or higher electricity rate on the economic impacts would be, two BC2 Electricity Price scenarios were modelled using the EcoReport tool. All inputs and assumptions used in this scenario were identical to those used in the BC2 model, except for the price of electricity which was obtained from Eurostat or PRIMES instead of calculated according to the MEErP.

The only effect that this change had in the outputs was a 22% decrease in the electricity cost over the life cycle of a product and a consequent 7% decrease in total costs when using the Eurostat rate, as pictured in Figure 5.22 or a 15% increase in the electricity cost over the life cycle of a product and a consequent 4% increase in total costs when using the PRIMES rate, as pictured in Figure 5.23. Decreased and increased costs in the EU28 are presented in Table 5.65 and Table 5.66, respectively.

Figure 5.22 Life Cycle Costs - BC2 vs. BC2 Electricity Price (Eurostat)

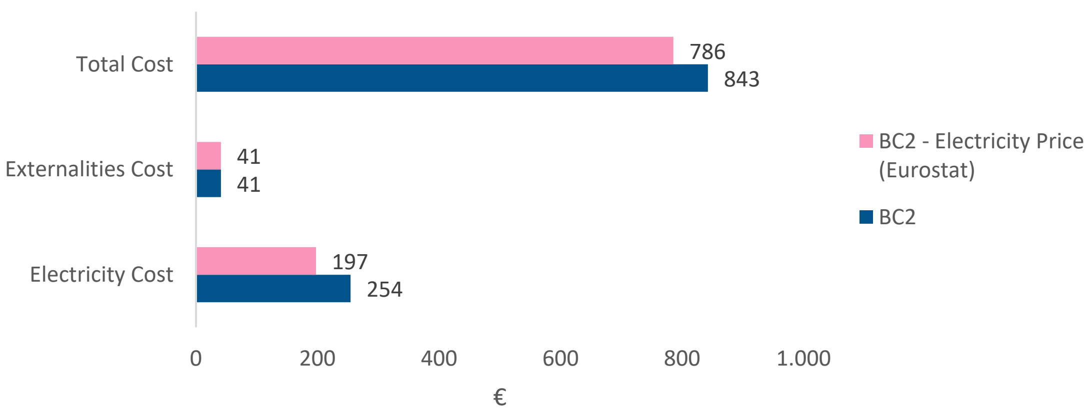
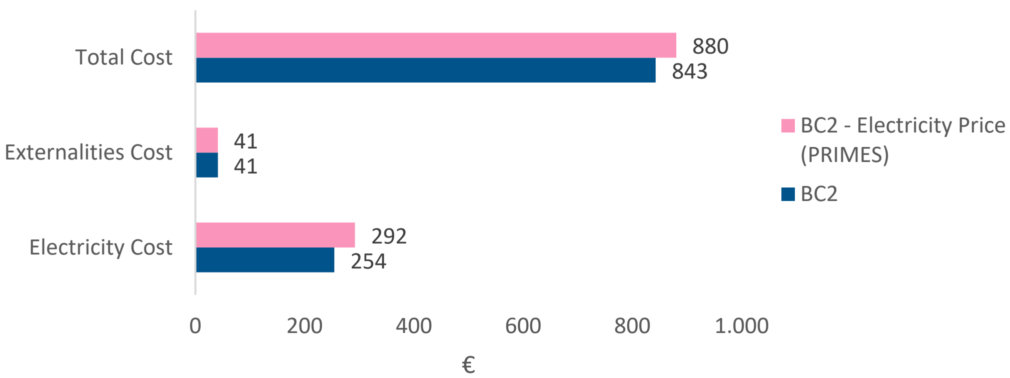


Figure 5.23 Life Cycle Costs - BC2 vs. BC2 Electricity Price (PRIMES)



carbon price trajectories. Available at https://ec.europa.eu/clima/policies/strategies/analysis/models_en#PRIMES.

Table 5.65 Economic impacts EU28 Total – BC2 vs. BC2 Electricity Price (Eurostat)

	Annual Expenditure	
	BC2	BC2 Electricity Price
Electricity Cost (€ million)	77	60
Externalities Cost (€ million)	13	13
Total Cost (€ million)	313	296

Table 5.66 Economic impacts EU28 Total – BC2 vs. BC2 Electricity Price (PRIMES)

	Annual Expenditure	
	BC2	BC2 Electricity Price
Electricity Cost (€ million)	77	88
Externalities Cost (€ million)	13	13
Total Cost (€ million)	313	325

6 INTRODUCTION TO TASK 6 DESIGN OPTIONS

The aim of this task is to identify design options, their monetary consequences in terms of Life Cycle Cost for the user, their economic and possible social impacts, and to attempt to pinpoint those solution(s) which incorporate designs leading to the Least Life Cycle Costs (LLCC) and the Best Available Technology (BAT).

The assessment of monetary Life Cycle Costs is relevant to indicate whether design solutions might have an impact on the user's total expenditure over the overall product life (purchase, operating, end-of-life costs, etc.). The distance between the LLCC and the BAT indicates (in the case where a LLCC solution is set as a minimum target) the remaining space for product differentiation (competition).

The BAT indicates a target in the shorter term that would probably promote improvement measures rather than potentially over-restrictive action(s). The BNAT indicates possibilities in the longer term and helps to define the exact scope and definition of possible measures.

6.1 IDENTIFICATION OF DESIGN OPTIONS

The objective of this sub-task is to identify design options by investigating and assessing the environmental impact and life cycle cost (LCC) of each suggested design option against each base case.

As mentioned in the Task 5 report, Base Cases (BCs) are defined to represent the average of a range of similar products. The following hand dryer BCs were selected according to the MEErP guidelines.

- BC1 – Conventional single point hands under dryer (category 1)
- BC2 – High speed single/multi-point hands under dryer (categories 2 and 3)
- BC3 – High speed trough style hands in dryer (Category 4)

6.1.1 Principles

Design options for further consideration have been selected following three basic principles:

- The functionality and quality of the products should not be significantly affected compared to the BCs.
- There should be a significant potential for improvement of at least one ecodesign parameter (e.g. energy, water and other resources consumption, use of hazardous substances, emissions to air, water or soil, weight and volume of the product, use of recycled material, quantity and nature of consumables needed, maintenance, ease for reuse and recycling, lifetime, and waste generation) without deteriorating others.
- The costs associated with implementing it should not be excessive and the impacts on manufacturers and the market should be investigated.

6.1.2 Potential design options

Multiple design options have been considered for modelling based on the principles mentioned in Section 6.1.1. These are presented in 5. They were assessed based on how objectively they could be defined, what potential effects they could bring in terms of environmental impacts and life cycle costs and on how feasible it would be to gather sufficient data to assess these impacts.

Table 6.1 Potential design options considered[165]

Sensor only	Hand dryers that operate with sensors (no push buttons).
No heat	Hand dryers that do not contain a dedicated heating component for the airstream.
Waste heat recovery	If heat is used, the heat must be recovered e.g. from the motor
Heating control thermostat	Installing a thermostat within the hand dryer to accurately track the heating required to the air stream for the desired air stream temperature.
Standby	Maximum standby energy consumption. Requirements as described in existing regulation e.g. network standby allowance and sensor allowance.
Brushless motors	Hand dryers with brushless DC motors, or possibly bring a technology neutral approach focusing on mechanical outputs for energy inputs. Requirements as described in existing regulation for motors.
Motor control	Incorporate motor controls to minimise the motor energy consumption and wear of the motor. This is done through a Variable Speed Drive (VSD) and/or soft start motor programming.
Cycle tracker	Install a motor counter to track the number of cycles.
Maximum energy consumption	Cap on total energy consumption can be set to e.g. 5kWh over 1000 cycles for a standard drying time under 15 seconds to achieve a maximum level of remaining moisture content.
No filter	Hand dryers that are built to operate without filter.
Filter mandatory	Hand dryers must operate with a filter.
Recyclable filters	Hand dryers' filters must be recyclable.
Filter change alert	Alert installed for filter change.
Minimise "run-on" time	Set a maximum run-on time for the hand dryer to be left on for each drying cycle.
Water collection	Remove water tanks and mandate that water drainage is directed to the sewage system (for Category 4 dryers only).
Bluetooth/Internet	Connectivity to provide real time user behaviour and product condition.
EoL disposal/collection	Define producer responsibility for end-of-life disposal or collection of equipment.

[165] Note that the recent circular economy measures identified and included within the recent revisions to a suite of Ecodesign regulations (known as the "November 2019 Package"), will be discussed further in Task 7.

Assembly design	Improved design to improve access, repair and disassembly. This results in increased lifetime and recycling rate of material end-of-life.
Lower environmental impact materials	Replacing plastics with metals or defining a minimum recycled content in plastic components used.
Minimise critical materials	Define limits to the use of critical materials mostly used in the electronic parts of the hand dryers.
Optimal aerodynamic design	Define optimal aerodynamic design to minimise materials used, reduce energy consumption and reduce noise.
Noise minimisation	Impose a maximum dB(A) for hand dryers.
Improve product durability	Legislate a minimum life expectancy for hand dryers.
Antimicrobial non-silver coatings	Require interior of hand dryers to be covered in non-silver anti-microbial coatings to improve hygiene.
Cosmetic appeal	Require products to be designed with materials that do not wear or tarnish with time, hence maintaining cosmetic appeal and avoiding replacement due to cosmetic appearance from ageing.

6.1.3 Design options selected for modelling

Out of the 26 design options considered, five were selected for modelling. Furthermore, a combination of multiple design options was modelled under DO6. These are listed in Table 6.2 and detailed in the following subsections.

Table 6.2 Design options modelled under Task 6

DO1	No heat
DO2	Standby
DO3	Sensor only / run-on time
DO4	Energy efficiency
DO5	Assembly Design
DO6	Combination of DO1, 2, 3, 4 and 5

The Design Options were prioritised because they target the key environmental impacts of the hand dryers product group. Electricity consumption from the heating element was identified in Task 4 as a significant consumer of energy within the hand dryer. Energy wastage through standby and from hand dryers continuing to operate following the removal of user's hands, were also identified.

It was also important to identify circular economy principles within the design mix. Specifying a minimum content of recycled plastic within hand dryers represents a BNAT measure (Best Not Available Technology) and has been identified as such within section 6.4. Section 6.4 considers future design options after the current suite of options are implemented, where there continues to be opportunities for product differentiation based upon the implementation of BNATs. A more nearer term option of designing hand dryers for ease of disassembly and recycling of components would target the issue of a lack of recycling of plastic and electronics. This has been included as a design option in Task 6 and as a proposed policy measure in Task 7.

6.1.3.1 Design Option 1 – No heat

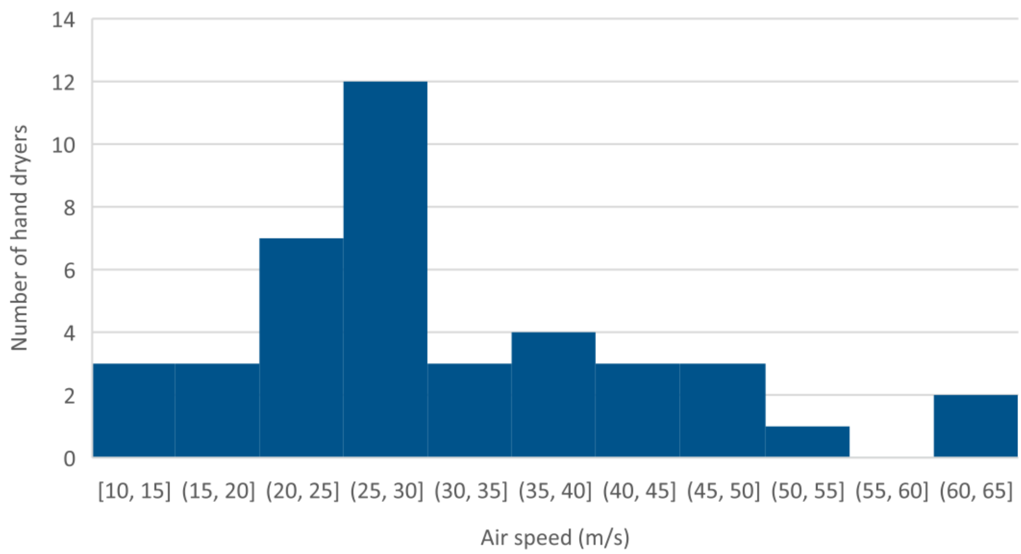
Under this design option, all heating elements of a hand-dryer would be removed which means that the units would rely only on the speed of the airstream to dry users' hands. This would lead to reduced energy consumption. An exemption is made for waste motor heat provided to the air stream.

There is no ecodesign regulation pertaining specifically to heating components.

In most BC1 hand dryers (conventional single point) hands are dried using heat, rather than a high-speed air flow.

Hand dryers with an air speed below 70m/s are classified as conventional hand dryers. A review of the air speed for conventional hand dryers was undertaken using the study product database. Out of 47 conventional hand dryers, air velocity was defined in the specification documentation for 41 models. As shown in Figure 6.1 the most common value of air speed in conventional hand dryers is 20-30m/s. The lowest recorded air speed is 14m/s, and the highest 64m/s.

Figure 6.1 Air speed in conventional single point hand dryers



6.1.3.2 Design Option 2 – Standby

Hand Dryers operate in two modes: "on" (actively blowing air to dry hands) and "standby" whilst waiting to activate. During standby, the main function in operation for the hand dryer is the sensor, which sends out a signal to detect if hands are present.

The current Ecodesign Commission Regulation (EU) No 801/2013, amending Regulation (EC) 1275/2008[166], imposes a maximum energy consumption which a household device may consume when in standby mode. The maximum standby power level for household goods is 0.5W in off or standby mode, with exceptions to 1W allowed for devices with an information or status display. As noted in Task 1, hand dryers are currently excluded from this regulation. This design option intends to impose this standard onto hand dryers for them to have a maximum energy consumption whilst in standby.

166 https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1511179319237&uri=CELEX:32013R0801

This design option would affect all categories of hand dryers as push-button operated hand dryers are estimated, from the Task 4 database and manufacturer feedback, to account for only 8% of the BC1 hand dryers, and are not present in the other categories. The industry has been moving towards sensor operated machines to improve hygiene.

6.1.3.3 Design Option 3 – Sensor only / Run-on Time

Under this design option, we have considered that all hand dryers are operated by a sensor only setup, where the hand dryer is on, only if and when it detects a hand underneath. It has been assumed, in all modelling, that all sensor operated hand dryers are "sensor only" and have no timer component. BC1 hand dryers are the only ones modelled here as they are the only products in scope which have push-button operated dryers.

No regulation is currently in place to regulate the use of push-button activation.

This design option also features a maximum one-second run-on time, once the hands are removed from the dryer. This measure applies to all hand dryers.

6.1.3.4 Design Option 4 – Energy Efficiency

The current Ecodesign regulation for electric motors Commission Regulation (EU) No 4/2014 amends the previous Regulation (EC) No 640/2009 on electric motors with a power rating between 0.75 kW to 375 kW[167]. The aforementioned 2014 regulation was revised in October 2019 by Ecodesign Regulation (EU) 2019/1781 for electric motors[168]. The study team's analysis has found hand dryers that operate from 200W to 2750W, meaning that not all electric motors for hand dryers are included in the scope of the current regulation. However, note that most types of motors in hand dryers are now included within the scope of the 2019 revised electric motors Ecodesign regulation, with its expanded scope including motors from 120 W up to 100 kW. The exclusions from scope are detailed below,

The 2019 motors Ecodesign regulation applies to brushless Alternating Current (AC) motors. However, the 2019 revised regulation still excludes motors with brushes, those powered by Direct Current (DC) and also universal motors. Note that AC brushless motors are found only in a minority of Category 1 hand dryers (i.e., the majority are AC motors with brushes). Hence, many hand dryer motors are still excluded from the Motors Ecodesign regulation, even in its updated form.

Design Option 4 intends to close this "loophole" by imposing on **all** hand dryers (irrespective of motor type) a minimum energy efficiency rating which considers both the electricity consumption and the drying time, to thus calculate the energy consumption per cycle. For modelling purposes, this study will calculate the energy consumption of hand dryers after imposing a maximum cycle length time of realistic usage by users, as described in Patrick DR et al.[169]. A maximum limit energy consumption per cycle is set for each hand dryer base case in order to exclude the 25% most inefficient hand dryers from the market.

6.1.3.5 Design Option 5 – Assembly Design

With an effort to improve circular economy principles within hand dryers, this design option is to improve the assembly/ disassembly design of the hand dryer. This would allow easier access to the interior of the hand dryer, improving the diagnosis of a hand dryer malfunction and minimising repair costs. This improved repairability would facilitate

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[167] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1521113260047&uri=CELEX:32014R0004

[168] https://ec.europa.eu/energy/sites/ener/files/documents/c-2019-2125_en_act_part1_v3.pdf

[169] *Residual moisture determines the level of touch-contact-associated bacterial transfer following hand washing*. By Patrick DR, Findon G, Miller TE, University of Auckland, 1997. Found at: https://www.ncbi.nlm.nih.gov/pubmed/9440435/ [Accessed on 01/11/2019]

an increase in the frequency of product repair, and hence increase the average product life expectancy. Moreover, the design option would allow for easy separation via disassembly of the hand dryer electronic board to ensure the components are sorted into an adequate WEEE recycling stream.

This design option would affect all product categories, as efforts to improve circular economy have not been undertaken consistently by the industry at large to date, as these were not mandated post sales.

Currently hand dryers fall under WEEE waste disposal directive 2012/19/EU. These ensure that difficult electronics are treated adequately. However, there are presently no directly-applicable European regulatory requirements that would result in better disassembly to improve recycling and repair of the product. Most hand dryers therefore do not get sorted adequately into a WEEE stream.

6.1.3.6 Design Option 6 – Combination of DOs 1, 2, 3, 4 and 5

With an effort to combine the energy efficiency gains from multiple avenues, this design option will look to model the consumption of hand dryers assuming:

- No heat generation is provided to the air stream
- A minimum standby consumption is set
- Sensor-only criteria and a maximum run-on time
- That the 25% least efficient hand dryers are removed from operation
- Improved assembly/ disassembly design to facilitate improved repair and recycling rates

6.2 ASSESSMENT OF ENVIRONMENTAL IMPACTS, LIFE CYCLE COSTS AND PURCHASE PRICE

The different design options have been modelled separately for each of the BCs. Table 6.3 identifies all the design options modelled under Task 6. This section provides the key assumptions used in each model as well as how environmental impacts and life cycle costs change in comparison to the BCs with each of the design options.

Table 6.3 Index of design options modelled under Task 6

	Base Case 1 **Conventional Single Point**	**Base Case 2** **High-speed Single/Multi-Point**	**Base Case 3** **High-speed trough style**
Base Case - As per Task 5	BC1	BC2	BC3
DO1 – No heat	BC1 DO1	BC2 DO1	BC3 DO1
DO2 – Standby	BC1 DO2	BC2 DO2	BC3 DO2
DO3 – Sensor only / run-on time	BC1 DO3	BC2 DO3	BC3 DO3
DO4 – Energy efficiency	BC1 DO4	BC2 DO4	BC3 DO4
DO5 – Assembly Design	BC1 DO5	BC2 DO5	BC3 DO5
DO6 – Combination of 1, 2, 3, 4 & 5	BC1 DO6	BC2 DO6	BC3 DO6

The same methodology followed in Task 5 and the EcoReport tool was used to assess the environmental impacts and life cycle costs for each of the design options presented in Table 6.3.

6.2.1 BC1 – Conventional single point hands under dryer

6.2.1.1 Design Option 1 – No heat

BC1 hand dryers almost exclusively rely on heat to dry hands and can therefore only be modelled by assuming the category is replaced by the products which can function without a heating component. Two products were found to fit this criterion: the Quantum Airdry and the Bobrick B-7125[170,171]. Both models deliver drying speeds of 50m/s, which is under the threshold of 70m/s for a category one dryer, as presented and defined in Task 1. After research into the models, it is apparent that these are in fact both the same product but marketed under separate brands.

Their average power consumption is 200W, which is significantly lower than that of an average BC1 unit and leads to a lower energy consumption per cycle. Still, when comparing the average cycle duration of a BC1 unit with a heating element to that of a no heat, there is no evidence of a significant difference.

In non-heating BC1 units the heating elements would be removed from the Bill of Materials (BoM). However, compensating for that, the motor of these units might be more robust which suggests that the average BoM should not change significantly. Considering this and due to the lack of sufficient data, no changes were made to the BoM when modelling for a no heat BC1.

With regard to the purchase price, evidence indicates that the average cost of a no heat BC1 unit is around €658, which is significantly higher than that of an average BC1 unit as these require different and proprietary technology requiring reuse of waste motor heat rather than a heating element coil.

The cost assumptions for BC1 are heavily dependent on the price of just two models; these are two models of conventional single point hands under dryers, the difference being that they do not use a heating element to dry hands. Due to the limited sample size, the estimated figure might not fully reflect a typical purchase price of a BC1 DO1 compliant unit.

It is important to note that the modelling for this Design Option relies on one product to replace the wide market range of current category 1 hand dryers. This in itself is an unrealistic expectation as the device has a much higher price than the category 1 hand dryer average. There is also a concern that the drying data relies on the self-reported drying times from the single manufacturer concerned, rather than via a harmonised testing standard. Note that this is a common difficulty factor across all hand dryer products examined but is particularly pertinent when there is solely one new variant type of a product being cited.

Table 6.4 Inputs and assumptions for BC1 DO1

Input / Assumption	BC1	BC1 DO1	Source
Electricity consumption per cycle (Wh / cycle)	7.94	0.80	www.Intelligenthanddryers.com www.ehanddryers.com and Task 4 data
Duration of cycle (s/cycle)	17.17	13.50	www.Intelligenthanddryers.com www.ehanddryers.com

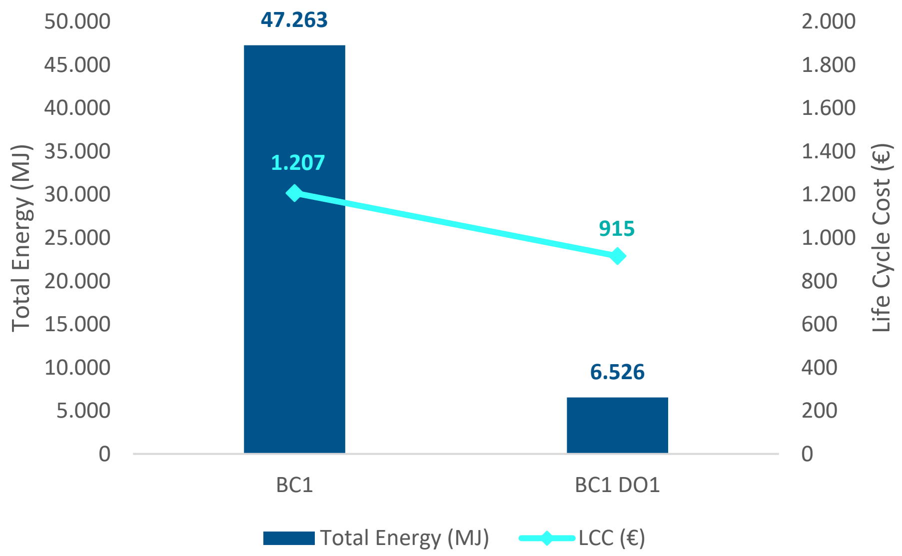
170 https://www.intelligenthanddryers.com/products/bobrick-b-7125-instadry-jet-hand-dryer#tab-4

171 https://www.ehanddryers.com/airdri-quantum-hand-dryer

Input / Assumption	BC1	BC1 DO1	Source
			and Task 4 data
Cost of material for repairing a unit	€ 27.25	€ 31.96	Review of repair calculation in line with Task 2 report due to change in cost of a unit.
Price of a unit	€ 188	€ 658	www.Intelligenthanddryers.com www.ehanddryers.com

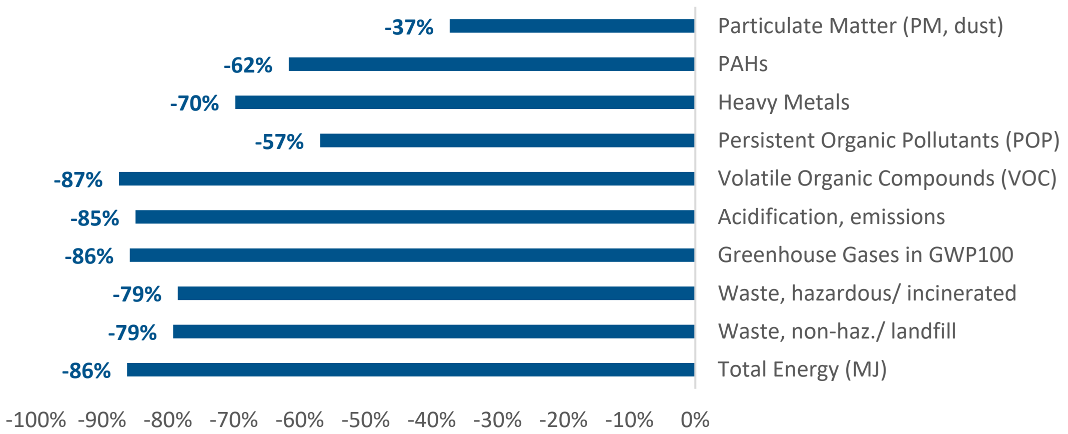
All other inputs and assumptions were assumed to be the same as those of an average BC1 unit as specified in the Task 5 report.

Figure 6.2 Total energy consumption and LCC of a BC1 DO1 unit



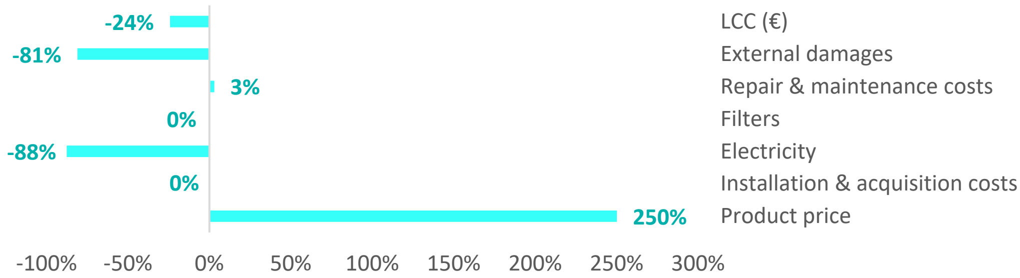
Over its life cycle, a "no heat" BC1 unit will consume around 86% less energy than an average BC1 unit, as presented in Figure 6.2. Most of the energy savings occur during the use phase as a "no heat" unit will consume less energy per hand drying cycle. Consequently, the life cycle environmental impacts of a unit will also be lower as presented in Figure 6.3.

Figure 6.3 Change in BC1 DO1 environmental indicators as compared to BC1



The life cycle cost of a no heat BC1 is 24% lower than that of an average BC1 mostly due the electricity savings and the better environmental performance that leads to lower cost of externalities (i.e. external damages). However, the purchase price of a no heat unit is about 2.5 times the price of an average BC1 unit.

Figure 6.4 Change in BC1 DO1 life cycle costs as compared to BC1



6.2.1.2 Design Option 2 – Standby

This design option intends to put in place a maximum consumption value for hand dryers on standby. The requirements modelled are those from the *Ecodesign requirements for standby, off-mode electric power consumption of electrical and electronic household and office equipment No 801/2013*. The requirements are for maximum power levels in standby to be 0.5W or 1W if an information or status display is available. Reviewing product datasheets from Task 4, a weighted standby consumption is calculated for BC1 between 1W for those with an information display, or 0.5W. As there are no examples of BC1 hand dryers with status displays, the standby consumption required would be **0.5W**.

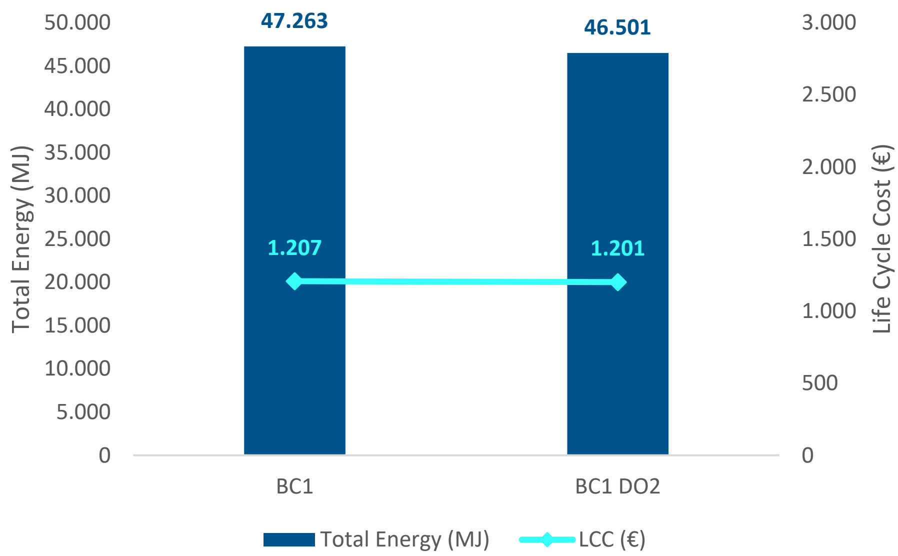
Manufacturer feedback has been used to estimate the cost of standby compliance by reviewing the cost of improvement and recertification of the product. This estimate increases the price of the hand dryer by €8.

Table 6.5 Inputs and assumptions for BC1 DO2

Input / Assumption	BC1	BC1 DO2	Source
Standby electricity consumption per cycle (Wh / hour)	1.36	0.50	Ecodesign 801/2013, plus Task 4 product database
Price of a unit	€ 188	€ 196	Manufacturer feedback

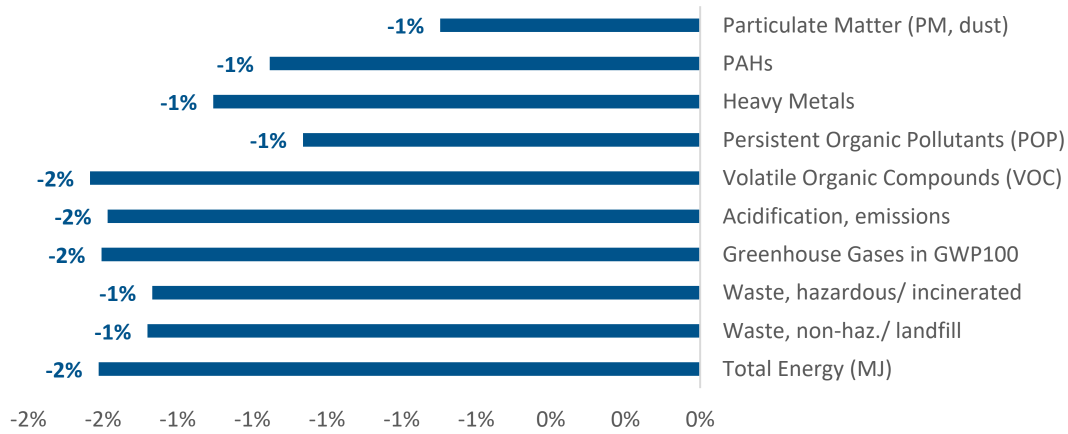
All other inputs and assumptions were assumed to be the same as those of an average BC1 unit as specified in the Task 5 report.

Figure 6.5 Total energy consumption and LCC of a BC1 DO2 unit



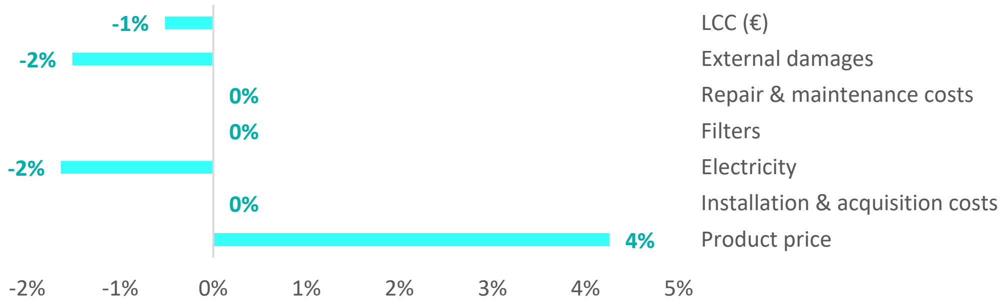
Over its life cycle, a BC1 compliant with the low standby criteria will consume around 2% less energy than an average BC1 unit as presented in Figure 6.5. The effect of this design option is marginal because standby electricity consumption is quite low when compared to the on-time electricity consumption of a BC1 over its lifetime. As a consequence of the lower electricity consumption, the life cycle environmental impacts of a BC1 DO2 unit are also slightly lower as presented in Figure 6.6.

Figure 6.6 Change in BC1 DO2 environmental indicators as compared to BC1



The life cycle cost of a BC1 DO2 unit is 1% lower than that of an average BC1 mostly due the electricity savings and the better environmental performance that leads to lower cost of externalities. Still, the purchase price of a unit compliant with the standby criteria is about 4% higher than that of an average BC1 unit.

Figure 6.7 Change in BC1 DO2 life cycle costs as compared to BC1



6.2.1.3 Design Option 3 – Sensor only / run-on time

From the Task 4 product database, it is estimated that 22% of BC1 hand dryers have the option to be equipped with a sensor or a push button. Manufacturer feedback has indicated that only 35% of these models are usually sold with the push button option, approximating the market share of category 1 push button operated products at 8%. The hand dryers using a push button will run for the full-length time, whereas the sensor hand dryers will run until the user leaves. Patrick DR et al.[172] indicate that on average users spend 15.15 seconds under a hand dryer. The study was conducted in 1997, and therefore applies solely to BC1 hand dryers (the only BC technology in existence at the time). With the additional measure limiting run-on time to 1 second, BC1 hand dryers under DO3 are estimated to operate for a maximum of 16.15 seconds and an average of **15.63 seconds.** The average electricity consumption per cycle is changed in line with this change in cycle length.

Manufacturers have confirmed that the hand dryers operating with a push button have 0 Watts standby consumption. Therefore, the replacement of these hand dryers with sensor operated hand dryers will increase average standby consumption across BC1 products. This increase is estimated at 8%, proportional to the new sensors on the market. The standby consumption therefore increases from 1.36W for BC1 to 1.47W for DO3 BC1.

The price of the hand dryer is revised upwards due to the sensor being more expensive than a push-button. The difference in price is assessed by comparing the price hand dryer models with both push button and sensor options.[173] The price difference was estimated at $37.6, which converts to €34.08.[174] As only 8% of the hand dryers are changed to sensors, this on average increase the price by **€2.73**.

Table 6.6 Inputs and assumptions for BC1 DO3

Input / Assumption	BC1	BC1 DO3	Source
Duration of cycles (seconds / cycle)	17.17	15.63	Patrick DR et al. 1997[175]

[172] *Residual moisture determines the level of touch-contact-associated bacterial transfer following hand washing*. By Patrick DR, Findon G, Miller TE, University of Auckland, 1997. Found at: https://www.ncbi.nlm.nih.gov/pubmed/9440435/ [Accessed on 01/11/2019]

[173] Models compared are: World Dryer A5-974 , AirMax M5-975 , World Dryer DA5-973, Excel Dryer LEXAN, Excel Dryer LEXAN series. Source: https://www.restroomdirect.com/hand-dryers.aspx [accessed 01/08/2019]

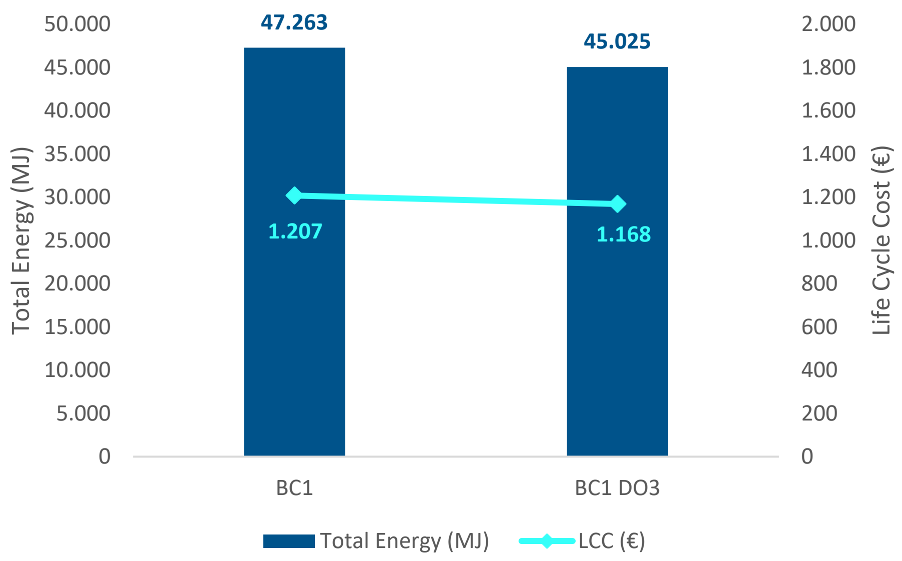
[174] Conversion ratio sourced from www.xe.com on 01/08/2019: 0.906454

[175] *Residual moisture determines the level of touch-contact-associated bacterial transfer following hand washing*. By Patrick DR, Findon G, Miller TE, University of Auckland, 1997. Found at: https://www.ncbi.nlm.nih.gov/pubmed/9440435/ [Accessed on 01/11/2019]

Input / Assumption	BC1	BC1 DO3	Source
Electricity consumption per cycle (Wh / cycle)	7.94	7.53	Task 4 product database
Standby electricity consumption (W)	1.36	1.47	Task 4 product database and 0W assumption for push button operated Hand Dryers
Price of a unit	€ 188	€ 191	https://www.restroomdirect.com/hand-dryers.aspx[176]

All other inputs and assumptions were assumed to be the same as those of an average BC1 unit as specified in the Task 5 report.

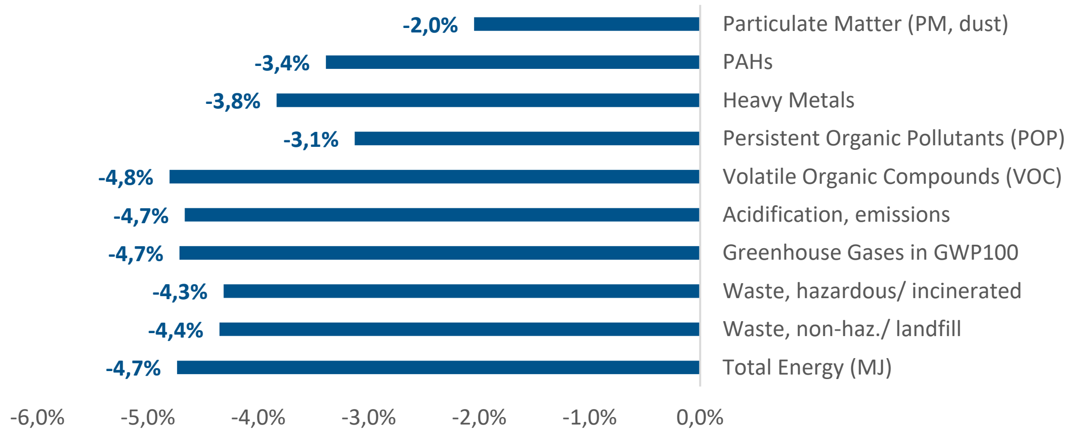
Figure 6.8 Total energy consumption and LCC of a BC1 DO3 unit



Over its life cycle, a BC1 DO3 unit will consume around 4.7% less energy than an average BC1 unit as presented in Figure 6.8. A sensor operated BC1 unit consumes less electricity per cycle and has a lower cycle duration, which leads to overall lower electricity consumption even when accounting for the marginally higher standby electricity consumption. Consequently, the life cycle environmental impacts of a unit will also be lower as presented in Figure 6.9.

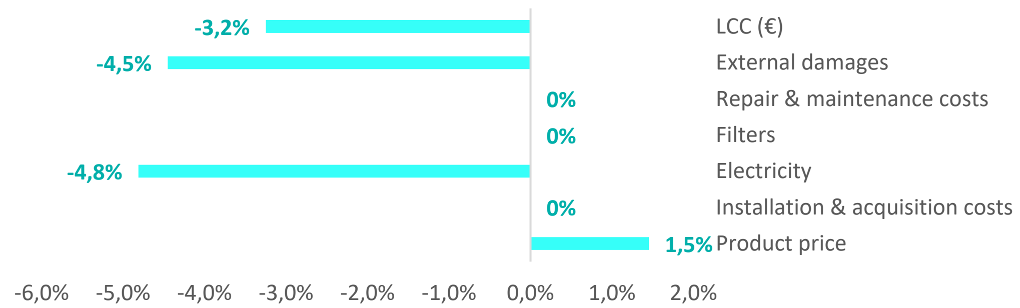
[176] Models compared are: World Dryer A5-974 , AirMax M5-975 , World Dryer DA5-973, Excel Dryer LEXAN, Excel Dryer LEXAN series. Source: https://www.restroomdirect.com/hand-dryers.aspx [accessed 01/082019]

Figure 6.9 Change in BC1 DO3 environmental indicators as compared to BC1



The life cycle cost of a BC1 DO3 unit is 3.2% lower than that of an average BC1 mostly due to the electricity savings and the better environmental performance that leads to lower cost of externalities. Still, the purchase price of a unit compliant with the standby criteria is about 1.5% higher than that of an average BC1 unit.

Figure 6.10 Change in BC1 DO3 life cycle costs as compared to BC1



6.2.1.4 Design Option 4 – Energy efficiency

Under this Design option, the 75% most energy efficient hand dryers per cycle were considered. After applying a maximum dry time per cycle for users to realistically dry hands, the product database gathered in Task 4 shows that the products consuming more than 10.7Wh per use do not meet the Design Option. This is modelled by assuming that these high consumption hand dryers improve their efficiency to meet the 10.7Wh/use target. On average, this results in a consumption for BC1 of **7.64 Wh/use**.

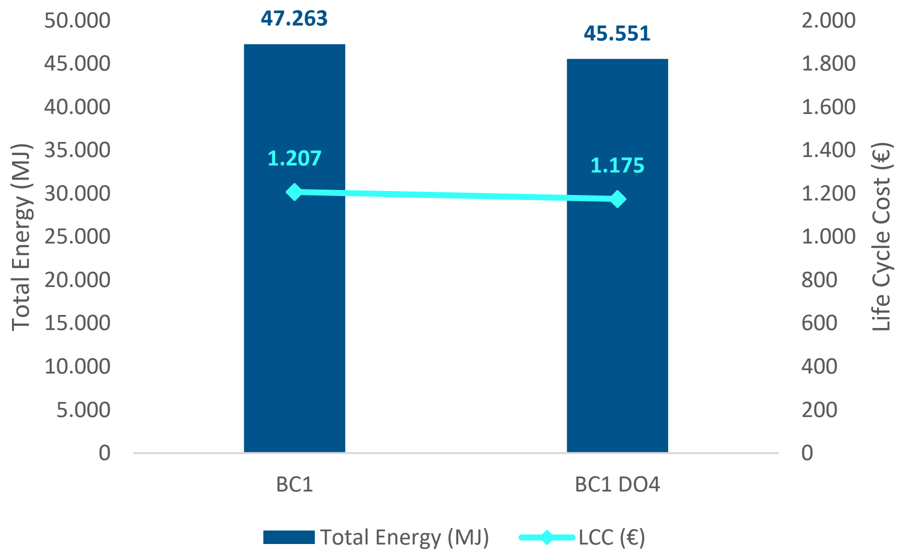
The products consuming more than 10.7 Wh/cycle are noted to all consume more than 2200W during operation. These products are marketed as higher performance products to dry hands faster. Therefore, these are more expensive than most BC1 hand dryers. To be compliant, the heat component of the product could be replaced by one with a lower power rating, which does not increase cost. As such, the price contribution of this Design Option is assumed to be zero.

Table 6.7 Inputs and assumptions for BC1 DO4

Input / Assumption	BC1	BC1 DO4	Source
Electricity consumption per cycle (Wh / cycle)	7.94	7.64	Task 4 product database

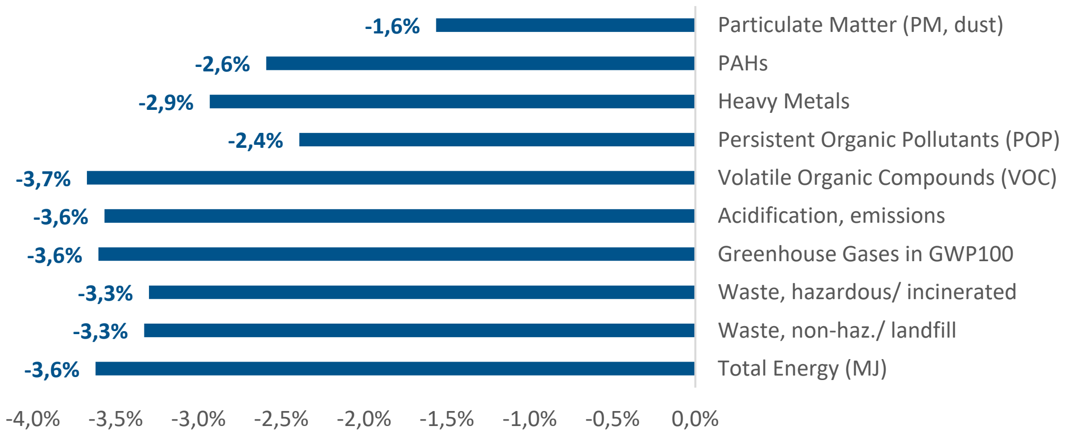
All other inputs and assumptions were assumed to be the same as those of an average BC1 unit as specified in the Task 5 report.

Figure 6.11 Total energy consumption and LCC of a BC1 DO4 unit



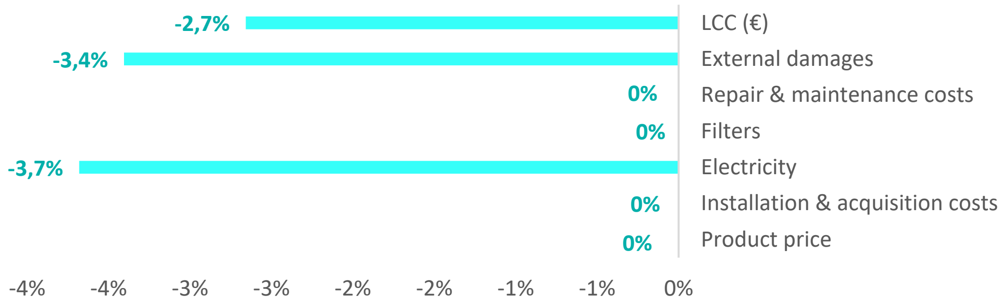
Over its life cycle, a BC1 DO4 unit will consume around 3.6% less energy than an average BC1 unit as presented in Figure 6.11. A BC1 unit with a more efficient motor consumes less electricity per cycle which leads to overall lower electricity consumption. Consequently, the life cycle environmental impacts of a unit will also be lower as presented in Figure 6.12.

Figure 6.12 Change in BC1 DO4 environmental indicators as compared to BC1



The life cycle cost of a BC1 DO4 unit is 2.7% lower than that of an average BC1 mostly due to the electricity savings and the better environmental performance that leads to lower cost of externalities.

Figure 6.13 Change in BC1 DO4 life cycle costs as compared to BC1



6.2.1.5 Design Option 5 – Assembly Design

Improved assembly/ disassembly design is assumed to allow for three things:

- easier separation of hand dryer PCB to allow for increase electronics recycling
- simplified interior layout allowing for faster repair times, and thus reduced labour costs (taking into account representative repair rates for qualified technicians/ engineers).
- faster repair times, thus increasing the incidence of repaired products, and hence the average life expectancy of products

Task 5 models the end of life of hand dryers where the items are not disposed of through a WEEE stream. Ordinary recycling streams would only recuperate and recycle 10% of electronics. Improved design could allow for the electronics board to be easily separable from the main product, allowing for the electronics to be separately sorted by the user into a specialised WEEE stream. WEEE streams typically reaching a 40% recuperation rate for electronics, with some high rate facilities reaching 80% recuperation. The DO5 model assumes that 50% of hand dryer electronic boards are disposed into a specialised WEEE stream. It also assumes that for those going through a WEEE stream, 20% of these reach high rate recycling facilities recuperating 80% of materials, and others only reaching 40%. This results in a recycling rate of electronics of **29%**.

Repair labour cost calculations were estimated in Task 2 to involve an electrician coming to site on two occasions of one hour each. The simplified interior layout of the hand dryer is assumed to make the electricians work simpler and reduce each visit to 30 minutes. Accounting for travel costs remaining constant, the labour cost of repair is therefore changed from €128.58 to **€87.25**.

Assuming that there is a 50% uptake in repair rates, we estimate that where the base case scenario envisions that 25% of BC1 hand dryers are repaired, DO5 will increase this percentage to **37.5%.** By extension, the increased repair rate means the average product service life is extended **from 11.58 to 11.92 years**. The effect on product lifespan is marginal; it is assumed that only motor replacement and motor brush repairs contribute to an extension of service life (in 25% of repair incidents).

Extending the Lifespan of Hand Dryers

BC1 units have a baseline service life of 10.9 years. The most common repairs for BC1 units are replacing the sensor (75% of times), replacing the carbon brushes (15% of times), or replacing the motor (10% of times). Replacing the motor or the carbon brushes is assumed to double a unit's service life and replacing the sensor is assumed to not affect the lifespan. The average product service life with repair was calculated based on the probabilities of each type of repair and how it affects the lifespan. To estimate the average service life of a unit, the percentage of units that are repaired was estimated at 25% for BC1, as per Task 5 and here at 37.5% (a 50% increase to the 25%, or 25% * 1.5) for BC1 DO5.

BC1	BC1 DO5
75% not repaired – lifespan 10.9 25%*25% motor repair – lifespan 21.0 25%*75% sensor repair – lifespan 10.9 **The weighted average lifespan is 11.58 years**	62.5% not repaired – lifespan 10.9 37.5%*25% motor repair – lifespan 21.0 37.5%*75% sensor repair – lifespan 10.9 **The weighted average lifespan is 11.92 years**

A similar rationale was used to estimate the lifespans of BC2 and BC3 units in DO5 as per Sections 6.2.2.5 and 6.2.3.5.

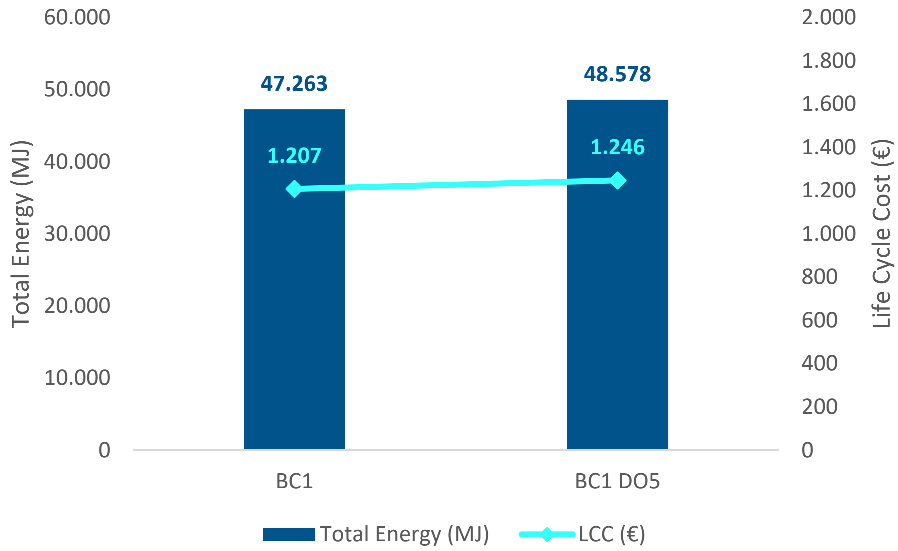
The price of the unit is increased to improve product design. Assuming that the product design accounts for 10% of the consumer price of the product, improving this design is estimated to require 50% extra design effort. This therefore resolves in a total product price increase of 5% from €188 to **€199**.

Table 6.8 Inputs and assumptions for BC1 DO5

Input / Assumption	BC1	BC1 DO5	Source
Recycling rate for electronic components	10%	29%	Assumption that 50% of PCBs enter WEEE stream and 20% of WEEE stream enters high recycling rate facilities
Cost of labour for repairing a unit	€ 129	€ 87	Assumption that repair time of electrician is reduced from 1 hour to 30 minutes.
Percentage of products that are repaired	25%	37.5%	Assumption that improved repair time improves rate of repair by 50%.
Average product service life	11.58	11.92	Consequence of increased repair rate
Price of a unit	€ 188	€ 197	Assumption that design costs are 10% of final product price and that design costs are increased by 50%

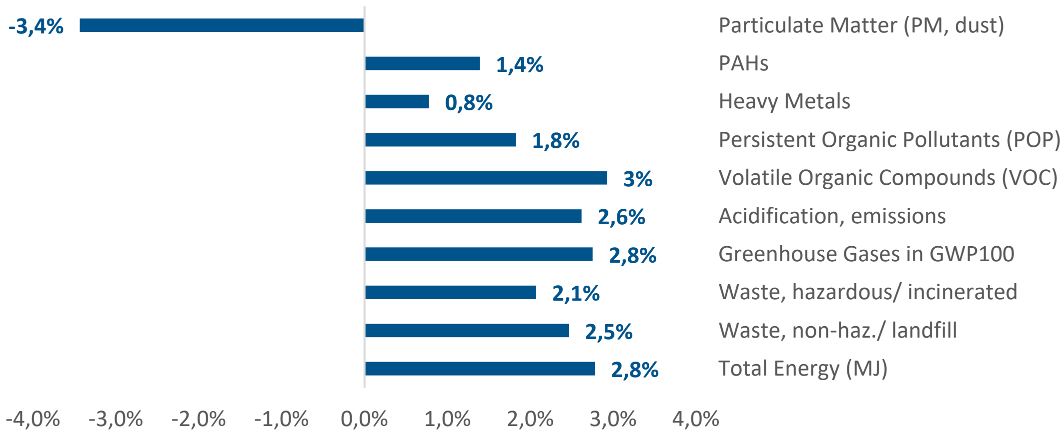
All other inputs and assumptions were assumed to be the same as those of an average BC1 unit as specified in the Task 5 report.

Figure 6.14 Total energy consumption and LCC of a BC1 DO5 unit



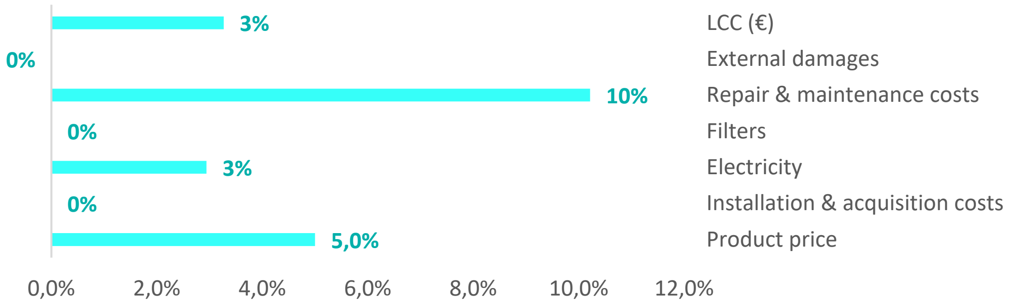
Over its life cycle, a BC1 DO5 unit will consume around 2.5% more energy than an average BC1 unit as presented in Figure 6.14. While energy savings occur in the end of life phase of the unit's lifecycle due to the increased percentage of electronic components that get recycled. However, energy consumption during the use phase is higher – but this is because the product lifespan per se has been extended. Figure 6.15 presents the changes this brings to the environmental impacts created over the lifecycle of a BC1 unit.

Figure 6.15 Change in BC1 DO5 environmental indicators as compared to BC1



The life cycle cost of a BC1 DO5 is about 3% higher than of that of an average BC1. The purchase cost of a unit is 5% higher and electricity costs are 3% higher due to the extended product lifespan. Furthermore, although the cost of repair is lower for each unit that is repaired, on average more units will be repaired and hence the average cost of repair per unit is 10% higher.

Figure 6.16 Change in BC1 DO5 life cycle costs as compared to BC1



The Trade-off for Improving Repair Rates

Only **6%** of average **BC1** units are assumed to have their motor replaced, which then doubles the lifespan of a unit. For **BC1 DO5** this percentage is increased to **9%**. Given these figures, with DO5 the average lifespan of a unit is increased from **11.58** to **11.92** years.

Furthermore, although the cost of repairing one BC1 DO5 unit is lower than that of repairing a BC1 unit, because of the increased percentage of products that are repaired – from **25%** to **38%** - the average cost of repair & maintenance rises from **€39** to **€43**.

The cost of electricity is assumed to be the same on a per year basis when comparing both products. The purchase price of a **BC1 DO5** unit is higher than that of an average **BC1** unit in absolute terms and also on an average per year basis (i.e. when dividing purchase price by the average lifespan) going from **€ 16.23** for **BC1** to **€ 16.56** for **BC1 DO5**.

	BC1 (average lifespan 11.58 years)			BC1 DO5 (average lifespan 11.92 years)		
	Purchase	Electricity	R&M	Purchase	Electricity	R&M
Average per year	€ 16.23	€ 66.06	€ 3.37	€ 16.56	€ 66.10	€ 3.61
Total LCC	€ 188.00	€ 765.00	€ 39.00	€ 197.40	€ 788.00	€ 43.00

6.2.1.6 Design Option 6 – Combination of Design Options 1, 2, 3, 4 and 5

DO6 consists of a combination of all five DOs assessed in Section 6.2.1. Combining the Design Options 1, 2, 3, 4 and 5 has the following effects to the inputs and assumptions used in the model:

- In the case of BC1, DO1 excludes most hand dryers from the category, meaning that the DO4 effects of removing the bottom 25% performers is superseded. Therefore, the consumption of the hand dryer will match the consumption shown in BC1 DO1 of **0.8 Wh/cycle.**
- DO3 would limit the hand dryer cycle duration to 16.15 seconds, however as the model from DO1 performs in less than 16.15 seconds, the modelled performance is from that product at **13.50 seconds per cycle**.
- The cost of materials for repair is brought up to **€31.96** following the repair cost of DO1.
- Standby consumption is reduced to **0.5W** as covered in DO2.
- DO5 improves the recycling rate of electronics to **29%** and reduces the labour costs of repair to **€87.25.** Furthermore, improved repair time is expected to increase the rate of repair of products to **37.5%** and hence the average life expectancy of the product to **11.92 years.**

- Product price for this option is brought up as a sum of the measures from DO1, DO2 and DO5. DO3 and DO4 are not considered as they are superseded by DO1. The unit cost therefore increases to **€699.55**.

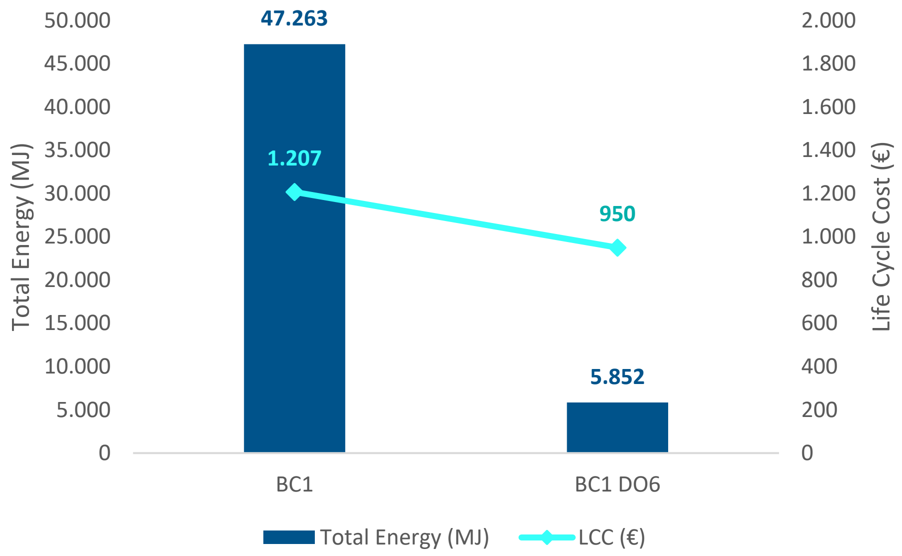
Table 6.9 Inputs and assumptions for BC1 DO6

Input / Assumption	BC1	BC1 DO6	Source
Duration of cycle (s/cycle)	17.17	13.50	www.Intelligenthanddryers.com www.ehanddryers.com and Task 4 data
Electricity consumption per cycle (Wh / cycle)	7.94	0.80	www.Intelligenthanddryers.com www.ehanddryers.com and Task 4 data
Standby electricity consumption (W)	1.36	0.50	Ecodesign 801/2013 And Task 4 product database
Cost of material for repairing a unit	€ 27	€ 32	Review of repair calculation in line with Task 2 report due to change in cost of a unit.
Recycling rate for electronic components	10%	29%	Assumption that 50% of PCBs enter WEEE stream and 20% of WEEE stream enters high recycling rate facilities
Cost of labour for repairing a unit	€ 129	€ 87	Assumption that repair time of electrician is reduced from 1 hour to 30 minutes.
Percentage of products that are repaired	25%	37.5%	Assumption that improved repair time improves rate of repair by 50%.
Average product service life	11.58	11.92	Consequence of increased repair rate
Price of a unit	€ 188	€ 700	www.Intelligenthanddryers.com www.ehanddryers.com EuP Lot 6 Prep study https://www.restroomdirect.com/hand-dryers.aspx[177]

[177] Models compared are: World Dryer A5-974 , AirMax M5-975 , World Dryer DA5-973, Excel Dryer LEXAN, Excel Dryer LEXAN series. Source: https://www.restroomdirect.com/hand-dryers.aspx (accessed 01/082019)

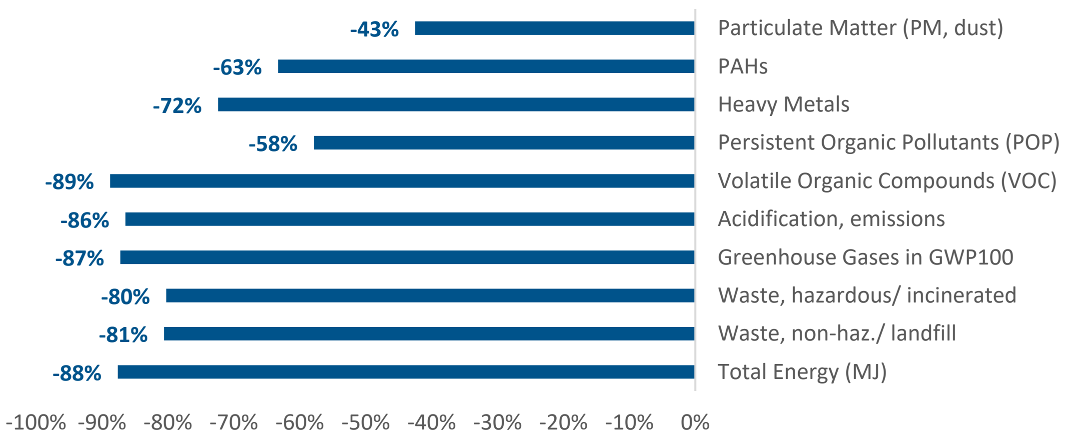
All other inputs and assumptions were assumed to be the same as those of an average BC1 unit as specified in the Task 5 report.

Figure 6.17 Total energy consumption and LCC of a BC1 DO6 unit



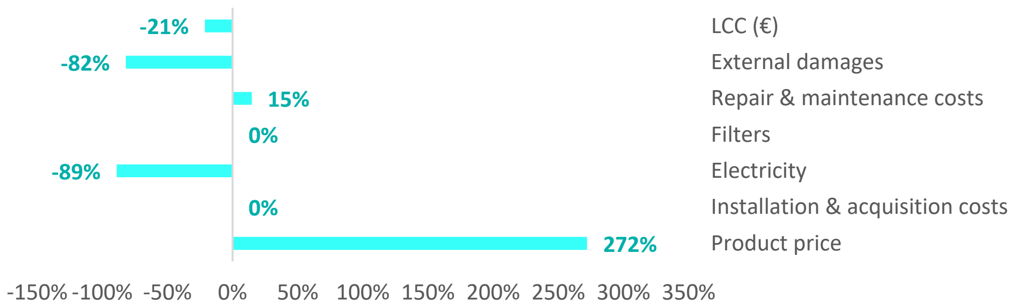
However, importantly, over its life cycle, a BC1 DO6 unit will consume around 88% less energy than an average BC1 unit, as presented in Figure 6.17. The lower electricity consumption is mostly derived from the reduced energy in both 'on' and 'standby' operating modes, combined with the lower duration of cycles. Consequently, the life cycle electricity use and associated environmental impacts of a BC1 DO6 unit will also be lower, as presented in Figure 6.18.

Figure 6.18 Change in BC1 DO6 environmental indicators as compared to BC1



The life cycle cost of a BC1 DO6 unit is 21% lower than that of an average BC1 mostly due to the electricity savings and the better environmental performance that leads to lower cost of externalities. Still, the purchase price of a unit compliant with the DO6 criteria is about 2.7 times that of an average BC1 unit and the repair and maintenance cost is 15% higher. The steep price increase is mostly due to the no heat criteria for BC1 products.

Figure 6.19 Change in BC1 DO6 life cycle costs as compared to BC1



6.2.2 BC2 – High speed single/multi point hands under dryer

6.2.2.1 Design Option 1 – No heat

The BC2 technology dries hands by applying a high air pressure air stream to blow water off users' hands. Heat can be added to accelerate the drying process and increase user comfort. Hand dryer products can be adjusted relative to their air speed and heating to deliver faster or slower dry times in requiring more or less energy. Manufacturer feedback has indicated that heat contributes little to improving the drying time. A conservative contribution of 100W of heat improving dry time by 0.25s is therefore assumed. Further manufacturer feedback estimates that the power of the average BC2 heating unit is 500W. The removal of this component is therefore estimated to increase dry time by **1.25s**.

In non-heating BC2 units the heating elements would be removed from the Bill of Materials (BoM) which affects the environmental impacts only marginally, regarding production and end-of-life phases. The heating element is thus removed from the BoM as presented in Task 4.

Manufacturer feedback has indicated that the heater element spare part price is €14. Accounting for products to which this Design Option does not apply (namely the hand dryers without a heating component), on average this amounts to a saving of **€10.92.** As DO1 assumes that the heater element is removed, the price of BC2 hand dryer was reduced from **€351.01** to **€340.09**.

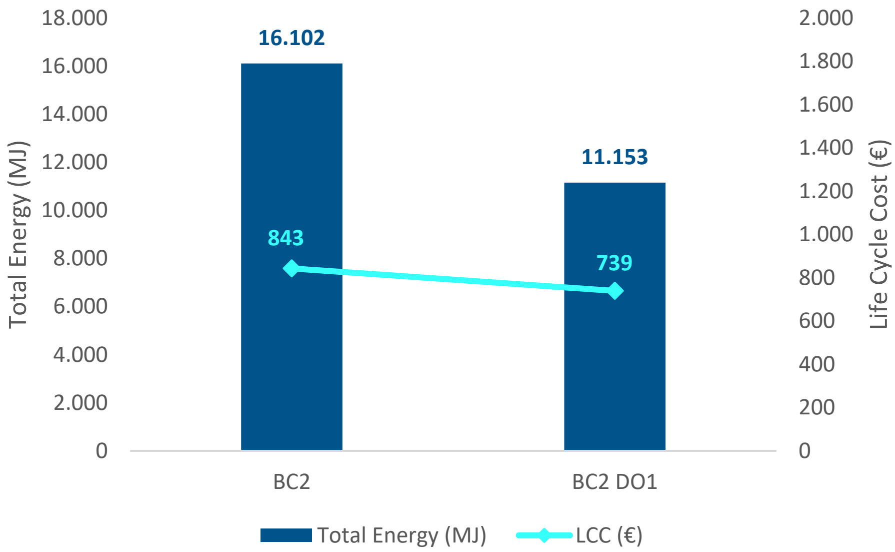
Table 6.10 Inputs and assumptions for BC2 DO1

Input / Assumption	BC2	BC2 DO1	Source
Electricity consumption per cycle (Wh / cycle)	4.59	3.06	www.intelligenthanddryers.com assumption that power spent on heat or motor speed contribute equally to dry time
Duration of cycles (seconds / cycle)	14.51	15.02	www.intelligenthanddryers.com assumption that power spent on heat or motor speed contribute equally to dry time
Price of a unit	€ 351	€ 340	https://www.intelligenthanddryers.com/category/hand-dryer-spare-parts

Input / Assumption	BC2	BC2 DO1	Source
			conversion: www.xe.com (31/07/2019)
BoM	heating element	no heating element	Task 4 BoM

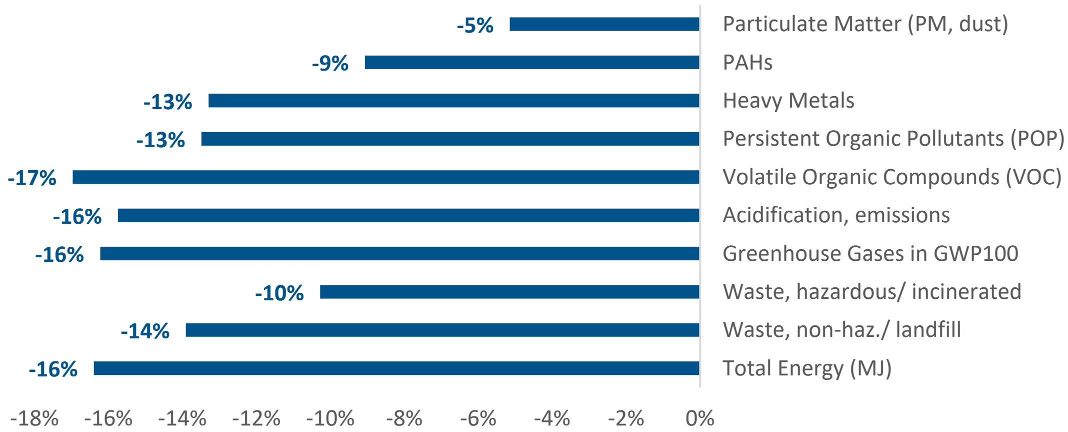
All other inputs and assumptions were assumed to be the same as those of an average BC2 unit as specified in the Task 5 report.

Figure 6.20 Total energy consumption and LCC of a BC2 DO1 unit



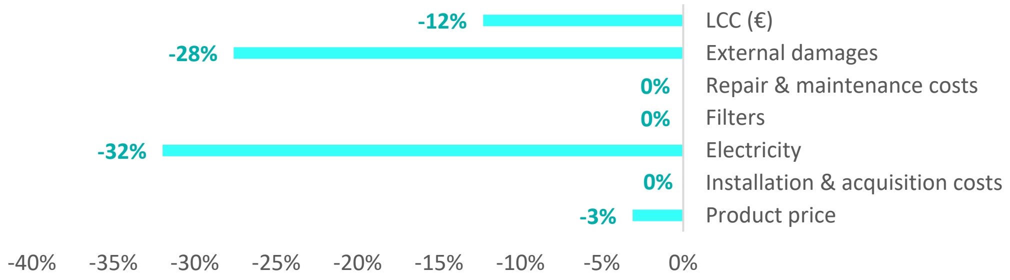
Over its life cycle, a no heat BC2 unit will consume around 31% less energy than an average BC2 unit, as presented in Figure 6.20. Most of the energy savings occur during the use phase as a no heat unit will consume less energy per hand drying cycle, even if the average duration of a cycle is slightly higher. Consequently, the life cycle environmental impacts of a BC2 DO1 unit will also be lower, as presented in Figure 6.21.

Figure 6.21 Change in BC2 DO1 environmental indicators as compared to BC2



The life cycle cost of a no heat BC2 is 12% lower than that of an average BC2 mostly due the electricity savings, the better environmental performance that leads to lower cost of externalities and the lower purchase price of a no heat unit.

Figure 6.22 Change in BC2 DO1 life cycle costs as compared to BC2



6.2.2.2 *Design Option 2 – Standby*

This design option intends to put in place a maximum consumption value for hand dryers on standby. The requirements modelled are those from the *ecodesign requirements for standby, off mode electric power consumption of electrical and electronic household and office equipment No 801/2013*. The requirements are for maximum power levels in standby to be 0.5W or 1W if an information or status display is available. Reviewing product datasheets from Task 4, a weighted standby consumption is calculated for BC2 between 1W for those with an information display, or 0.5W. There is solely one example of BC2 hand dryers with a status display out of 27 in the database; the weighted standby consumption is therefore **0.518W**.

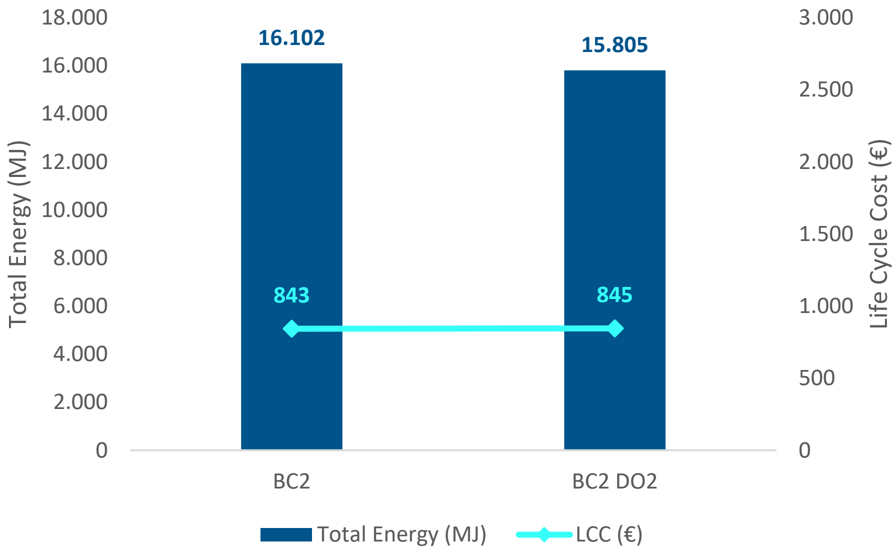
Manufacturer feedback has been used to estimate the cost of standby compliance by reviewing the cost of improvement and recertification of the product. This is estimated to increase the price of the hand dryer by €8.

Table 6.11 Inputs and assumptions for BC2 DO2

Input / Assumption	BC2	BC2 DO2	Source
Standby electricity consumption (W)	1.11	0.52	Ecodesign 801/2013 And Task 4 product database
Price of a unit	€ 351	€ 359	EuP Lot 6 Prep study

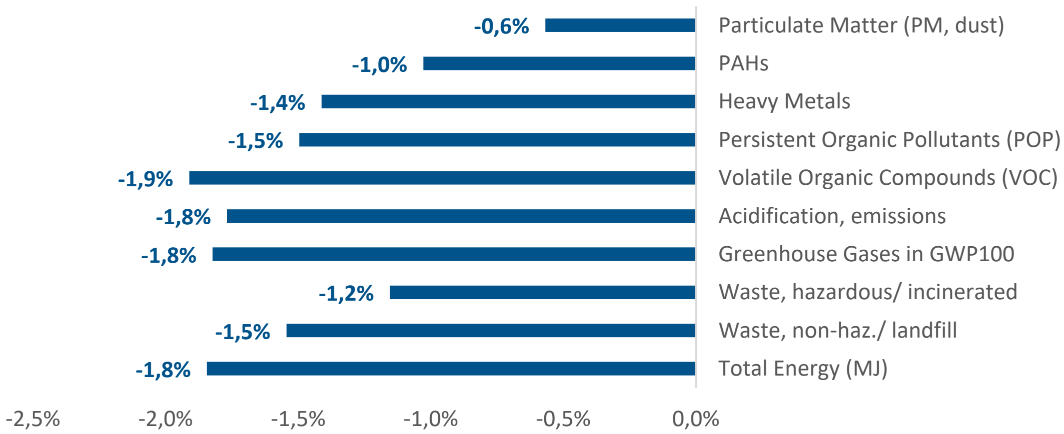
All other inputs and assumptions were assumed to be the same as those of an average BC2 unit as specified in the Task 5 report.

Figure 6.23 Total energy consumption and LCC of a BC2 DO2 unit



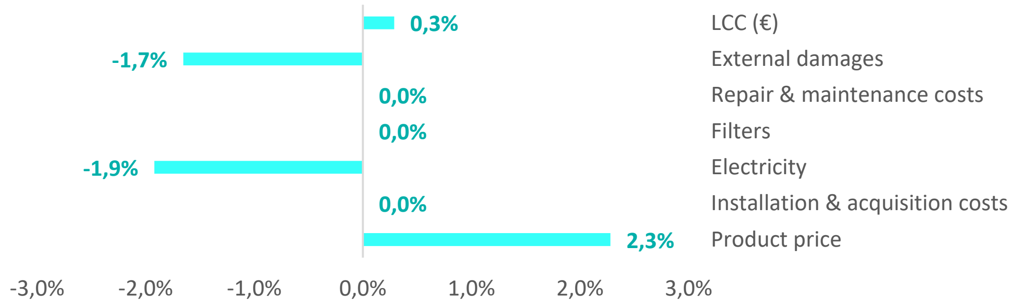
Over its life cycle, a BC2 compliant with the low standby criteria will consume around 2% less energy than an average BC2 unit as presented in Figure 6.23. The effect of this design option is marginal because standby electricity consumption is quite low when compared to the on-time electricity consumption of a BC2 over its lifetime. As a consequence of the lower electricity consumption, the life cycle environmental impacts of a BC2 DO2 unit are also slightly lower as presented in Figure 6.24.

Figure 6.24 Change in BC2 DO2 environmental indicators as compared to BC2



The life cycle cost of a BC2 DO2 unit is 0.3% higher than that of an average BC2 as the increased purchase price outweighs the electricity savings and the lower cost of externalities.

Figure 6.25 Change in BC2 DO2 life cycle costs as compared to BC2



6.2.2.3 *Design Option 3 – Sensor only / run-on time*

Under this design option, BC2 hand dryers on the market are already operated under sensor only. Therefore, the benefit of this design option is to limit the run-on time of the hand dryer to 1s.

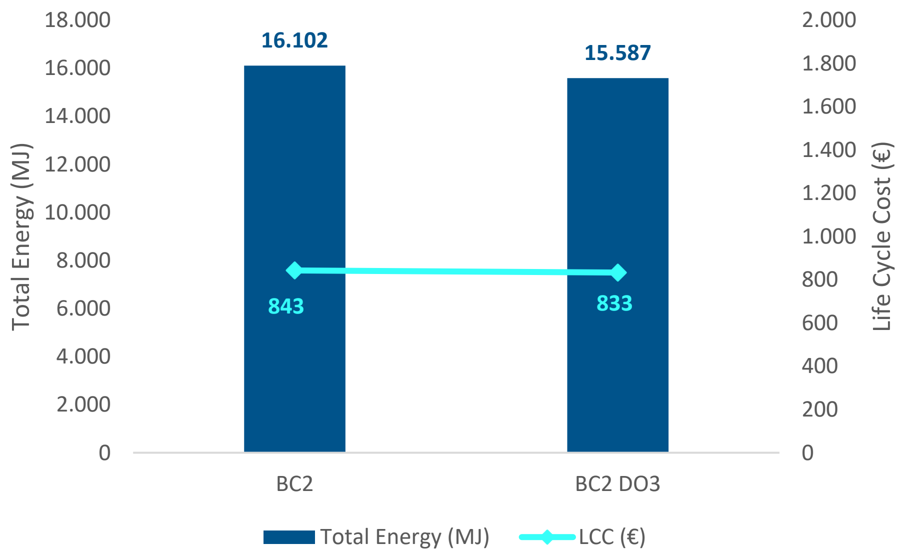
Currently BC2 estimates the run on time to be 1.5s. This design option revises this estimation to 1s. This design assumption is assumed to be without cost. This brings the average duration of cycle to **14.01 seconds**. The reduced cycle length reduces the energy consumption per cycle to **4.43 Wh/ cycle**.

Table 6.12 Inputs and assumptions for BC2 DO3

Input / Assumption	BC2	BC2 DO3	Source
Duration of cycles (seconds / cycle)	14.51	14.01	Task 4 product database and manufacturer feedback
Electricity consumption per cycle (Wh / cycle)	4.59	4.43	Task 4 product database

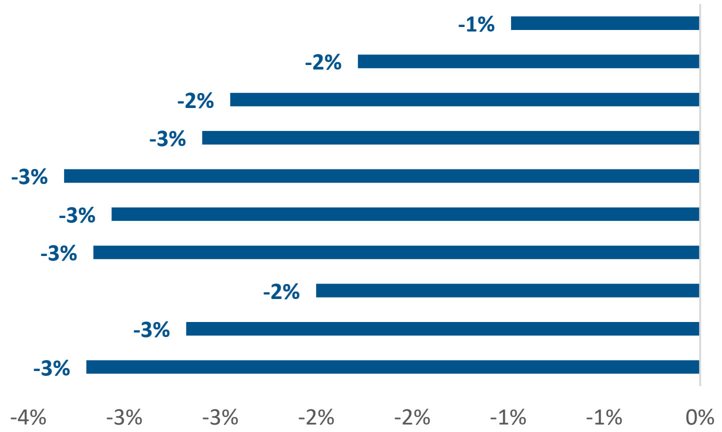
All other inputs and assumptions were assumed to be the same as those of an average BC2 unit as specified in the Task 5 report.

Figure 6.26 Total energy consumption and LCC of a BC2 DO3 unit



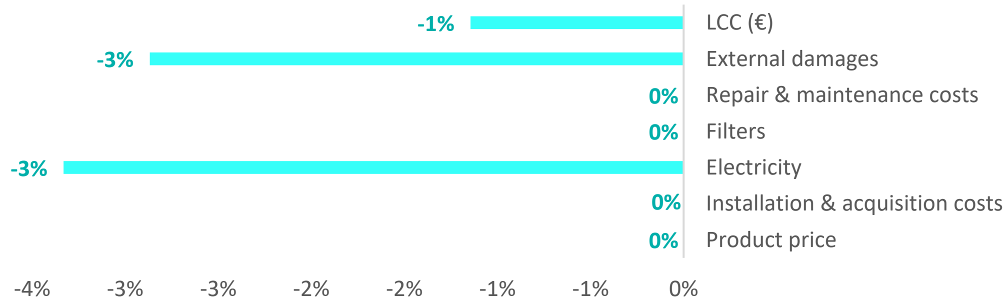
Over its life cycle, a BC3 compliant with the run-on time criteria will consume around 3% less energy than an average BC3 unit as presented in Figure 6.26. As a consequence of the lower electricity consumption, the life cycle environmental impacts of a BC3 DO3 unit are also lower as presented in Figure 6.27.

Figure 6.27 Change in BC3 DO3 environmental indicators as compared to BC3



The life cycle cost of a BC3 DO3 is 1% lower than that of an average BC3 unit, mostly due the electricity savings, and the better environmental performance that leads to lower cost of externalities.

Figure 6.28 Change in BC3 DO3 life cycle costs as compared to BC3



6.2.2.4 Design Option 4 – Energy efficiency

Under this Design option, the 75% most energy efficient hand dryers per cycle were considered. According to the product database gathered in Task 4, this assumes that the products consuming more than 6Wh per use do not meet the Design Option. This is modelled by assuming that these high consumption hand dryers improve their efficiency to meet 6Wh/use. On average, this results in a consumption for BC2 of **4.43 Wh/use**.

The main energy consumption for BC2 hand dryers is from the motor. The simplest way to make the product more efficient is therefore to replace the motor for a more efficient motor. This is a "like for like" improvement, which increases the cost but not the functioning or design of the product (other cheaper options exist, such as reducing heat output or improving airflow by revised design exist which are not considered in this model).

According to the motors Ecodesign preparatory study[178], replacing motors of a 1.1 kW power rating from an IE1 efficiency, at €96, to IE2, at €125, have an improved efficiency of 6.3%. Improving the motor efficiency of the hand dryers under DO4 equates to 3.4%

[178] https://www.eceee.org/static/media/uploads/site-2/ecodesign/products/electricmotors/finalreport-motors.pdf

which we have approximated as the improvement cost of switching from IE1 motors to IE2 motors. This is a 30% price increase in the motor in order to achieve the required efficiency. As was described in Task 2, manufacturer feedback indicates that BC2 hand dryer motor costs 10% of the final item price. Therefore, the final BC2 product price increases by **3% to €361.54**.

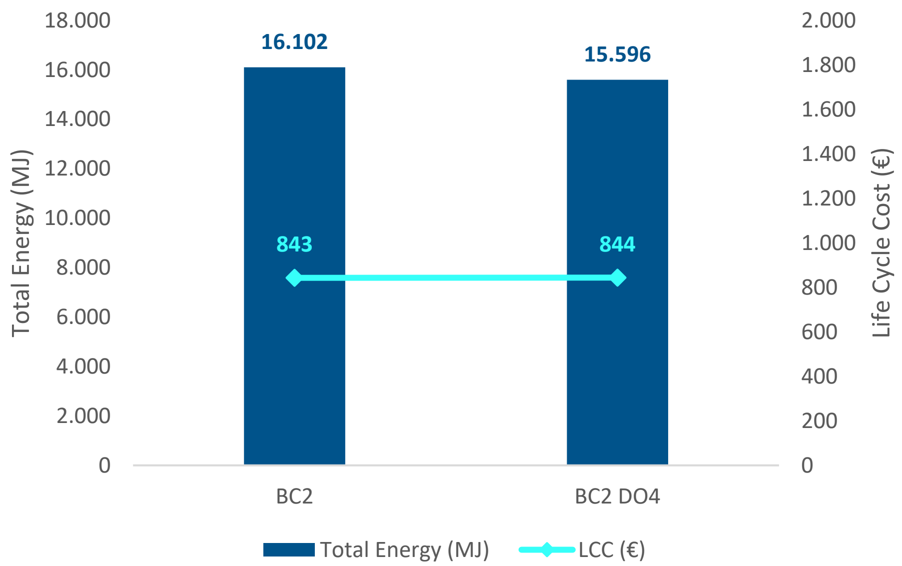
This increase in motor price also increases the cost of material for repairing a unit to **€53.63**.

Table 6.13 Inputs and assumptions for BC2 DO4

Input / Assumption	BC2	BC2 DO4	Source
Electricity consumption per cycle (Wh / cycle)	4.59	4.43	Task 4 product database
Cost of material for repairing a unit	€53	€ 54	Motor preparatory study Manufacturer motor price estimation
Price of a unit	€ 351	€ 362	Motor preparatory study Manufacturer motor price estimation

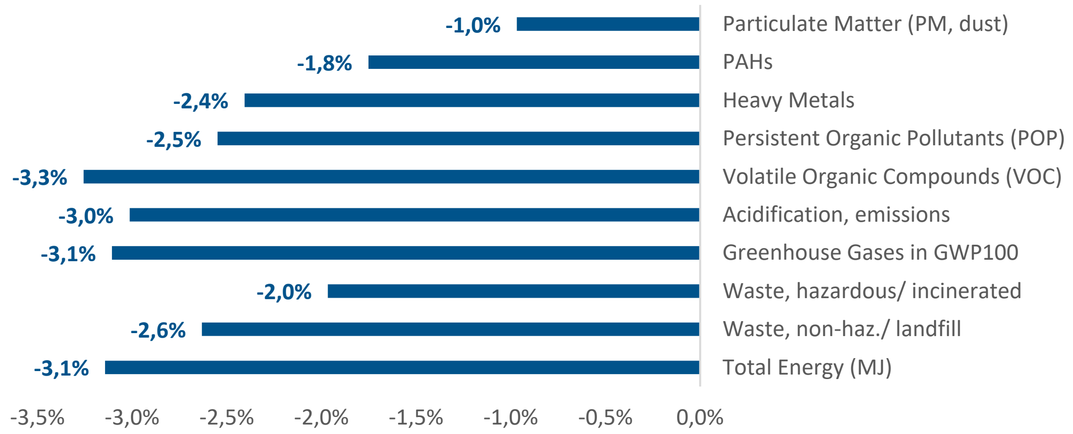
All other inputs and assumptions were assumed to be the same as those of an average BC2 unit, as specified in the Task 5 report.

Figure 6.29 Total energy consumption and LCC of a BC2 DO4 unit



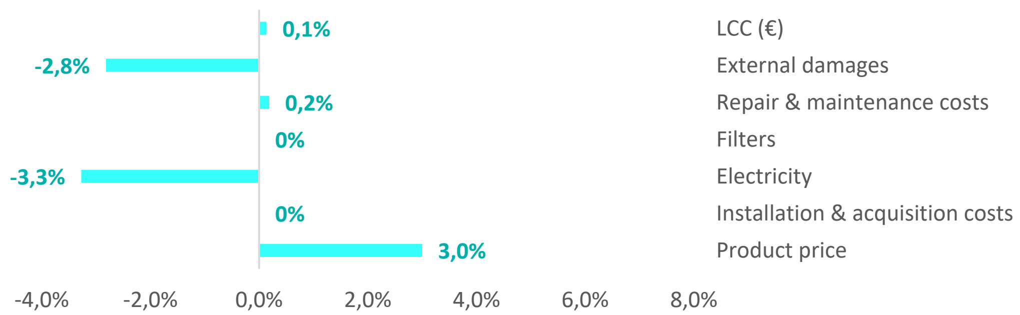
Over its life cycle, a BC2 DO4 unit will consume around 3% less energy than an average BC2 unit, as presented in Figure 6.29. A BC2 unit with a more efficient motor consumes less electricity per cycle which leads to overall lower electricity consumption. Consequently, the life cycle environmental impacts of a unit will also be lower as presented in Figure 6.30.

Figure 6.30 Change in BC2 DO4 environmental indicators as compared to BC2



The life cycle cost of a BC2 DO4 unit is 0.1% higher than that of an average BC2 mostly due to the electricity savings and the better environmental performance that leads to lower cost of externalities. Still, the purchase price of a unit compliant with the motor efficiency is about 3% higher than that of an average BC2 unit.

Figure 6.31 Change in BC2 DO4 life cycle costs as compared to BC2



6.2.2.5 Design Option 5 – Assembly Design

Improved assembly/ disassembly design is assumed to allow for three improvement aspects:

- easier separation of hand dryer PCB to allow for increase electronics recycling
- simplified interior layout allowing for faster repair rates.
- Faster repair times to increase the incidence of repaired products, and hence the average life expectancy of products overall.

Task 5 models the end of life of hand dryers where the items are not disposed of through a WEEE stream. Ordinary recycling streams would only recuperate and recycle 10% of electronics. Improved design could allow for the electronics board to be easily separable from the main product, allowing for the electronics to be separately sorted by the user into a specialised WEEE stream. WEEE streams typically reaching a 40% recuperation rate for electronics, with some high rate facilities reaching 80% recuperation. The DO5 model assumes that 50% of hand dryer electronic boards are disposed into a specialised WEEE stream. It also assumes that for those going through a WEEE stream, 20% of these reach high rate recycling facilities recuperating 80% of materials, and others only reaching 40%. This results in a recycling rate of electronics of **29%**.

Assuming that there is a 50% uptake in repair rates, it is estimated that where the base case scenario sees 30% of BC2 hand dryers are repaired, DO5 will increase this percentage to **45%.** By extension, the increased repair rate means the average product service life is extended from 6.59 to **6.89 years**. The effect on product lifespan is marginal because only motor repairs are assumed to extend service life.

Repair labour cost calculations were estimated in Task 2 to involve an electrician coming to site on two occasions of one hour each. The simplified interior layout of the hand dryer is assumed to make the work of the electricians simpler and reduce each visit to 30 minutes. Accounting for travel costs remaining constant, the labour cost of repair is therefore reduced from €128.58 to **€87.25**.

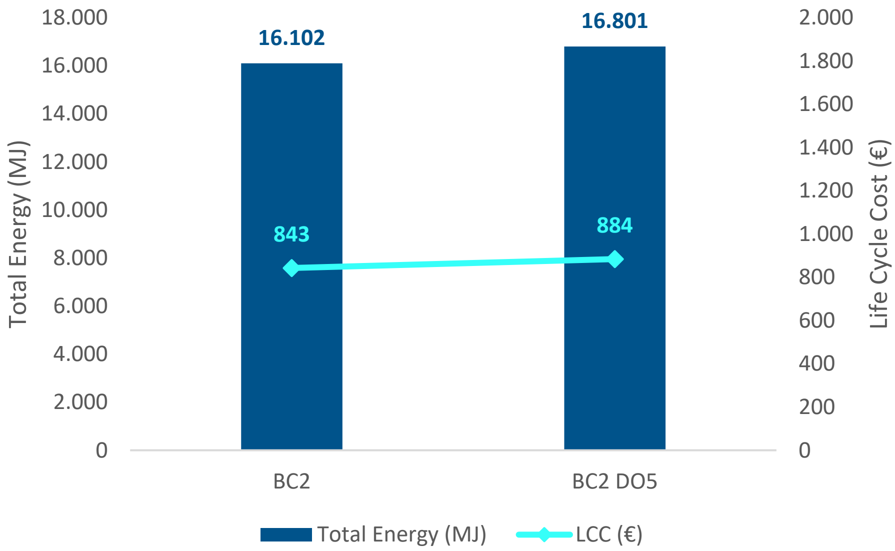
The price of the unit is increased to improve product design. Assuming that the product design accounts for 10% of the consumer price of the product, improving this design is estimated to require 50% extra design effort. This therefore resolves in a total product price increase of 5% from €351 to **€369**.

Table 6.14 Inputs and assumptions for BC2 DO5

Input / Assumption	BC2	BC2 DO5	Source
Recycling rate for electronic components	10%	29%	Assumption that 50% of PCBs enter WEEE stream and 20% of WEEE stream enters high recycling rate facilities
Percentage of products that are repaired	30%	45%	Assumption that improved repair time improves rate of repair by 50%.
Average product service life	6.59	6.89	Consequence of increased repair rate
Cost of labour for repairing a unit	€ 129	€ 87	Assumption that repair time of electrician is reduced from 1 hour to 30 minutes.
Price of a unit	€ 351	€ 369	Assumption that design costs are 10% of final product price and that design costs are increased by 50%

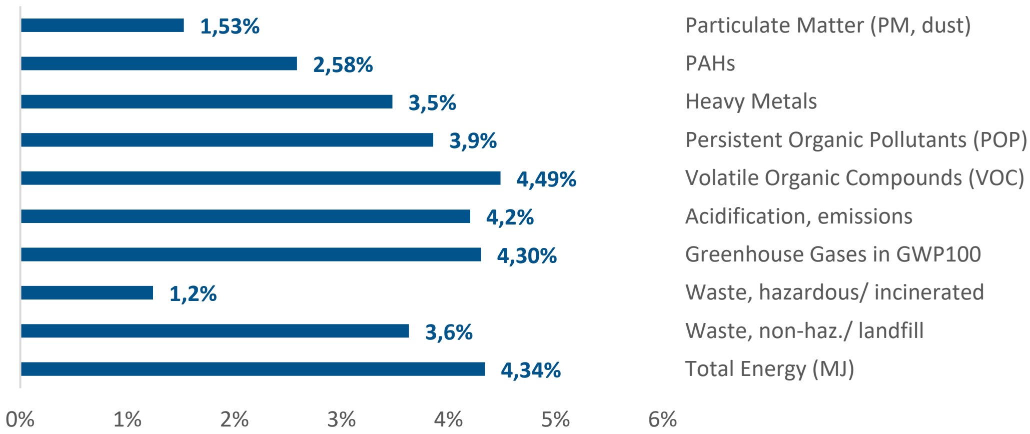
All other inputs and assumptions were assumed to be the same as those of an average BC2 unit as specified in the Task 5 report.

Figure 6.32 Total energy consumption and LCC of a BC2 DO5 unit



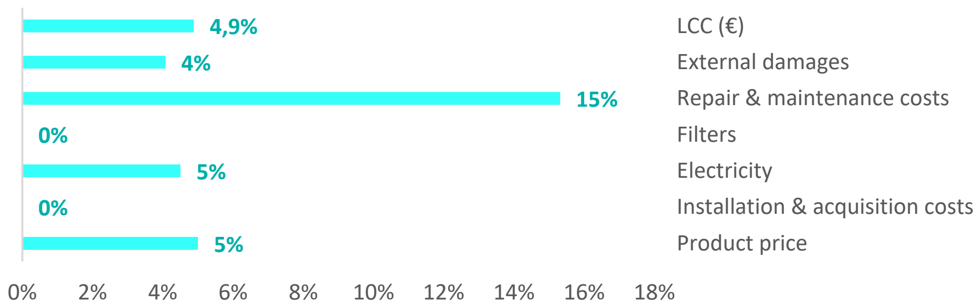
Over its life cycle, a BC2 DO5 unit will consume around 4.3% more energy than an average BC3 unit as presented in Figure 6.32. While energy savings occur in the end of life phase of the unit's lifecycle due to the increased percentage of electronic components that get recycled, energy consumption during the use phase is higher due to the extended product lifespan. Figure 6.33 presents the changes this brings to the environmental impacts created over the lifecycle of a BC3 unit.

Figure 6.33 Change in BC2 DO5 environmental indicators as compared to BC2



The life cycle cost of a BC2 DO5 is about 4.9% higher than of that of an average BC2. The purchase cost of a unit is 5% higher and electricity costs are 5% higher due to the extended product lifespan. Furthermore, although the cost of repair is lower for each unit that is repaired, on average more units will be repaired and hence the average cost of repair per unit is also 15% higher.

Figure 6.34 Change in BC2 DO5 life cycle costs as compared to BC2



The Trade-off for Improving Repair Rates

Only **10%** of average **BC2** units are assumed to have their motor replaced, the effect of which is to then double the lifespan of a unit. For **BC2 DO5** this percentage is increased to **15%**. Given these figures, with DO5 the average lifespan of a unit is increased from **6.59 years** to **6.89** years.

Furthermore, although the cost of repairing one BC1 DO5 unit is lower than that of repairing a BC1 unit, because of the increased percentage of products that are repaired – from **30%** to **45%** - the average cost of repair & maintenance goes up from **€57** to **€65**.

The cost of electricity is assumed to be the same on a per year basis when comparing both products. The purchase price of a **BC2 DO5** unit is higher than that of an average **BC2** unit in absolute terms and also on an average per year basis (i.e. when dividing purchase price by the average lifespan) going from **€ 53.23** for **BC2** to **€ 53.48** for **BC2 DO5**.

	BC2 (average lifespan 6.59 years)			BC2 DO5 (average lifespan 6.89 years)		
	Purchase	Electricity	R&M	Purchase	Electricity	R&M
Average per year	€ 53.23	€ 38.56	€ 8.60	€ 53.48	€ 38.56	€ 9.49
Total LCC	€ 351.01	€ 254.28	€ 56.69	€ 368.56	€ 265.74	€ 65.37

6.2.2.6 Design Option 6 – Combination of Design Options 1, 2, 3, 4 and 5

DO6 consists of a combination of all five DOs assessed in Section 6.2.2 Combining the Design Options 1, 2, 3, 4 and 5 has the following effects to the inputs and assumptions used in the model:

- The duration of cycles for BC2 DO6 reflects an increase from DO1 and a decrease from DO3 keeping the average cycle duration at **14.51 seconds per cycle**.
- Energy consumption per cycle is calculated at an average **2.94 Wh/cycle** based on the effects of DO1, DO3 and DO4.
- The cost of materials for repair is brought up to **€54** following the repair cost increase of DO4.
- Standby consumption is reduced to **0.52W** as covered in DO2.
- DO5 improves the recycling rate of electronics to **29%** and reduces the labour costs of repair to **€87.25.** Furthermore, improved repair time is expected to increase the rate of repair of products to **45%** and hence the average life expectancy of the product to **6.89 years.**
- The heating element is removed from the BoM as covered under DO1.

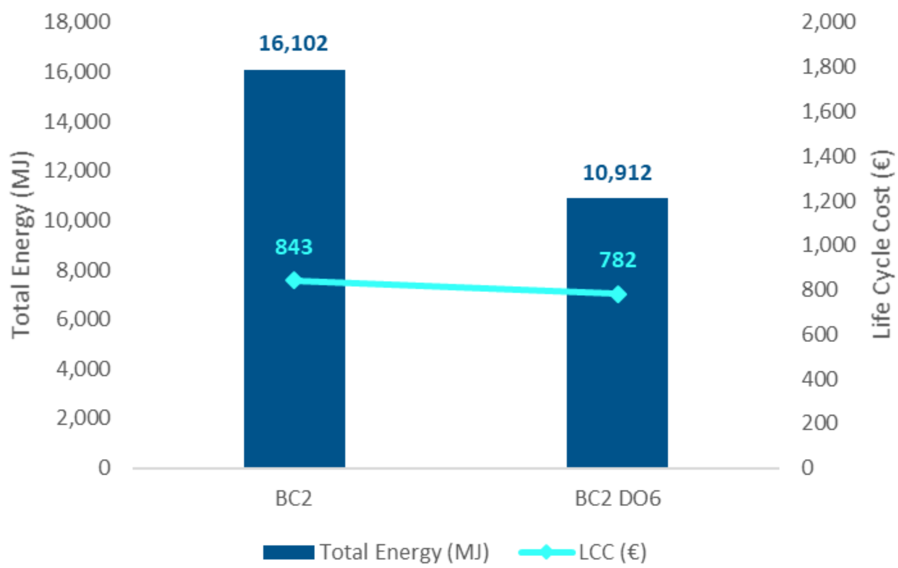
Product price for this option is brought up to **€376.56** as a reflection of the measures from DO1, DO2, DO4 and DO5. DO3 is assumed to not bring a cost increase to BC3 products.

Table 6.15 Inputs and assumptions for BC2 DO6

Input / Assumption	BC2	BC2 DO6	Source
Duration of cycles (seconds / cycle)	14.51	14.51	www.intelligenthanddryers.com assumption that power spent on heat or motor speed contributes equally to hand drying time
Electricity consumption per cycle (Wh / cycle)	4.59	2.94	Task 4 product database www.intelligenthanddryers.com assumption that power spent on heat or motor speed contributes equally to hand drying time
Standby electricity consumption (W)	1.11	0.52	Ecodesign 801/2013 (Standby Reg.) plus inputs from Task 4 product database
Cost of material for repairing a unit	€ 53	€ 54	Proxy price taken from household tumble drier review study. Manufacturer motor price estimation
Price of a unit	€ 351	€ 377	Household tumble drier review study EuP Lot 6 Prep study https://www.intelligenthanddryers.com/category/hand-dryer-spare-parts conversion: www.xe.com (31/07/2019)
BoM	heating element	no heating element	Task 4 BoM

All other inputs and assumptions were assumed to be the same as those of an average BC2 unit as specified in the Task 5 report.

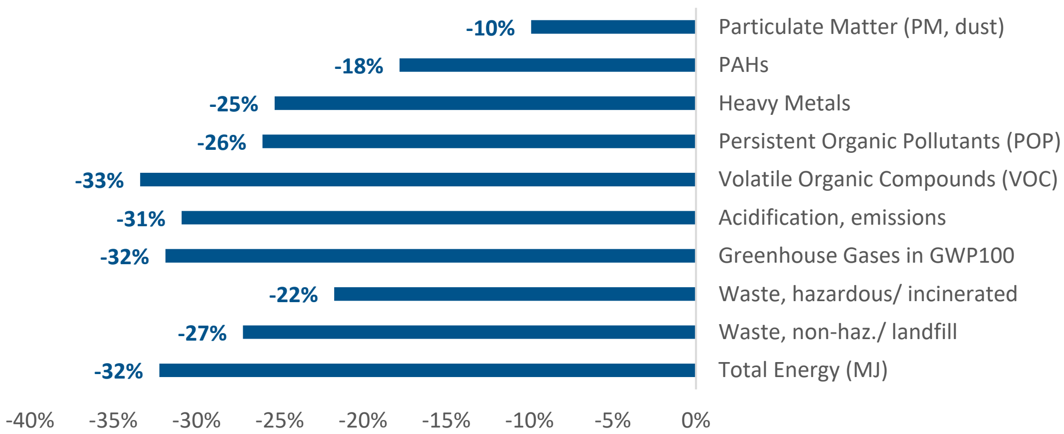
Figure 6.35 Total energy consumption and LCC of a BC2 DO6 unit



Over its life cycle, a BC2 DO6 unit will consume around 32% less energy than an average BC2 unit, as presented in Figure 6.35.

The lower electricity consumption in both on and standby operating modes account for most of the energy savings. Consequently, the life cycle environmental impacts of a BC2 DO6 unit will also be lower, as presented in Figure 6.36.

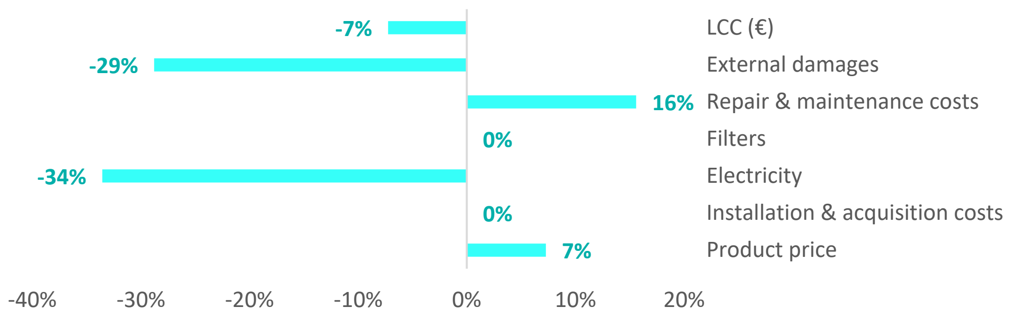
Figure 6.36 Change in BC2 DO6 environmental indicators as compared to BC2



The life cycle cost of a BC2 DO6 unit is the same as that of an average BC2 as the increased purchase price is compensated by the electricity savings and the lower cost of externalities.

The life cycle cost of a BC2 DO6 unit is 7% lower than that of an average BC3 due to the electricity savings and the better environmental performance. These improvements outweigh the higher purchase price and the higher repair and maintenance costs of a unit compliant with the DO6 criteria.

Figure 6.37 Change in BC2 DO6 life cycle costs as compared to BC2



6.2.3 BC3 – High speed trough style hands in dryer

6.2.3.1 Design Option 1 – No heat

The BC3 technology dries hands by applying a high air pressure air stream to blow water off users' hands. Heat can be added to accelerate the drying process and increase user comfort. Hand dryer products can be adjusted relative to their air speed and heating to deliver faster or slower dry times in requiring more or less energy. Manufacturer feedback has indicated that heat contributes little to improving the drying time. A conservative contribution of 100W of heat improving dry time by 0.25s is therefore assumed. Further manufacturer feedback estimates that the average heating unit of BC3 is **550W**. The removal of this component is therefore estimated to increase dry time by **1.375s**.

In non-heating BC3 units the heating elements would be removed from the Bill of Materials (BoM) which brings an only marginal effect to the environmental impacts in the production and end-of-life phases. This element is removed from the BoM as presented in Task 4.

Manufacturer feedback has indicated that the heater element spare part price is €14. Accounting for products to which this Design Option does not apply (namely the hand dryers without a heating component), this results in a saving of **€10.92** made on average. As DO1 assumes that the heater element is removed, the price of BC3 hand dryer was reduced from **€715** to **€701**.

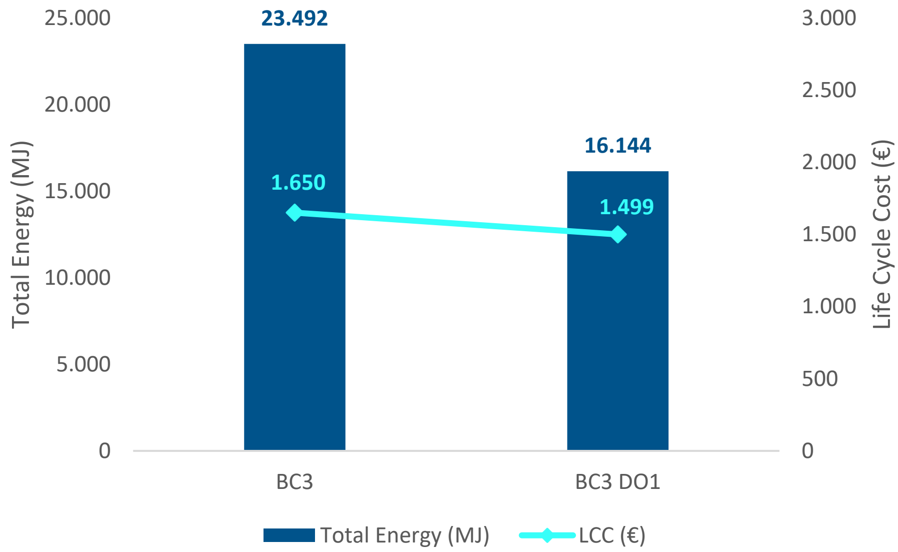
Table 6.16 Inputs and assumptions for BC3 DO1

Input / Assumption	BC3	BC3 DO1	Source
Electricity consumption per cycle (Wh / cycle)	4.99	3.28	www.intelligenthanddryers.com assumption that power spent on heat or motor speed contribute equally to dry time
Duration of cycles (seconds / cycle)	12.78	13.94	www.intelligenthanddryers.com assumption that power spent on heat or motor speed contribute equally to dry time
Price of a unit	€ 715	€ 701	https://www.intelligenthanddryers.com/category/hand-dryer-spare-parts

Input / Assumption	BC3	BC3 DO1	Source
			conversion: www.xe.com (31/07/2019)
BoM	heating element	no heating element	Task 4 BoM

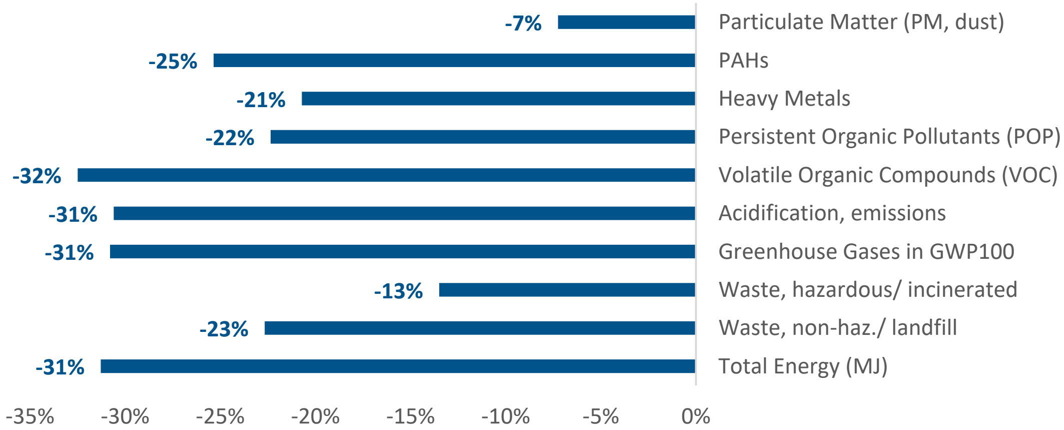
All other inputs and assumptions were assumed to be the same as those of an average BC3 unit as specified in the Task 5 report.

Figure 6.38 Total energy consumption and LCC of a BC3 DO1 unit



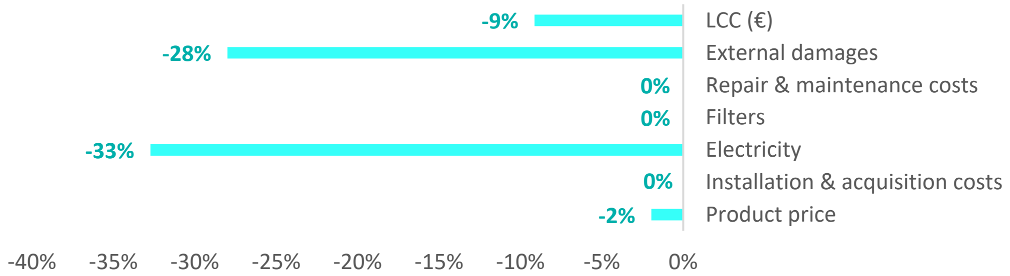
Over its life cycle, a no heat BC3 unit will consume around 31% less energy than an average BC3 unit as presented in Figure 6.38. Most of the energy savings occur during the use phase as a no heat unit will consume less energy per hand drying cycle, even if the average duration of a cycle is slightly higher. Consequently, the life cycle environmental impacts of a BC3 DO1 unit will also be lower as presented in Figure 6.39.

Figure 6.39 Change in BC3 DO1 environmental indicators as compared to BC3



The life cycle cost of a "no heat" BC3 is 9% lower than that of an average BC3 unit, mostly due the electricity savings, the better environmental performance that leads to lower cost of externalities, and the lower purchase price of a no heat unit.

Figure 6.40 Change in BC3 DO1 life cycle costs as compared to BC3



6.2.3.2 *Design Option 2 – Standby*

This design option intends to put in place a maximum consumption value for hand dryers on standby. The requirements modelled are those from the *ecodesign requirements for standby, off mode electric power consumption of electrical and electronic household and office equipment No 801/2013*. The requirements are for maximum power levels in standby to be 0.5W or 1W if an information or status display is available. Reviewing product datasheets from Task 4, a weighted standby consumption is calculated for BC3 between 1W for those with an information display, or 0.5W. There nine examples of BC3 hand dryers with status displays out of 13 in database, the standby consumption is therefore **0.846W**.

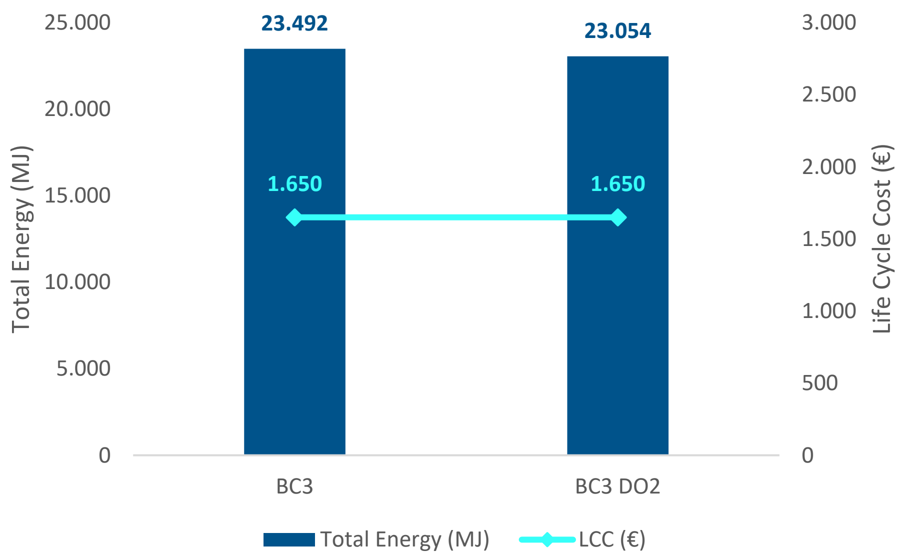
Manufacturer feedback has been used to estimate the cost of standby compliance by reviewing the costs of improvement and recertification of the product. This is estimated to increase the price of the hand dryer by €8.

Table 6.17 Inputs and assumptions for BC3 DO2

Input / Assumption	BC3	BC3 DO2	Source
Standby electricity consumption (W)	1.51	0.85	Ecodesign 801/2013 And Task 4 product database
Price of a unit	€ 715	€ 723	EuP Lot 6 Prep study

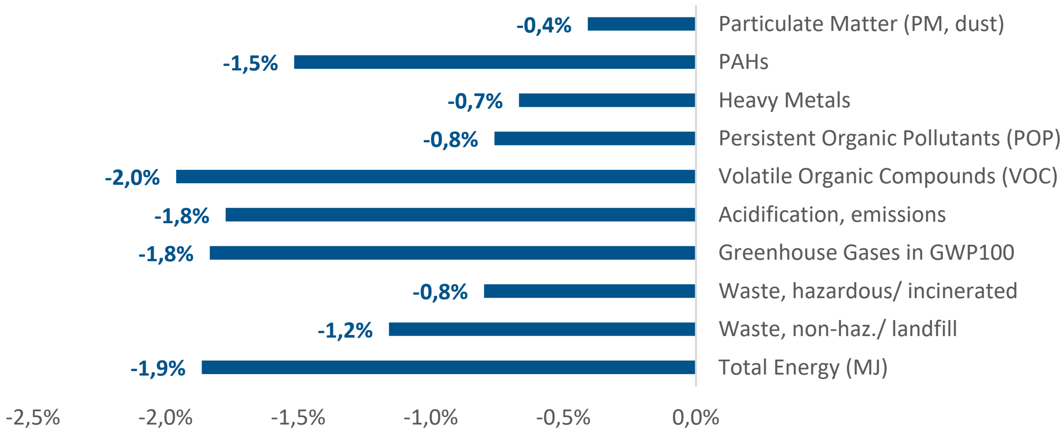
All other inputs and assumptions were assumed to be the same as those of an average BC3 unit as specified in the Task 5 report.

Figure 6.41 Total energy consumption and LCC of a BC3 DO2 unit



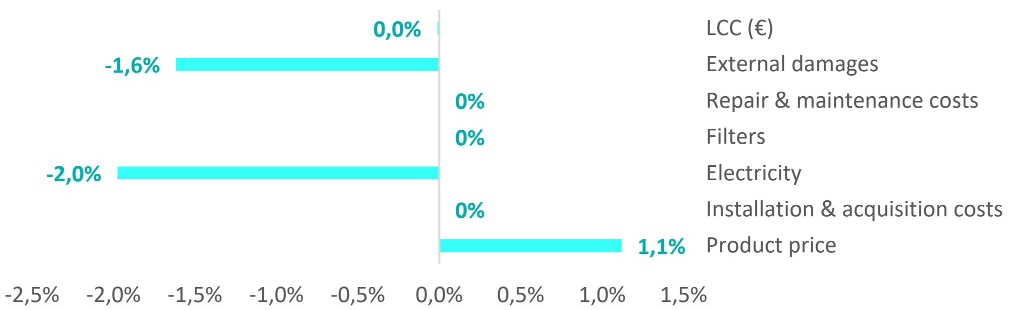
Over its life cycle, a BC3 compliant with the low standby criteria will consume around 1.9% less energy than an average BC3 unit as presented in Figure 6.41. As a consequence of the lower electricity consumption, the life cycle environmental impacts of a BC3 DO2 unit are also slightly lower as presented in Figure 6.42.

Figure 6.42 Change in BC3 DO2 environmental indicators as compared to BC3



The life cycle cost of a BC3 DO2 unit is about the same as that of an average BC3 as the electricity savings and the better environmental performance are compensated by the higher purchase price of a unit compliant with the standby criteria.

Figure 6.43 Change in BC3 DO2 life cycle costs as compared to BC3



6.2.3.3 *Design Option 3 – Sensor only / run-on time*

With regard to this design option, it must be noted that BC3 hand dryers on the market are already operated via sensor only. Therefore, the benefit of this design option is to limit the run-on time of the hand dryer to 1s.

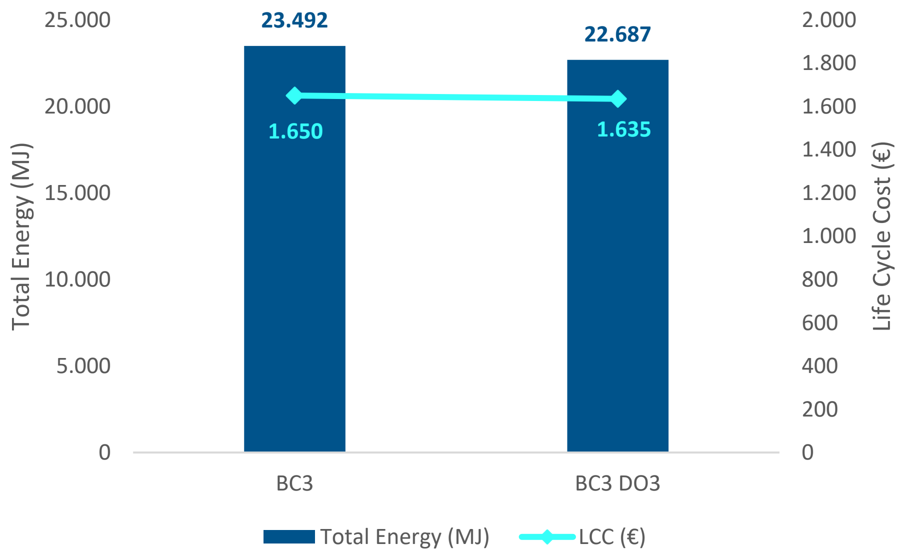
Currently BC3 estimates the run on time to be 1.5s. This design option revises this estimation to 1s. This design assumption is assumed to be without cost. This brings the average duration of cycle to **12.28 seconds**. The reduced cycle length reduces the energy consumption per cycle to **4.80 Wh/cycle**.

Table 6.18 Inputs and assumptions for BC2 DO3

Input / Assumption	BC2	BC2 DO3	Source
Duration of cycles (seconds / cycle)	12.78	12.28	Task 4 product database and manufacturer feedback
Electricity consumption per cycle (Wh / cycle)	4.99	4.80	Task 4 product database

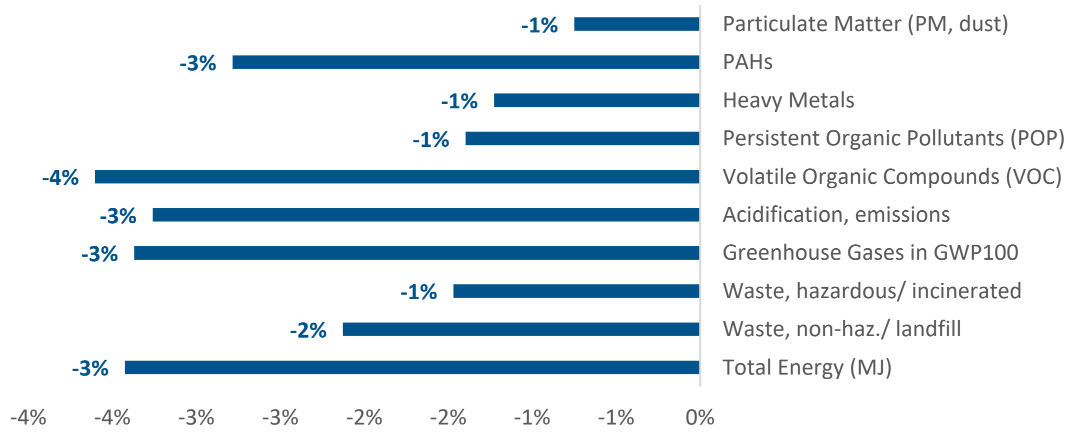
All other inputs and assumptions were assumed to be the same as those of an average BC3 unit as specified in the Task 5 report.

Figure 6.44 Total energy consumption and LCC of a BC3 DO3 unit



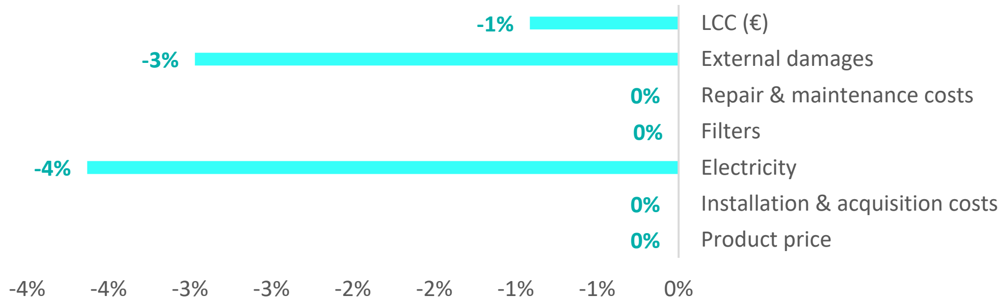
Over its life cycle, a BC3 compliant with the run-on time criteria will consume around 3% less energy than an average BC3 unit as presented in Figure 6.44. As a consequence of the lower electricity consumption, the life cycle environmental impacts of a BC3 DO3 unit are also lower as presented in Figure 6.45.

Figure 6.45 Change in BC3 DO3 environmental indicators as compared to BC3



The life cycle cost of a BC3 DO3 is 1% lower than that of an average BC3 unit, mostly due the electricity savings, and the better environmental performance that leads to lower cost of externalities.

Figure 6.46 Change in BC3 DO3 life cycle costs as compared to BC3



6.2.3.4 Design Option 4 – Energy efficiency

Under this Design option, the 75% most energy efficient hand dryers per cycle were considered. According to the product database gathered in Task 4, this assumes that the products consuming more than 5.5Wh per use do not meet the Design Option. This is modelled by assuming that these high consumption hand dryers improve their efficiency to meet 5.5Wh/use. On average, this results in a consumption for BC3 of **4.45 Wh/use**.

The main energy consumption for BC3 hand dryers is from the motor. The easiest way to make the product more efficient is therefore to replace the motor with a more efficient motor. This is a "like for like" improvement, which increases the cost but not the functioning or design of the product (other cheaper options such as reducing heat output or improving airflow by revised design exist, but these have not been considered in this model).

According to the motors preparatory study[179], motors of a 1.1 kW power rating from an IE1 efficiency, at €96, to IE3, at €154, have an improved efficiency of 9%. Improving the motor efficiency of the hand dryers under DO4 is of 10.8% which we will approximate as the improvement cost of switching from IE1 motors to IE3 motors. This is a 60% price increase in the motor in order to achieve the required efficiency. As was described in Task 2, manufacturer feedback indicates that BC3 hand dryer motor costs 10% of the final item price. Therefore the final BC3 product price increases by **6% to €757.90**.

[179] https://www.eceee.org/static/media/uploads/site-2/ecodesign/products/electricmotors/finalreport-motors.pdf

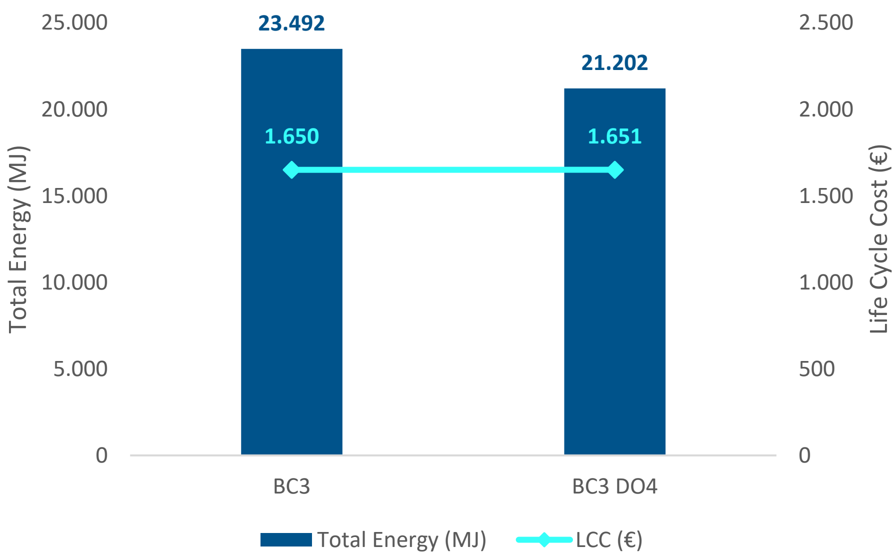
This increase in motor price also increases the cost of material for repairing a unit to **€66.85**.

Table 6.19 Inputs and assumptions for BC3 DO4

Input / Assumption	BC3	BC3 DO4	Source
Electricity consumption per cycle (Wh / cycle)	4.99	4.45	Task 4 product database
Cost of material for repairing a unit	€ 65	€ 67	Motor preparatory study Manufacturer motor price estimation
Price of a unit	€ 715	€ 758	Motor preparatory study Manufacturer motor price estimation

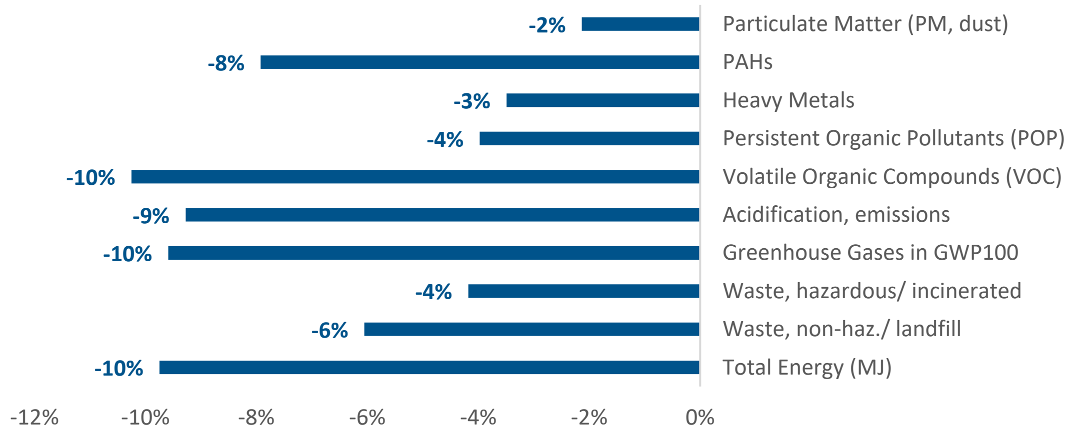
All other inputs and assumptions were assumed to be the same as those of an average BC3 unit as specified in the Task 5 report.

Figure 6.47 Total energy consumption and LCC of a BC3 DO4 unit



Over its life cycle, a BC3 DO4 unit will consume around 10% less energy than an average BC3 unit as presented in Figure 6.47. A BC3 unit with a more efficient motor consumes less electricity per cycle which leads to overall lower electricity consumption. Consequently, the life cycle environmental impacts of a unit will also be lower as presented in Figure 6.48.

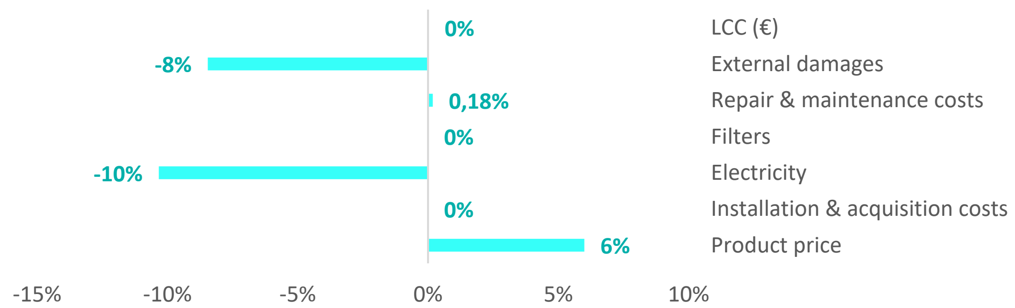
Figure 6.48 Change in BC3 DO4 environmental indicators as compared to BC3



The life cycle cost of a BC3 DO4 unit is 2% lower than that of an average BC3 mostly due to the electricity savings and the better environmental performance that leads to lower cost of externalities. Still, the purchase price of a unit compliant with the motor efficiency is about 2% higher than that of an average BC3 unit.

The life cycle cost of a BC3 DO4 unit is about the same as that of an average BC3 as the electricity savings and the better environmental performance are compensated by the higher purchase price of a DO4 unit.

Figure 6.49 Change in BC3 DO4 life cycle costs as compared to BC3



6.2.3.5 Design Option 5 – Assembly Design

Improved assembly/ disassembly design is assumed to allow for:

- easier separation of hand dryer PCB to allow for increase electronics recycling
- simplified interior layout allowing for faster repair rates.
- faster repair times to increase the incidence of repaired products, and hence the average life expectancy of products overall.

Task 5 models the end of life of hand dryers where the items are not disposed of through a WEEE stream. Ordinary recycling streams would only recuperate and recycle 10% of electronics. Improved design could allow for the electronics board to be easily separable from the main product, allowing for the electronics to be separately sorted by the user into a specialised WEEE stream. WEEE streams typically reach a 40% recuperation rate for electronics, with some high rate facilities reaching 80% recuperation. The DO5 model assumes that 50% of hand dryer electronic boards are disposed into a specialised WEEE stream. It also assumes that for those going through a WEEE stream, 20% of these reach high rate recycling facilities which recuperate 80% of materials, but that the remaining electronic boards are in recycling facilities which reach a recuperation rate of 40%. This results in a recycling rate of electronics of **29%**.

Assuming that there is a 50% uptake in repair rates, we estimate that where the base case scenario models 30% of BC3 hand dryers being repaired, DO5 will increase this percentage to **45%.** By extension, the increased repair rate means the average product service life is extended **from 8.61 to 8.99 years**.

Repair labour cost calculations were estimated in Task 2 to involve an electrician coming to site on two occasions of one hour each. The simplified interior layout of the hand dryer is assumed to make the electricians work simpler and reduce each visit to 30 minutes. Accounting for travel costs remaining constant, the labour cost of repair is therefore changed from €128.58 to **€87.25**.

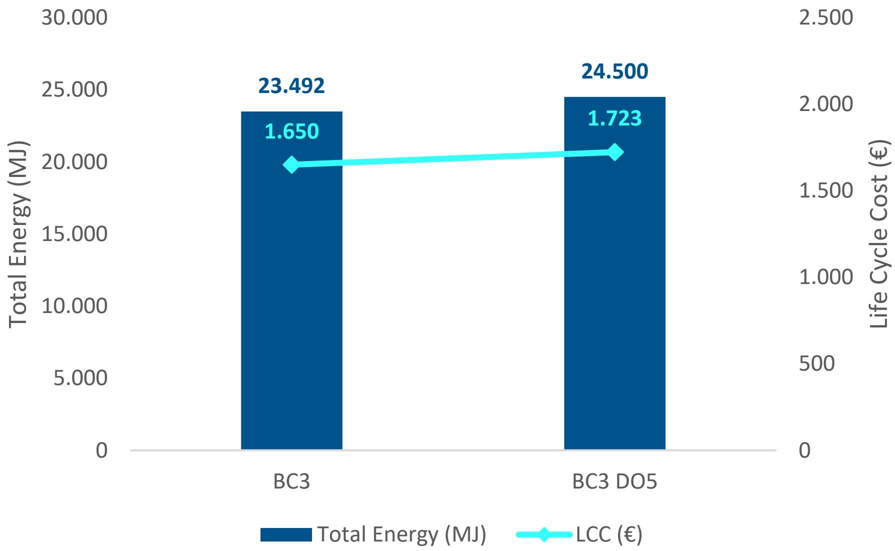
The price of the unit is increased to improve product design. Assuming that the product design accounts for 10% of the consumer price of the product, improving this design is estimated to require 50% extra design effort. This therefore resolves in a total product price increase of 5% from **€715** to **€751**.

Table 6.20 Inputs and assumptions for BC3 DO5

Input / Assumption	BC3	BC3 DO5	Source
Percentage of products that are repaired	30%	45%	Assumption that improved repair time improves rate of repair by 50%.
Average product service life	8.61	8.99	Consequence of increased repair rate
Recycling rate for electronic components	10%	29%	Assumption that 50% of PCBs enter WEEE stream and 20% of WEEE stream enters high recycling rate facilities
Cost of labour for repairing a unit	€ 129	€ 87	Assumption that repair time of electrician is reduced from 1 hour to 30 minutes.
Price of a unit	€ 715	€ 751	Assumption that design costs are 10% of final product price and that design costs are increased by 50%

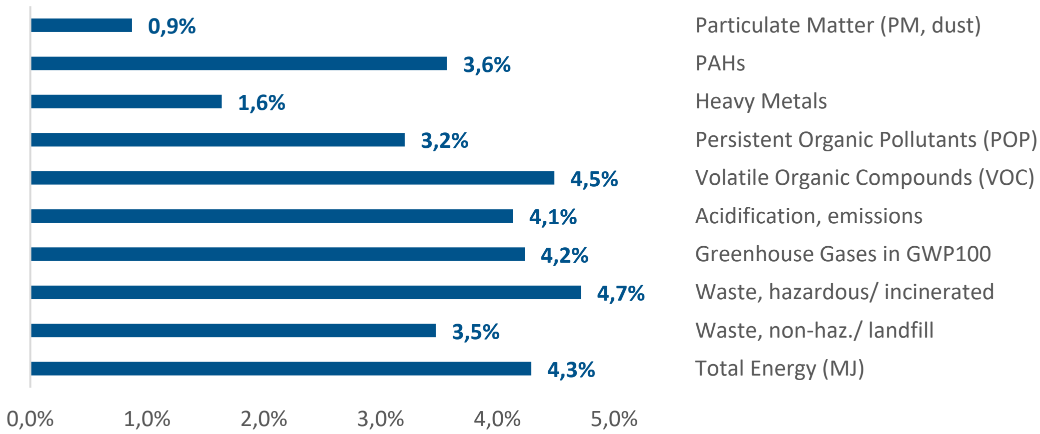
All other inputs and assumptions were assumed to be the same as those of an average BC3 unit as specified in the Task 5 report.

Figure 6.50 Total energy consumption and LCC of a BC3 DO5 unit



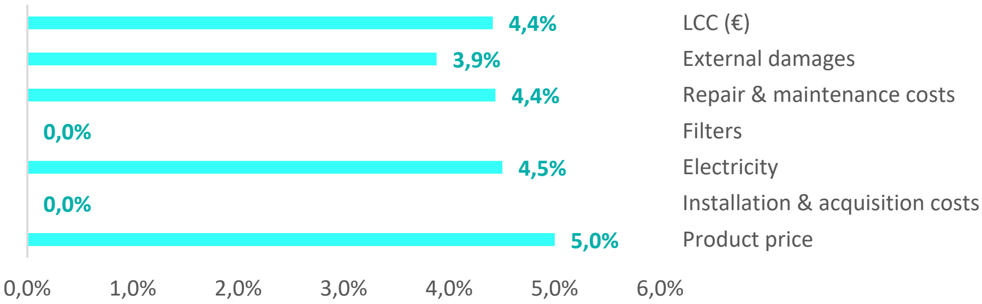
Over its life cycle, a BC3 DO5 unit will consume around 4.3% more energy than an average BC3 unit as presented in Figure 6.50Figure 6.14. While energy savings occur in the end of life phase of the unit's lifecycle due to the increased percentage of electronic components that get recycled, energy consumption during the use phase is higher due to the extended product lifespan. Figure 6.51Figure 6.15 presents the changes this brings to the environmental impacts created over the lifecycle of a BC3 unit.

Figure 6.51 Change in BC3 DO5 environmental indicators as compared to BC3



The life cycle cost of a BC3 DO5 is about 4.4% higher than of that of an average BC3. The purchase cost of a unit is 5% higher and electricity costs are 4.5% higher due to the extended product lifespan. Furthermore, although the cost of repair is lower for each unit that is repaired, on average more units will be repaired and hence the average cost of repair per unit is also 4.4% higher.

Figure 6.52 Change in BC3 DO5 life cycle costs as compared to BC3



The Trade-off for Improving Repair Rates

Only **10%** of average **BC3** units are assumed to have their motor replaced, which then doubles the lifespan of a unit. For **BC3 DO5** this percentage is increased to **15%**. Given these figures, with DO5 the average lifespan of a unit is increased from **8.61** to **8.99** years.

Furthermore, although the cost of repairing one BC3 DO5 unit is lower than that of repairing a BC1 unit, because of the increased percentage of products that are repaired – from **30%** to **45%** - the average cost of repair & maintenance goes up from **€237** to **€247**.

The cost of electricity is assumed to be the same on a per year basis when comparing both products. The purchase price of a **BC3 DO5** unit is higher than that of an average **BC3** unit in absolute terms and also on an average per year basis (i.e. when dividing purchase price by the average lifespan) going from **€ 83.09** for **BC3** to **€ 83.48** for **BC3 DO5**.

	BC3 (average lifespan 8.61 years)			BC3 DO5 (averge lifespan 8.99 years)		
	Purchase	Electricity	R&M	Purchase	Electricity	R&M
Average per year	€ 83.09	€ 42.36	€ 27.49	€ 83.48	€ 42.36	€ 27.47
Total LCC	€ 715.00	€ 364.47	€ 236.56	€ 750.75	€ 380.89	€ 247.06

6.2.3.6 Design Option 6 – Combination of Design Options 1, 2, 3, 4 and 5

DO6 consists of a combination of all five DOs assessed in Section 6.2.3. Combining the Design Options 1, 2, 3, 4 and 5 has the following effects to the inputs and assumptions used in the model:

- The duration of cycles for BC3 DO6 reflects an increase from DO1 and a decrease from DO3 bringing the average cycle duration to **13.44 seconds per cycle**.
- Energy consumption per cycle is calculated at an average **3.12 Wh/cycle** based on the effects of DO1, DO3 and DO4.
- The cost of materials for repair is brought up to **€66.85** following the repair cost of DO4.
- Standby consumption is reduced to **0.85W** as covered in DO2.
- DO5 improves the recycling rate of electronics to **29%** and reduces the labour costs of repair to **€87.25.** Furthermore, improved repair time is expected to increase the rate of repair of products to **45%** and hence the average life expectancy of the product to **8.99 years.**
- The heating element is removed from the BoM as covered under DO1.

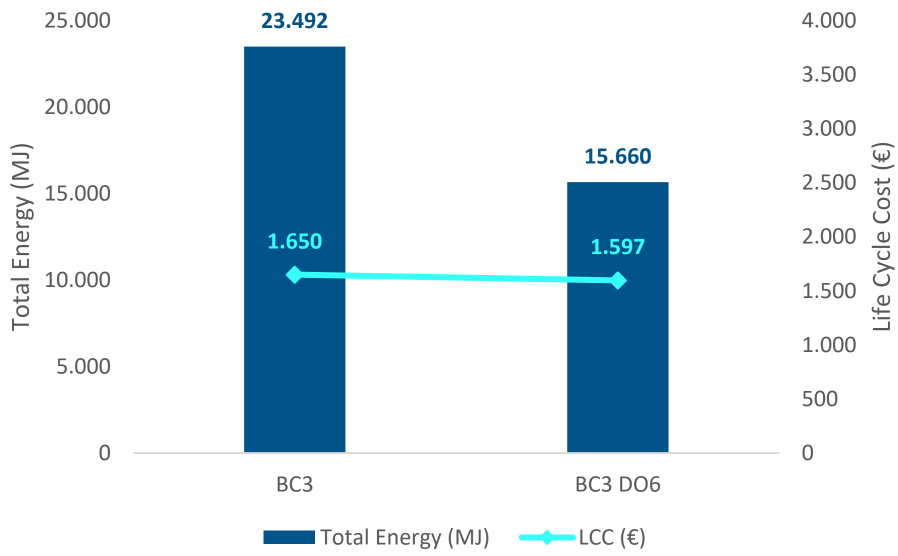
Product price for this option is brought up to **€788.55** as a reflection of the measures from DO1, DO2, DO4 and DO5. DO3 is assumed not to imply any cost increase to BC3 products.

Table 6.21 Inputs and assumptions for BC3 DO6

Input / Assumption	BC3	BC3 DO6	Source
Duration of cycles (seconds / cycle)	12.78	13.44	www.intelligenthanddryers.com assumption that power spent on heat or motor speed contribute equally to dry time
Electricity consumption per cycle (Wh / cycle)	4.99	3.12	Task 4 product database www.intelligenthanddryers.com assumption that power spent on heat or motor speed contribute equally to dry time
Standby electricity consumption (W)	1.51	0.85	Ecodesign regulation 801/2013, plus Task 4 product database
Cost of material for repairing a unit	€ 65	€ 67	Household tumble drier review study (proxy use), plus manufacturer motor price estimation
Recycling rate for electronic components	10%	29%	Assumption that 50% of PCBs enter WEEE stream and 20% of WEEE stream enters high recycling rate facilities
Cost of labour for repairing a unit	€ 129	€ 87	Assumption that repair time of electrician is reduced from 1 hour to 30 minutes.
Percentage of products that are repaired	30%	45%	Assumption that improved repair time improves rate of repair by 50%.
Average product service life	8.61	8.99	Consequence of increased repair rate
Price of a unit	€ 715	€ 789	Household tumble drier review study (proxy use): EuP Lot 6 Prep study https://www.intelligenthanddryers.com/category/hand-dryer-spare-parts conversion: www.xe.com (31/07/2019)
BoM	heating element	no heating element	Task 4 BoM

All other inputs and assumptions were assumed to be the same as those of an average BC3 unit as specified in the Task 5 report.

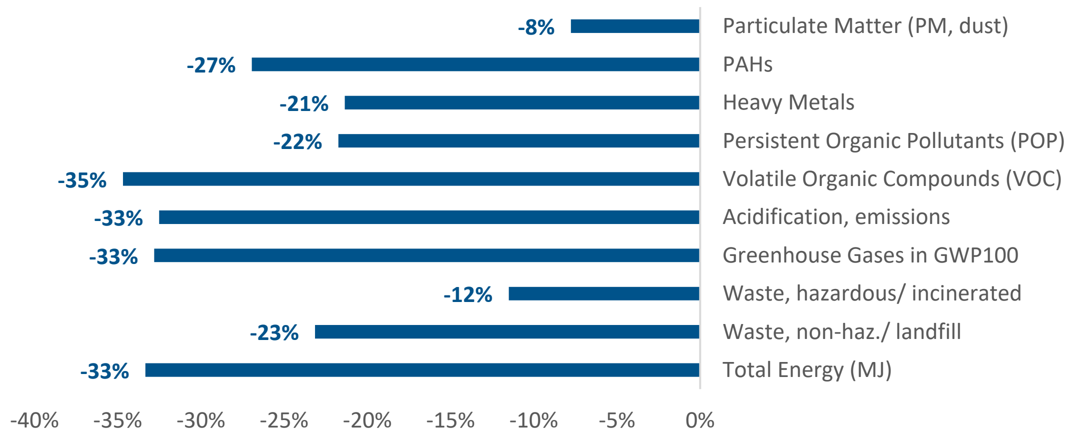
Figure 6.53 Total energy consumption and LCC of a BC3 DO6 unit



Over its life cycle, a BC3 DO6 unit will consume around 33% less energy than an average BC3 unit as presented in Figure 6.53.

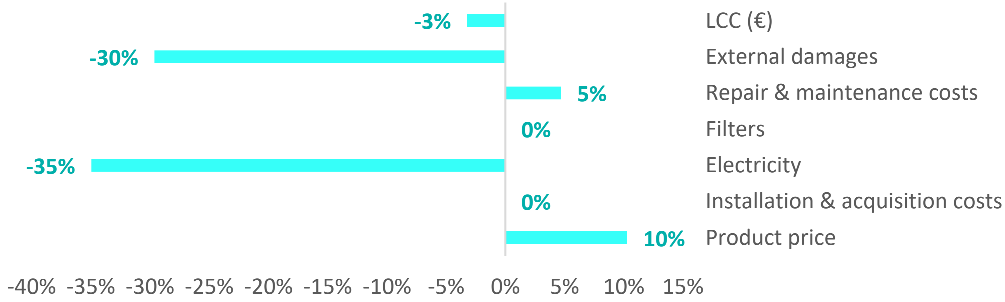
The lower electricity consumption in both on and standby operating modes account for most of the energy savings. Consequently, the life cycle environmental impacts of a BC3 DO6 unit will also be lower as presented in Figure 6.54.

Figure 6.54 Change in BC3 DO6 environmental indicators as compared to BC3



The life cycle cost of a BC3 DO6 unit overall is 3% lower than that of an average BC3. This is a result of the electricity savings and the better environmental performance, which outweigh the higher purchase price and the higher repair and maintenance costs over its lifetime, for a unit that complies with the DO6 criteria.

Figure 6.55 Change in BC3 DO6 life cycle costs as compared to BC3



6.3 ANALYSIS OF BAT AND LLCC

The objective of this sub-task is to take the design options identified above in sub-task 6.1 and identify which has the Least Life Cycle Cost (LLCC) and which is the Best Available Technology (BAT) with the lowest environmental impact.

Each DO is compared against the BC in terms of total energy consumption and LCC, which is the sum of the purchase price of a product, the installation cost, the cost of electricity and repair and maintenance expenses.

The MEErP provides guidance on ranking the DOs according to the Equivalent Annual Cost (EAC) whenever the lifespan differs between the different design options. This method compares the average per year cost of owning and operating an asset over its entire lifespan.

In this study, the escalation and discount rates used were the default MEErP values, which have the same value. Thus, following the MEErP guidelines, Equivalent Annual Cost (EAC) method was used to rank the DOs through the formula below, where *PP* is the purchase price, *N* is the lifespan, and *OE* the annual operating expense.

$EAC = PP/N + OE$

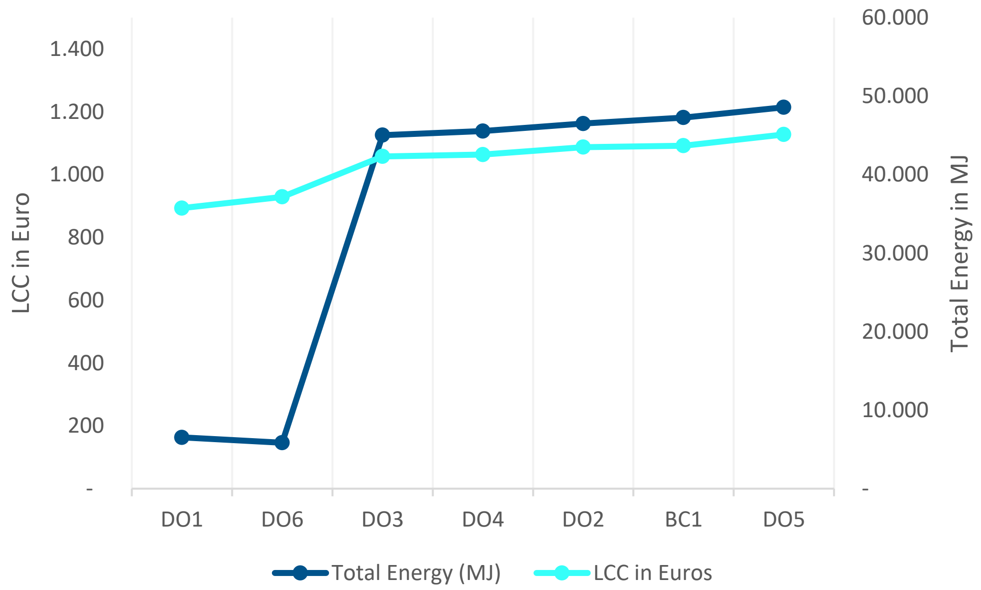
6.3.1 BC1 – Conventional single point hands under dryer

In Table 6.22, the different DOs for BC1 are ranked according to its Equivalent Annual Cost (EAC), presented in the top row. The MEErP indicates that this is the method to be used to rank the Design Options when products have different lifespans. The LCC and the total energy consumption of each DO is presented in Figure 6.56.

Table 6.22 Equivalent Annual Cost for Design Options of BC1

	DO1	DO6	DO3	DO4	DO2	BC1	DO5
	No heat	Combo	Sensor only / Run-on time	Energy Efficiency	Standby	Base Case	Assembly Design
EAC (EUR/year)	68.5	69.6	82.7	83.2	85.3	85.7	86.2
PP/N (EUR/year)	56.8	58.7	16.5	16.2	16.9	16.2	16.6
OE (EUR/year)	11.7	10.9	66.2	67.0	68.3	69.4	69.7

Figure 6.56 Life Cycle Cost Curve for BC1 and Design Options



The point of the Least Life Cycle Cost in the curve is for DO1 which represents a no heat BC1. Even though the purchase price of a DO1 unit is about 2.5 times greater that of an average BC1 unit, the energy savings over the product's lifetime more than compensate for that as the cost with electricity of an average BC1 is about 8 times higher than that of a DO1.

DO6 – which combines DOs 1, 2, 3, 4 and 5 and represents a BC1 unit that: does not use heat to dry the user's hands; complies with the minimum electricity consumption on standby; is operated with sensors; has a more efficient motor; and, finally has improved assembly design – is the Best Available Technology, as its energy consumption is the lowest among all DOs. Most of the savings in the annual operating expenses are achieved through removing the heat element of the BC1, which is why DO1 would be the next LLCC/BAT after the combination design option (DO6).

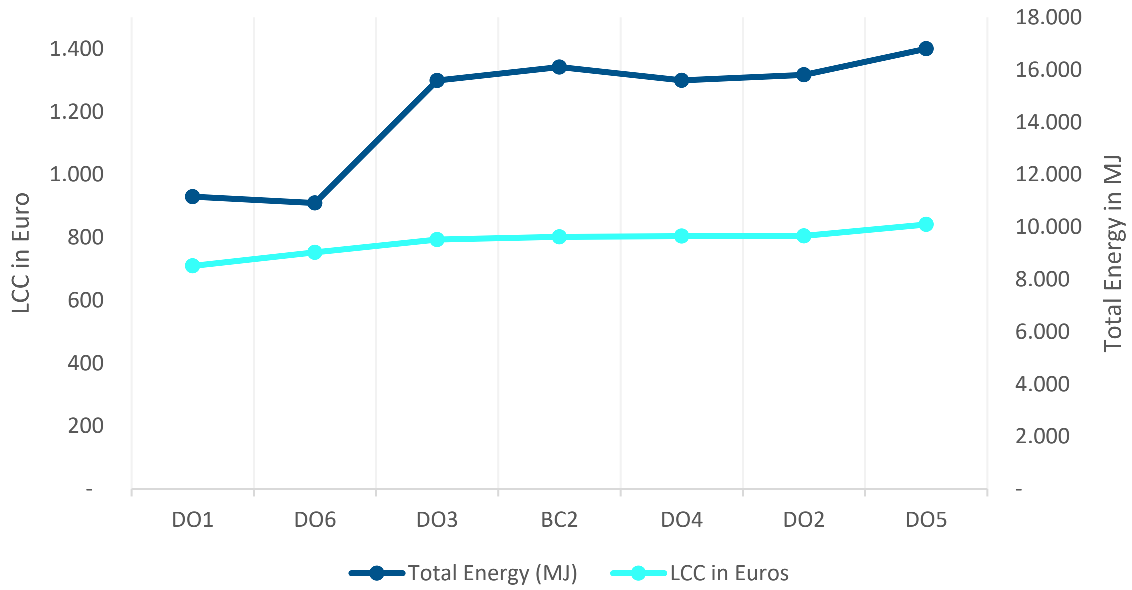
6.3.2 BC2 – High speed single/multi point hands under dryer

In Table 6.23, the different DOs for BC2 are ranked according to its Equivalent Annual Cost (EAC), presented in the top row. The MEErP indicates that this is the method to be used to rank the Design Options when products have different lifespans. The LCC and the total energy consumption of each DO is presented in Figure 6.57.

Table 6.23 Equivalent Annual Cost for Design Options of BC2

	DO1	DO6	DO3	BC2	DO4	DO2	DO5
	No heat	Combo	Sensor only / run-on time	Base Case	Energy Efficiency	Standby	Assembly Design
EAC (EUR/year)	92.4	94.7	105.1	106.4	106.7	106.9	107.5
PP/N (EUR/year)	51.6	54.6	53.2	53.2	54.8	54.4	53.5
OE (EUR/year)	40.8	40.0	51.9	53.2	51.9	52.4	54.0

Figure 6.57 Life Cycle Cost Curve for BC2 and Design Options



The point at which the Least Life Cycle Cost curve is shown is for DO1, which represents a no heat BC2. That is the case because there are no increased costs for the consumer associated with DO1, only cost savings. DO1 is followed in terms of LCC optimisation by DO6, which has the second lower lifecycle cost to the consumer mostly due to the savings with electricity.

DO6 is also the Best Available Technology, as its energy consumption is the lowest among all DOs. Most of the energy savings are achieved through removing the heat element of the BC3, which is why DO1 would be the next BAT after the combination design option (DO6).

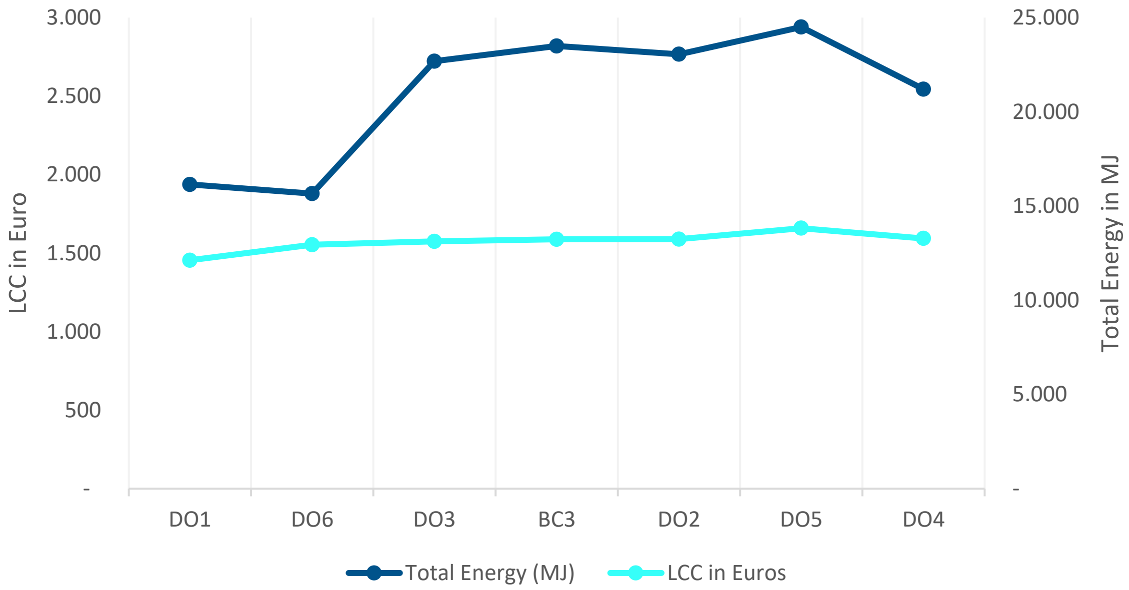
6.3.3 BC3 – High speed trough style hands in dryer

In Table 6.24, the different DOs for BC3 are ranked according to its Equivalent Annual Cost (EAC), presented in the top row. The MEErP indicates that this is the method to be used to rank the Design Options when products have different lifespans. The LCC and the total energy consumption of each DO is presented in Figure 6.58.

Table 6.24 Equivalent Annual Cost for Design Options of BC3

	DO1	DO6	DO3	BC3	DO2	DO5	DO4
	No heat	Combo	Sensor only / Run-on time	Base Case	Standby	Assembly Design	Energy Efficiency
EAC (EUR/year)	157.4	161.6	171.4	172.9	173.0	173.3	173.6
PP/N (EUR/year)	81.5	87.7	83.1	83.1	84.0	83.5	88.1
OE (EUR/year)	76.0	73.9	88.3	89.8	89.0	89.8	85.5

Figure 6.58 Life Cycle Cost Curve for BC3 and Design Options



The point at which the Least Life Cycle Cost may be observed is for DO1, which represents a no heat BC3. This is the case, since there are no increased costs associated with DO1 for the consumer, only cost savings. DO1 is closely followed by DO6, which has the second lowest lifecycle costs to the consumer, mostly due to the derived electricity savings.

DO6 is also the Best Available Technology, as its energy consumption is the lowest among all DOs. Most of the energy savings are achieved through removing the heat element of the BC3, which is why DO1 would be the next BAT after the combination design option (DO6).

6.4 LONG TERM TECHNICAL POTENTIAL (BNAT)

The objective of this sub-task is to consider the longer-term potential of design options based on BNAT(s) as benchmark(s).

After the current suite of Design Options are implemented there is further scope for product differentiation based upon the consideration/implementation of the following Best Not Yet Available Technologies (BNAT) as future design options, which were previously identified in Task 4:

- Motor controls and hard coding to prolong the lifetime and longevity of the motor
- Sensors to detect reduced air flow through filters to signal replacement
- Reusable air filters
- Digital twins to foresee key maintenance milestones, prolong lifetime and reducing electrician costs by targeting repairs
- Producer take-back schemes to improve plastics and electronics recycling
- Incorporate a minimum recycled content within the dryer – mainly targeted at plastics

Note that Internet of Things (IoT) connectivity had previously been identified as a BNAT but was removed upon the identification of one hand dryer model which had IoT connectivity (Savortex's adDryer). Nonetheless, due to its very early adoption in the marketplace, IoT connectivity should arguably still be considered in this discussion for the circular economy benefits of improved monitoring, maintenance and repair, provided that adequate networked standby energy consumption controls accompany such IoT connectivity advances.

Considering circular economy benefits, besides IoT connectivity, a number of the BNATs provide further scope. These include producer responsibility / product take back schemes, which could improve the current negligible rate in plastics and electronics recycling, air filters which are reusable and not sent straight to landfill (as all current filters are). Filters with air-flow sensors to alert replacement and avoid motor overheating and early failure. As we see in the smart building controls sector, digital twins can foresee key maintenance milestones, prolong the lifetime and facilitate repair of the dryer.

Note that in mandating automatic ambient air temperature sensors for all high-speed warm air dryers, it would reduce unnecessary heating energy consumption, which is the biggest single energy savings opportunity for hand dryers which rely on air-speed as the primary drying medium.

7 INTRODUCTION TO TASK 7 SCENARIOS

The aim of this task is to look at suitable policy means to achieve the potential improvement. For example, this could include implementing the Least Life Cycle Cost (LLCC) as a minimum requirement, using the environmental performance of the Best Available Technology (BAT) or Best Not Available Technology (BNAT) as a benchmark and using standards, labelling or incentives relating to public procurement.

This task also aims to draw together scenarios quantifying the improvements that can be achieved versus a Business-as-Usual (BaU) scenario and compares the outcomes with EU environmental targets and societal costs.

This task aims to estimate the impact on users and industry considering the typical design cycle in a product sector.

This task provides an analysis of which significant impacts may have to be measured under possible implementing measures and what measurement methods would need to be developed or adapted.

7.1 POLICY ANALYSIS

The objective of this sub-task is to identify policy options considering the outcomes of the previous tasks. The analysis will:

- Include a description of the main stakeholders' positions
- Discuss possible market and legislative barriers and opportunities for measures
- Be based on the exact definition of the products, according to subtask 1.1
- Provide Ecodesign requirements, such as minimum (or maximum) requirements
- Be complemented with (dynamic) labelling and benchmark categories
- Where appropriate, apply existing standards or propose needs/ generic requirements for harmonised standards to be developed
- Provide requirements on installation of the product or on user information.

7.1.1 Stakeholders

SME hand dryer manufacturers have been well represented by the electric Hand dryer Association (eHA)[180], who have actively engaged in the preparatory study since its inception. eHA members have provided detailed comments and insight throughout the study, helping the development and evolution of the task reports. eHA's membership includes international hand dryer manufacturers with significant market share (e.g. World Dryer, Excel and Hokwang) and manufacturers who produce "white label" products for branding and onward supply by local partners. Not all hand dryer manufacturers are part of eHA and some global electronics manufacturers operate outside of the association.

Other stakeholders who have made significant contributions to the evolving discussions and draft documents include those from ECOS, the European environmental standardisation NGO[181], who have provided detailed support and information on the challenges with respect to the circular economy.

In addition to the inception meeting (September 2018) and first stakeholder meeting (January 2019), stakeholders have fed comments to the study team via an interim stakeholder meeting in September 2019. This was an additional meeting to the contracted schedule in order to facilitate the ongoing dialogue and effective working relationship with stakeholders. A record of all the feedback received from stakeholder

[180] https://handdryerassociation.org/members/

[181] https://ecostandard.org/

participants can be found on the study website[182], together with how each piece of feedback has been dealt with.

Hand dryer manufacturers have consistently requested the study team consider – in parallel to electric hand dryers – the life cycle assessment of alternative hand drying methods (e.g. use of paper towels) and compare and contrast the environmental impacts resulting from both methods. As stated in the inception meeting, the first stakeholder meeting and documented in Task 1 and Task 3, the study has focused on electric hand dryers. Stakeholders can refer to Task 1 (scope) and Task 3 (systems approach) for further context and explanation.

7.1.2 Barriers & Opportunities

7 presents market and legislative barriers and opportunities with respect to sustainable product policy measures (e.g. Ecodesign and Energy Labelling) for the hand dryers product group.

Table 7.1 Barriers & Opportunities for Product Measures

	Barriers	Opportunities
Market	*Research and development spend on category 1 dryers has generally reduced with the advent of high-speed hand dryers.*	*Product group already innovating towards lower energy designs by substituting warm air drying for high speed dryers.* *Medium speed category 1 dryers offer a differentiating opportunity compared with low speed, high power category 1 dryers.*
Legislative	*The manufacturer/supplier base for this product group is quite widespread, typically comprising of multiple SME entities. Speaking to the industry "as one" is in its early phase, with a product sector specific trade association being ~18 months old. Reaching all suppliers with the news of legislation could be challenging.* *Lack of harmonised standards for measuring remaining moisture content on hands and "dryness" in general.*	*Incorporation of standby power requirements is likely perceived as a common measure regardless of the technology.* *Ground paved for circular economy measures from implementation of the "November Package" (2019)*

[182] http://www.ecohanddryers.eu/documents-3

7.1.3 Scope

The product scope for the proposed measures is in line with the categories and definitions for hand dryers presented and agreed within the earlier Task 1 report. The categories and definitions are repeated below in Table 7.2.

Table 7.2 Hand Dryer Categories and Definitions

No	Category	Description	Form[183]
1	Conventional single-point (hands under) dryer	A hand dryer where hands are placed underneath the dryer exit nozzle for drying, having a predominantly single, unfocused direction air stream at the air exit plane and having average exit air velocity of less than 70 m/s (13,780 ft/min) when supplied with nominal supply voltage at 120V or 230V consistent with the product's certified electrical rating.	
2	High speed single point (hands under) dryer	A hand dryer where hands are placed underneath the dryer exit nozzle for drying, having a predominantly single direction air stream focused for high velocity at the air exit plane and having average exit air velocity greater than or equal to 70 m/s (13,780 ft/min) when supplied with nominal supply voltage at 120V or 230V consistent with the product's certified electrical rating.	
3	High speed multi-point (hands under) dryer	A hand dryer having exit air streams in at least two distinct independent air streams, intended for the left and right hands focused for high velocity at the air exit plane and having average exit air velocity greater than or equal to 70 m/s (13,780 ft/min) when supplied with nominal supply voltage at 120V or 230V consistent with the product's certified electrical rating.	

[183] Type 1, 2 and 4 images courtesy of the electric Hand Dryers (eHA) association. Type 3 and 5 images were sourced via Google images.

No	Category	Description	Form[183]
4	High speed Trough style (hands in) dryer	A hand dryer where the user places their hands into the drying cavity that has generally opposing air streams in either a blade like stream, or from multiple points, for drying the palm and back side of the hands concurrently with an average exit air velocity greater than or equal to 70 m/s (13,780 ft/min) when supplied with nominal supply voltage at 120V or 230V consistent with the product's certified electrical rating. Trough style hand dryers can either have a blade like air stream or the air can originate from multiple points.	
5	Air tap	A hand dryer which is installed over the basin. The air tap has two variants: standalone, designed to be housed next to water taps, or incorporating mains water in an all-in-one unit.	 

7.1.4 Proposed Measures

The proposed measures for the hand dryer product group are presented and discussed below.

7.1.4.1 Standby Power Consumption

As reported in Task 4, standby power consumption in hand dryers varies from 0.3 Watts to 3 Watts[184]. The majority of surveyed hand dryers have a standby power consumption ranging from 1W to 2W (Table 4.11). However, there are many hand dryers with standby power consumption lower than 1W or lower than 0.5W. All surveyed air taps (four models) have a standby power consumption ranging from 0.4W or 0.5W.

[184] 6 watts for Ffuuss HD-1 hand dryer when including operation of an air preheater

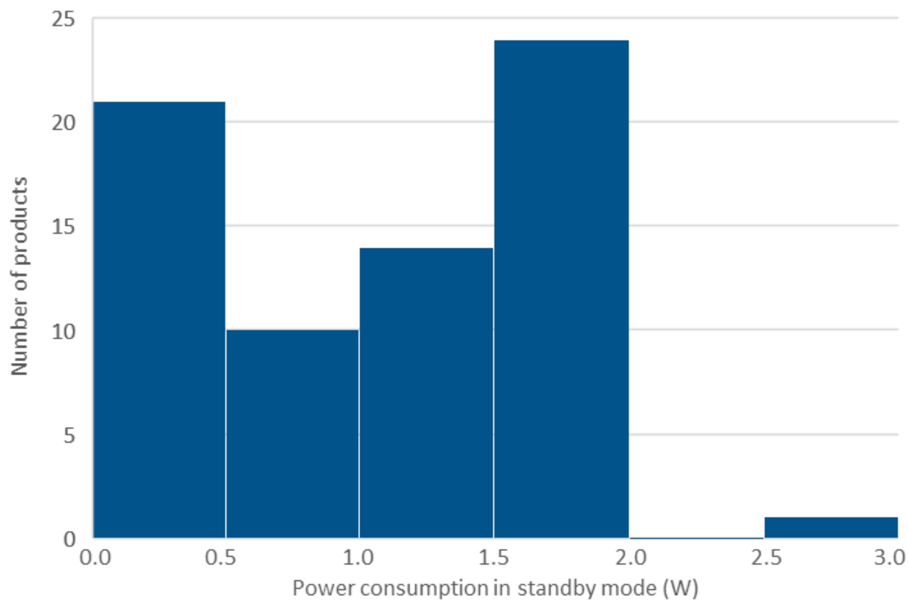
Table 7.3 Standby power consumption in hand dryers

	Standby Power Consumption (W)			Sample Size
	≤0.5	>0.5 and ≤1	>1 and ≤2	
Conventional single point (hands under) dryer	19%	22%	59%	27
High speed single point (hands under) dryer	35%	4%	61%	23
High speed multi-point (hands under) dryer	60%	0%	40%	5
High speed trough style (hands in) dryer[185]	15%	23%	46%	13
Air Tap	100%	0%	0%	4
Total	31%	14%	56%	72

Source: Manufacturer's Technical Specifications

Figure 4.13 shows the range of standby power consumption values across the surveyed hand dryers.

Figure 7.1 Standby power consumption in hand dryers



Source: Manufacturer's Technical Specifications

A measure to limit standby power consumption in hand dryers is proposed. This could be done progressively in the form of two tiers. As modelled in Task 6, the first tier could comprise an upper limit of 0.5W (1W where an information/status display is included in the product), leading to a 0.5W limit (whether or not the product is equipped with an information/ status display) in tier two. The definitions for standby are as proposed in the Task 1 report, and based upon the Ecodesign implementing measure for network

[185] One model – standby power consumption 3W
One model – 6W for 2 hours after plugged-in, otherwise 1-1.5W standby power consumption

standby, Commission Regulation (EU) Nº 801/2013[186], amending Commission Regulation (EC) Nº 1275/2008[187] regarding Ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment, namely:

- *'standby mode(s)' means a condition where the equipment is connected to the mains power source, depends on energy input from the mains power source to work as intended and provides only the following functions, which may persist for an indefinite time:*
    - *reactivation function, or reactivation function and only an indication of enabled reactivation function, and/or*
    - *information or status display;*
- *'reactivation function' means a function facilitating the activation of other modes, including active mode, by remote switch, including remote control, internal sensor, timer to a condition providing additional functions, including the main function;*
- *'information or status display' means a continuous function providing information or indicating the status of the equipment on a display, including clocks;*
- *'active mode(s)' means a condition in which the equipment is connected to the mains power source and at least one of the main function(s) providing the intended service of the equipment has been activated;*

7.1.4.2 Sensors & Run-on Time

A measure to require all hand dryers to control activation (on and off) by sensor only is proposed. This includes a requirement to cap run on time to 1 second[188]. "Run-on time" is defined as:

> *the time duration from when the hands are removed from the dryer to when the dryer's controls stop dryer operation. Run-on time is complete when the dryer's supply current returns to normal levels in standby mode[189].*

This measure would remove three of the four activation controls from the market, namely:

- push button on/off,
- push button and timer; and
- sensor and timer

Task 4 (Technologies) and the sub-section on activation controls provides further definitions. This measure would leave the sensor only as the activation control for hand dryers, which is defined as:

> *The hand dryer activates automatically when an infrared sensor detects the user's hands being placed within the drying cavity (hands-in dryer) or under the air outlet (other dryer types) and sends a signal to the motor controller. The hand dryer returns to standby automatically when the sensor detects the user's hands have been removed from the air cavity, or from under the air outlet, and sends a signal to the motor controller.*

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[186] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0801&from=EN

[187] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32008R1275

[188] A 1 second cap on run time is set from manufacturer feedback indicating that a 1 to 2 seconds cap is an appropriate detection time to accommodate for real world behaviour.

[189] Source: Product Category Rule for Hand Dryer Environmental Product Declaration (2016) http://bit.ly/29QtRXx

The study team has modelled that whilst mandating sensor-only dryers on category 1 models would add standby power consumption to models that were previously push button only (on average resulting in a slight increase in standby consumption from 1.36W to 1.47W), this additional consumption would be outweighed by the energy savings resulting from the avoidance of energy wastage from a push button – timer combination. For example, in the case where a user's hands were removed after 5 seconds, but the dryer continued for the longer timer setting period, of perhaps 15 seconds, then the sensor-only design would mean that this extra 10 second period of energy wastage would then be eliminated.

For all hand dryers, this feature encourages savings as the run-on time is reduced. Manufacturer feedback has estimated run-on time on average to be at 1.5 seconds. Mandating run-on time to a maximum of 1 second brings down cycle length of all hand dryers on average by 0.5 second.

This mandatory design change would also take push button on / push button off models from the market, since these models could run constantly if the user neglects to push the button to turn off the model. It should also be noted that there would also be hygiene benefits from removing push button models.

7.1.4.3 Hand Dryer Energy Consumption

The Ecodesign regulation for electric motors Commission Regulation (EU) No 4/2014 which amended the Regulation (EC) No 640/2009 on electric motors with a power rating between 0.75 kW to 375 kW[190] has recently been superseded. The new EU regulation 2019/1781 for electric motors repeals the previous regulation and will take effect from 1 July 2021[191].

The study team's analysis has found hand dryers that operate from 200W to 2750W, meaning that not all electric motors for hand dryers are included in the scope of Commission Regulation (EU) 4/2014. However, with the newly revised electric motors Ecodesign regulation expanding the scope of motors covered down to 0.12kW, the lower end of the hand dryer motor range will be included.

Commission Regulation (EU) 2019/1781 has in its scope brushless Alternating Current (AC) motors, but the following motor types/ technologies are excluded from their scope: brushed motors, Direct Current (DC) and universal motors. AC brushless motors used in only approximately one-third of hand dryers, which means that the majority of hand dryers are exempt from the scope of the 2019 electric motors Ecodesign regulation. Hence, the measure proposed for hand dryers and their motors intends to close this "loophole", by applying an efficiency metric to *all* hand dryers, regardless of internal motor mechanisms and related technologies.

Rather than test the motors individually and "separate" them from the hand dryer, the measure proposes to regulate hand dryer energy consumption as a whole. The measure would be implemented in two tiers such that in 2024 hand dryers must have an energy consumption of **≤10 Wh/cycle.** A second Ecodesign mandatory Tier would be implemented in 2027 for hand dryers to perform at a maximum energy consumption cap of **≤7.5 Wh/cycle**.

The proposed criteria effect all hand dryers, regardless of the drying air speed. Although conventional dryers differ from high speed dryers in some regards, they provide similar services (i.e. drying hands). There is a significant overlap of the price ranges for the two products, specifically for Category 1 and Category 2 units. Furthermore, a third of Category 1 products currently on the market already comply with Tier 2 criteria. That

[190] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1521113260047&uri=CELEX:32014R0004

[191] https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficient-products/list-regulations-product-groups-energy-efficient-products

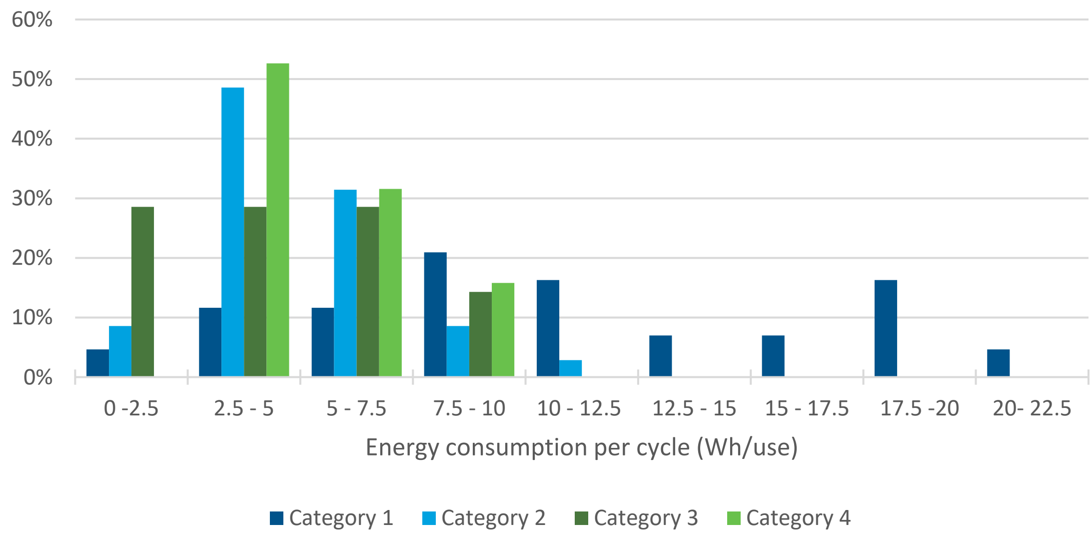
said, it should be noted that the proposed MEPS are expected to remove poor performers from the market which in the case of hand-dryers will mostly affect Category 1 dryers.

Under this criterion, the on-mode power consumption of a hand dryer is divided by the minimum dry time. This calculates the energy consumption of the cycle, accommodating the hand dryers consuming more power, but accomplishing "dry" hands in a reduced time.[192]

Figure 7.2 shows the distribution of hand dryer categories related to energy consumption per cycle. A cut-off at 10 Wh/cycle was chosen, as this allows nearly all high-speed hand dryers to meet Tier 1 of the Minimum Energy Performance Standard (MEPS). The high-speed dryer technologies represent – to date – many of the innovators in the market, and this policy would allow for their continued development. Approximately half of the category 1, conventional hand dryers, are relatively inefficient and would thus be removed from the market by this measure.

Applying a Tier 2 limit cap of at 7.5 Wh/cycle allows more than 85% of high-speed hand dryers to meet the limit already, which would incentivise necessary "lower-end" innovation in the sector without excessive punitive measures to the sector overall. The measure is more challenging for conventional hand dryers as it is estimated that only 28% of current models would meet the performance metric, currently scheduled to take effect in 2027.

Figure 7.2 Hand Dryer Energy Consumption Distribution



7.1.4.4 Heating elements in high-speed dryers

Research and feedback gathered from manufacturers in Task 6 indicates that heating components for high speed hand dryers can vary from 250W to 1250W, averaging 500W for hands-under dryers and 550W for hands-in dryers. Manufacturer feedback in Task 6 estimated that heaters are usually on and at full power output capabilities.

The proposed measure for high-speed hand dryers is to limit the rating of the heating element. Manufacturer feedback suggested that the use of warm air was more for user comfort than for improving drying performance, and this was estimated in Task 6 to contribute to improved drying time by solely 0.25s per 100W of heat provided. The measure proposes to limit the rating of the heating element of high-speed hand dryers to 500W for hands-under and 550W for hands-in. The modelling in Section 7.2 assumes

[192] Using the Task 4 hand dryer database, it is estimated that 66% of Category 1 hand dryers would not meet Tier 1.

that capping the heating component would reduce the average heating element to 400W for hands-under, and 450W for hands-in dryers, respectively. Modelling savings of 100W are only applied to hand dryers with heating components.

7.1.4.5 Measures designed for a Circular Economy

The recently published revisions to a suite of Ecodesign measures[193] set a new minimum threshold and common set of precedents for requirements designed to address and improve the circular economy. These common set of circular economy requirements are featured across a range of product groups including displays (i.e. televisions), washing machines, dishwashers and cold appliances. They are summarised below:

- Availability of spare parts – manufacturers, importers or authorised representatives of hand dryers shall make available to professional repairers a list of important spare parts. They shall ensure these parts can be replaced with commonly available tools and without causing permanent damage to the product. The spare parts and the process for ordering them shall be available on a free to access website. A proposed list of spare parts that hand dryer manufacturers should make available are presented below:

  - Casing
  - Fan
  - Fan housing
  - Filters
  - Heating element
  - Motor, motor brushes
  - Nozzle
  - Printed Circuit Board
  - Sensor, timer
  - Wall mounting
  - Water Tank

  Note that stakeholders have given feedback that to prevent theft and vandalism to hand dryers and to maintain safety, screws and fixings are designed not to be used with commonly available tools.

- Access to repair and maintenance information – manufacturers, importers or authorised representatives shall provide access to the product's repair and maintenance information to professional repairers. The process to access the repair information can involve a registration process for professional repairers where they demonstrate their competence and insurance. The manufacturers, importers or authorised representatives can charge reasonable fees for this service but are required to respond under certain timescales e.g. to applications, to provision of information and delivery of spare parts. The repair information can include: model identification, disassembly map and exploded view, list of necessary repair and test equipment, component and diagnosis information (such as minimum and maximum theoretical values for measurements), wiring and connection diagrams, diagnostic fault and error codes and data records of reported failure incidents stored on the product. Instruction shall also be provided to end users detailing how to replace filters and instructions to empty water tray for trough style dryers.
- Requirements for dismantling for material recovery and recycling – manufacturers, importers or authorised representatives shall ensure that products are designed in such a way that the materials and components referred to in Annex VII to

[193] https://ec.europa.eu/energy/en/regulation-laying-down-ecodesign-requirements-1-october-2019

Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE)[194] can be removed with the use of commonly available tools and without using joining, fastening or sealing techniques that prevent their removal (although note that the list of components from the WEEE Annex VII are unlikely to be found within a hand dryer).
- Marking of plastic components – plastic components heavier than a certain mass shall be marked by specifying the type of polymer with the appropriate standard symbols or abbreviated terms. Components containing flame retardants shall additionally be marked with the abbreviated term of the polymer followed by hyphen, then the symbol "FR" (denoting "flame retardant") followed by the code number of the flame retardant in parentheses.

Given the precedent that has been set with the inclusion of these requirements horizontally across a suite of measures and product groups, they would be expected to be included in any proposed measure for hand dryers.

7.1.4.6 Improved Design requirements for electronics material recovery and improved repair

In line with DO5 from Task 6, this measure proposes for the design of hand dryers to be improved such that they:

- allow for electronic components to be easily separated from the hand dryer to allow for the electronics board to be sorted in a WEEE stream.
- allow for easier dismantling and system diagnosis, improving the speed of repair.

The resulting improvement in speed of repair is assumed to improve the appetite for repair by 50%, which in turn increases the average lifespan of dryers.

Table 7.4 Improved Repair Rates

Category	Baseline (BaU) Repair Rate	Repair Rate after MEPS
Category 1	25%	37.5%
Categories 2, 3 and 4	30%	45%

Under the assumptions made in Task 6, this measure improves the recycling rate of electronics from 10% to 29%. Repair timings are reduced, resulting in repair labour costs dropping from €128.58 to €87.25.

7.1.4.7 Neodymium, Critical Raw Material

Since 2017, the EU has added neodymium to its official list of 27 critical raw materials. Within the list, neodymium is one of four Light Rare Earth Elements (LREE)[195]. According to EU research, neodymium is commonly used in permanent magnet motors[196]. Neodymium is not regulated in the revised electric motors Ecodesign Commission Regulation (EU) 2019/1781. However, within the new servers and data storage products Ecodesign Commission Regulation (EU) No 2019/424, neodymium is included as an information requirement[197]. Namely, from the 1 March 2020 suppliers of servers and data storage products shall provide an indicative weight range of neodymium found within their products, according to the following size ranges: <5g; between 5 and 25g and

[194] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012L0019&from=DE

[195] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52017DC0490

[196] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/substitution-critical-raw-materials-low-carbon-technologies-lighting-wind-turbines-and

[197] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32019R0424

>25g. We propose that a similar information requirement could be expected to be included in any proposed measure for hand dryers.

7.1.5 Labelling

An Energy Label is considered pertinent for the hand dryer group of products. The proposed labelling scheme intends to rank hand dryers by their energy performance compared to the average performance on the market at the time of writing (2019). For this reason, the labelling calculation will be different depending on whether the MEPs are adopted or not, since the products removed from the market by the MEPs (i.e., forming the lowest label boundary, and the minimum allowable threshold for placing on the market) will shift average energy and quality performance of hand dryers.

7.1.5.1 Labelling scheme

The proposed formula for the energy label is as follows:

$$Energy\ Efficiency\ Index = \frac{energy\ consumption\ per\ cycle}{Average\ energy\ consumption\ per\ cycle}$$

Where:

$$energy\ consumption\ per\ cycle = Electrical\ power\ consumption\ \times Cycle\ length$$

Where:

Electrical power consumption is the electrical power consumed by the hand dryer (in Watts)

Cycle length is the time taken to dry hands to a remaining moisture content of 0.25g[198] *as declared by the manufacturer (in hours)*

*The Average energy consumption per cycle of hand dryers was calculated using the task 4 database with a weighting according to the sales of the four hand dryer category sales. This value is estimated for this calculation at **7.5 Wh/cycle**.*

7.1.5.2 Energy label classes

In proposing a suggested energy label distribution, due consideration has been given to the new requirements under the revised Energy Labelling Regulation (EU) 2017/1369[199] for the introduction of labels (article 11). Paragraph 8 states that where a label is introduced, the Commission shall ensure that no products are expected to fall into energy class A at the moment of the introduction of the label and the estimated time within which a majority of models falls into that class is at least 10 years later. Paragraph 9 states that where a technology is expected to develop more rapidly, requirements shall be laid down so that no products are expected to fall into energy classes A and B at the moment of the introduction of the label. For the purposes of this assessment is has been assumed that any regulation for hand dryers would not be introduced before 2024[200].

Under the calculation of the EEI, the hand dryers can be categorised according to the follow energy label classes:

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[198] Source: Product Category Rule for Hand Dryer Environmental Product Declaration (2016) http://bit.ly/29QtRXx

[199] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2017.198.01.0001.01.ENG

[200] For example, the final report from this preparatory study will be published in 2020. A Consultation Forum may proceed the following year, in 2021. Typically, it may take two further years for a regulation to be approved (2023) and a year's notice for the introduction of requirements.

Table 7.5 Distribution of EEI per label class

Energy Label Class	EEI	Equivalent Energy consumption per cycle (Wh)	Sales weighted market estimation
A	0 to 0.15	Less than 1.125	1%
B	0.15 to 0.3	1.125 to 2.25	6%
C	0.3 to 0.5	2.25 to 3.75	15%
D	0.5 to 0.75	3.75 to 5.625	30%
E	0.75 to 1	5.625 to 7.5	12%
F	1 to 1.33	7.5 to 10	14%
G	Greater than 1.33	Greater than 10	22%

If MEPS are applied to the labelling scheme, the proposed classes would mean that:

- G-class hand dryers would not meet Tier 1
- F-class hand dryers would not meet Tier 2

Classes A and B are currently populated, despite the requirements of the revised Energy Labelling Regulation 2017/1369. However, it should be noted that in the gathered database, only one product met the class A label criteria. As previously mentioned, the calculation for the energy consumption values are dependent on the "drying time" as reported by manufacturers in datasheets. Once a Harmonised standard for "drying time" is established, it is possible that the product currently in category A may no longer meet the criteria.

7.1.5.3 Additional Icons

It is recommended that an icon for noise emissions feature within the label for hand dryers. The content featured could be an absolute value embedded within a letter rating, as per the recently revised dishwasher, washing machine, washer drier and refrigerator energy labels[201]. Within these examples, noise is presented in dB as opposed to dB(A). In the database held by the study team of 106 hand dryers the sound level in dB is published for 59 hand dryers and in dB(A) for 23. The sound level is identified as a sound pressure level which is a measurable parameter and its value differs at different distance from the sound source (e.g. at 1 metre or 2 metres). Values expressed in dB(A) refer to the sound pressure level in dB adjusted to reflect the human ear perception of relative loudness. For 58 hand dryers out of a database populated by 106 hand dryer models, the distance of sound level measurement is identified. For 57% of these 58 hand dryer products, the sound level is cited as having been measured at 1m, and for the remaining 43% at a distance of 2m.

Manufacturer feedback was consistent that noise emissions should be defined in dB(A) from a distance measured at 1m. This is the recommendation which features within Figure 7.3.

[201] https://ec.europa.eu/commission/presscorner/detail/en/MEMO_19_1596

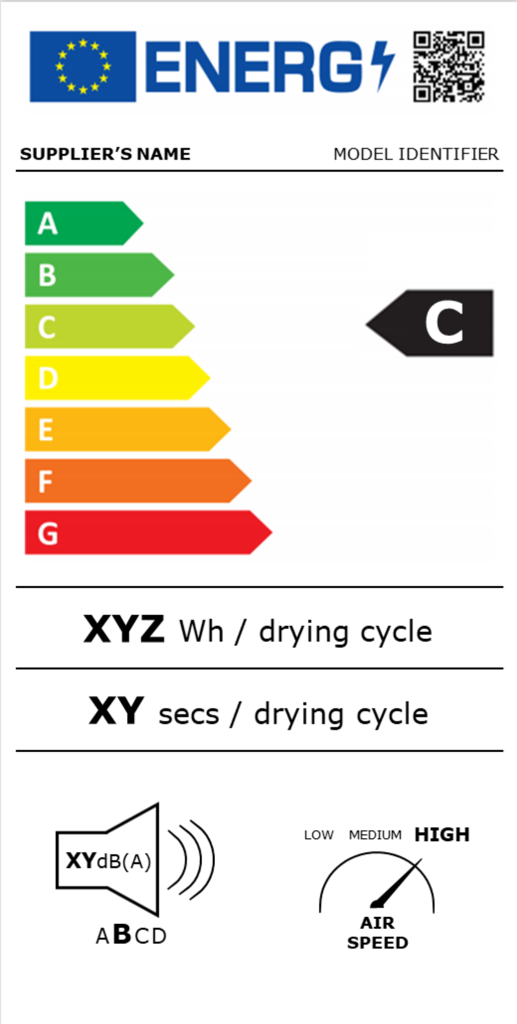
In order to differentiate products, manufacturer feedback has indicated that the label should indicate clearly the drying cycle length along with a logo to indicate the category of hand dryer used. In the following section, the former is indicated in clear wording, and the latter is created with an air speed logo differentiating low, medium and high-speed hand dryers.

7.1.5.4 Proposed label design

In line with current energy labelling scheme and the information described above, the proposed label design is shown in Figure 7.3.

The proposed draft label is of course subject to further discussion with the European Commission services, stakeholder comment and consumer testing of recognition of the proposed icons and intelligibility and appropriateness/ usefulness of the information provided.

Figure 7.3 Illustration of the proposed energy label for the hand dryer product group



7.1.6 Standards

As presented in Task 1 (Scope), there are no harmonised measurement or test standards for hand dryers covering the product performance parameters of remaining moisture content and power consumption. As detailed in Task 1, there are a number of free to access measurement and test standards covering the measurement of remaining moisture content and the measurement of electrical power consumption. These are:

- UK's Energy Technology List Test Method for High Speed Hand Air Dryers[202]
- Germany's Blue Angel Criteria for Electric Hand Dryers[203]
- UL's Product Category Rule for Hand Dryer Environmental Product Declarations

In order to accompany the proposed energy label, a harmonised measurement and test standard would be required.

7.2 SCENARIO ANALYSIS – RESOURCE USE AND ENVIRONMENTAL IMPACTS

The objective of this sub-task is to create a stock-model between 1990 and 2050 and calculate resources use and environmental impacts in the following scenarios:

- BaU – Business as usual
- MEPS – Implementation of Minimum Energy Performance Standard, as proposed in Section 7.1.4
- Labelling – Implementation of an Energy Label, as proposed in Section 7.1.5
- MEPS + Labelling – Implementation of both MEPS and an Energy Label

7.2.1 Inputs and Assumptions

7.2.1.1 Stock and Sales

The stock and sales assumptions from Tasks 2 and 5 are used for modelling the BaU scenario. Sales of hand-dryers over time are based on PRODCOM data, the split between categories based on manufacturer feedback and the stock is calculated based on the sales and the average lifespan of the products. There is further detail on the assumptions used to model stock and sales in the Task 2 and Task 5 reports.

In the Labelling scenario, the implementation of the Energy Label is assumed not to affect sales, stock, or the split per category. This means that figures used in the Labelling scenario are the same as those in the BaU scenario.

The rationale behind this assumption is that the label does not directly affect the price of products on the market nor the consumer's decision to buy a hand dryer. Instead, the effect of the label is to improve the performance of a market average product by shifting sales to more efficient products within each category.

In the MEPS and MEPS + Labelling scenarios, the total sales figures are the same as those in the BaU scenario. However, the sales split per category and the stock of hand dryers are assumed to be affected from 2024 onwards, after the efficiency requirements are implemented.

From the database of products prepared for Task 4, the performance of conventional hand dryers (Category 1) is as follows:

- Approximately one-third of products meet the Tier 2 criteria (i.e. is below the 7.5 Wh/cycle threshold)
- Another one-third performs between 7.5 and 12.5 Wh/cycle
- The last one-third of products consumes more than 12.5 Wh/cycle.

[202] https://www.gov.uk/government/publications/energy-technology-list-etl-method-for-the-testing-of-high-speed-hand-air-dryers

[203] https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%2087-201405-en%20Criteria.pdf

Additionally, market research and analysis on conventional hand dryers pricing shows that there are multiple products which meet Tier 2 criteria within the average price range of Category 1 hand dryers.

Based on these analysis, for the two-thirds of products that consume less than 12.5 Wh/cycle, it is assumed that there is sufficient development time for improving products to meet the standards without a large increase in price before Tiers 1 and 2 come into effect in 2024 and 2027, respectively. Therefore, two-thirds of Category 1 sales are assumed to be unaffected by the MEPS and are kept as the BaU.

Conventional hand dryers performing at a higher than 12.5 Wh/cycle consumption are not expected to adapt to the regulation. Their market share is expected to shift gradually to Category 2 from 2025 onwards as Category 2 products are those closer to Category 1 in terms of price and performance.

As a result, sales from Category 1 and Category 2 hand dryers are respectively lower and higher in the MEPS and MEPS + Labelling scenarios from 2025 onwards, while the total sales is kept constant.

Because currently more than 85% of high-speed hand dryers (Categories 2, 3 and 4) already meet Tier 2 requirements, no further effects to sales were considered in the model for the MEPS and MEPS + Labelling scenarios.

Finally, the total stock figures in the MEPS and MEPS + Labelling scenarios are slightly affected by the increase in the average lifespan of products instigated by the higher repair rate. The change to the split of sales per category also has an effect on the split of stock per category from 2024 onwards.

Table 7.6 Lifespan of products sold after 2024 in the different scenarios

Category	BaU & Labelling Lifespan (years)	MEPS & MEPS + Labelling Lifespan (years)
Category 1	11.6	11.9
Category 2	6.6	6.9
Category 3	6.6	6.9
Category 4	8.6	9.0

Table 7.7 and Table 7.8 present the estimated sales of hand-dryers in the EU28 over time and the split per category in the different scenarios. Table 7.9, Table 7.10, Figure 7.4, and Figure 7.5 present the estimated stock of hand-dryers in the EU28 between 1990 and 2050.

Table 7.7 Estimated Sales of Hand Dryers in the EU28 – BaU and Labelling scenarios (1990-2050)

	Sales of Hand Dryers in the EU28 - BaU and Labelling Scenarios				
	Category 1	Category 2	Category 3	Category 4	Total
1990	182,000	-	-	-	182,000
1995	260,000	-	-	-	260,000
2000	398,000	-	-	-	398,000
2005	636,000	-	-	3,000	639,000
2010	534,000	97,000	-	36,000	667,000
2015	436,000	300,000	54,000	159,000	949,000
2020	409,000	373,000	58,000	178,000	1,018,000
2025	389,000	472,000	65,000	208,000	1,134,000
2030	359,000	581,000	71,000	237,000	1,248,000
2035	316,000	702,000	76,000	267,000	1,361,000
2040	261,000	833,000	82,000	299,000	1,475,000
2045	193,000	977,000	87,000	333,000	1,590,000
2050	113,000	1,131,000	93,000	368,000	1,705,000

Table 7.8 Estimated Sales of Hand Dryers in the EU28 – MEPS and MEPS + Labelling scenarios (1990-2050)

	Sales of Hand Dryers in the EU28 - MEPS & MEPS + Labelling Scenarios				
	Category 1	Category 2	Category 3	Category 4	Total
1990	182,000	-	-	-	182,000
1995	260,000	-	-	-	260,000
2000	398,000	-	-	-	398,000
2005	636,000	-	-	3,000	639,000
2010	534,000	97,000	-	36,000	667,000
2015	436,000	300,000	54,000	159,000	949,000
2020	409,000	373,000	58,000	178,000	1,018,000
2025	345,800	515,200	65,000	208,000	1,134,000
2030	239,300	700,700	71,000	237,000	1,248,000
2035	210,700	807,300	76,000	267,000	1,361,000
2040	174,000	920,000	82,000	299,000	1,475,000
2045	128,700	1,041,300	87,000	333,000	1,590,000
2050	75,300	1,168,700	93,000	368,000	1,705,000

Table 7.9 Estimated Stock of Hand Dryers in the EU28 – BaU and Labelling scenarios (1990-2050)

	Stock of Hand Dryers in the EU 28 - BaU and Labelling Scenarios				
	Category 1	Category 2	Category 3	Category 4	Total
1990	1,293,000	-	-	-	1,293,000
1995	1,897,000	-	-	-	1,897,000
2000	2,795,000	-	-	-	2,795,000
2005	4,266,000	-	-	-	4,266,000
2010	5,773,000	163,000	-	81,000	6,017,000
2015	5,994,000	810,000	108,000	482,000	7,394,000
2020	5,179,000	1,670,000	318,000	1,120,000	8,287,000
2025	4,606,000	2,345,000	367,000	1,466,000	8,784,000
2030	4,338,000	2,979,000	406,000	1,693,000	9,416,000
2035	4,029,000	3,665,000	440,000	1,930,000	10,064,000
2040	3,588,000	4,420,000	473,000	2,176,000	10,657,000
2045	3,011,000	5,246,000	508,000	2,436,000	11,201,000
2050	2,295,000	6,144,000	540,000	2,710,000	11,689,000

Table 7.10 Estimated Stock of Hand Dryers in the EU28 – MEPS and MEPS + Labelling scenarios (1990-2050)

	Stock of Hand Dryers in the EU 28 - MEPS & MEPS + Labelling Scenarios				
	Category 1	Category 2	Category 3	Category 4	Total
1990	1,293,000	-	-	-	1,293,000
1995	1,897,000	-	-	-	1,897,000
2000	2,795,000	-	-	-	2,795,000
2005	4,266,000	-	-	-	4,266,000
2010	5,773,000	163,000	-	81,000	6,017,000
2015	5,994,000	810,000	108,000	482,000	7,394,000
2020	5,179,000	1,670,000	318,000	1,120,000	8,287,000
2025	4,606,000	2,352,000	367,000	1,466,000	8,791,000
2030	3,833,000	3,463,000	416,000	1,709,000	9,421,000
2035	2,971,000	4,473,000	461,000	2,012,000	9,917,000
2040	2,500,000	5,264,000	495,000	2,272,000	10,531,000
2045	2,090,000	6,014,000	531,000	2,543,000	11,178,000
2050	1,603,000	6,801,000	566,000	2,830,000	11,800,000

Figure 7.4 Estimated Stock of Hand Dryers in the EU28 – BaU and Labelling scenarios (1990-2050)

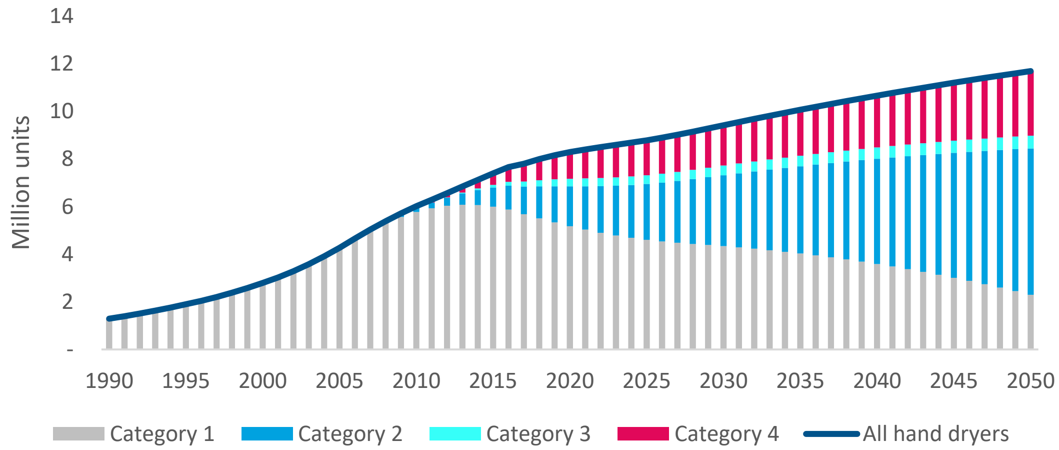
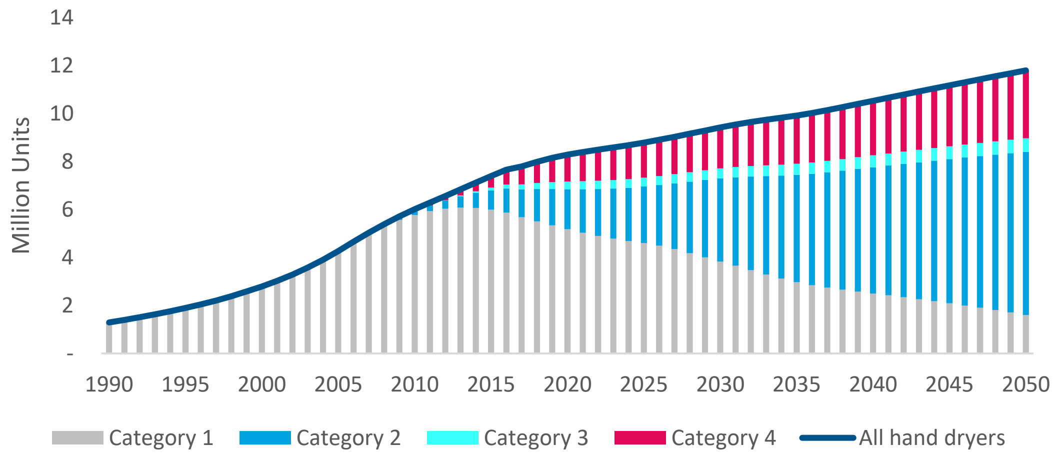


Figure 7.5 Estimated Stock of Hand Dryers in the EU28 – MEPS and MEPS + Labelling scenarios (1990-2050)



7.2.1.2 Emission Factors

To estimate electricity consumption in all scenarios, the Primary Energy Factor (PEF) has been taken into account. The PEF indicates how much primary energy is used to generate a unit of electricity. In the modelling, the default PEF used was 2.1, meaning that 2.1 MWh of primary energy is used to generate each 1 MWh of electricity used. This value is in line with what has been used in the latest analyses undertaken by the European Commission.

The following environmental impacts are calculated in the use and end-of-life (EoL) phases in all four scenarios:

- Greenhouse gases emissions in GWP100 (GHG)
- Acidification emissions
- Volatile Organic Compounds emissions (VOC)
- Persistent Organic Pollutants emissions (POP)
- Heavy Metals emissions to air
- PAHs
- Particulate Matter
- Heavy Metals emissions to water

- Eutrophication

In the use phase, these impacts are calculated using emission factors for the electricity consumed. The GHG emission factors used are presented in Table 7.11 and are year specific. Emission factors for all other environmental impacts are constant over time and presented in Table 7.12

Table 7.11 Emission factors for GHG emissions from electricity consumption in the use phase (Source: Ecodesign Impact Accounting Status Report 2017)

Year	GHG Emission Factor (GWP100) in kgCO2e/kWh
1990	0.500
2010	0.410
2015	0.395
2020	0.380
2025	0.360
2030	0.340
2035	0.320
2040	0.300
2045	0.280
2050	0.260

Table 7.12 Emission factors for other environmental impacts from electricity consumption in the use phase (Source: MEErP, EcoReport Tool)

Environmental Impact	Emission Factor	Unit
Acidification emissions	1,700	g SO2e
Volatile Organic Compounds (VOC)	201	g
Persistent Organic Pollutants (POP)	21	ng i-Te
Heavy Metals emissions to air	91	mg Ni eq.
PAHs	21	mg Ni eq.
Particulate Matter	36	g
Heavy Metals emissions to water	39	mg Hg/20
Eutrophication	1,700	g PO4

In the EoL phase, these impacts were calculated using the EcoReport tool which estimates: (i) emission savings generated by reusing, recycling and recovering fractions of the hand dryer components and (ii) emissions generated from disposing components (e.g. incineration, landfill). Depending on the product’s BoM and on the EoL assumptions on the fraction of components for each type of disposal (e.g. recycled, incinerated, etc.)

the EoL phase of the lifecycle of a product can create net emission saving. In other words, the savings generated in recycling and recovering components can be greater than the emissions generated in incinerating components, leading to net emission savings.

7.2.1.3 Business as Usual – BaU Scenario

In the BaU scenario, the energy consumption in the use phase[204] and the consequent environmental impacts are calculated considering the technical inputs used to model the Base Cases in Task 5. Environmental impacts are also calculated for the EoL phase using the EcoReport tool, as per Task 5.

Energy consumption in the use phase for 2019 is calculated based on the average duration of cycles (seconds/cycle), the average electricity consumption per cycle (Wh/cycle), the average electricity consumption in standby (Wh/h) and the average number of cycles per day (150 cycles/day for all Categories in all scenarios, as per Task 5).In the BaU scenario, the approach for calculating energy consumption of units sold before 2019 is based on the historic efficiency of products as estimated in Task 5. The energy consumption of units that will be sold after 2019 is assumed to remain constant for Category 1 units as this has been the trend at least over the past 10 years, according to manufacturers. For Categories 2, 3 and 4 products sold, energy consumption is estimated to reduce by 1% on average each year, which is a conservative figure considering the more ambitious historic trend that has been calculated for these products in Task 5 for the past ten years. The 1% figure is also consistent with what has been used in other preparatory studies.[205]

Table 7.13 presents the key inputs for calculating energy consumption of hand dryers sold in 2019 in the BaU scenario. Table 7.14 presents the estimated average electricity consumption of units sold between 1990 and 2050.

Table 7.13 Key Inputs for calculating energy consumption of hand dryers in 2019

Input	Category 1	Category 2	Category 3	Category 4
Cycle duration (s/cycle)	17.17	14.57	14.09	12.78
Electricity consumption per cycle (Wh/cycle)	7.94	4.61	4.43	4.99
Electricity consumption on standby (Wh/h)	1.36	1.11	1.08	1.51

[204] As per the MEErP, only the most significant impacts should be modelled in the Scenarios in Task 7. Thus, only the energy consumption and environmental impacts generated in the use phase are included in the models in Section 7.2.

[205] The preparatory study for commercial refrigeration, for example, also assumes a 1% yearly decrease in the average energy consumption in the BaU scenario. Available at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC91168/comm_refrig_published_bkg_doc%20-%202014%20august%2026.pdf.

Table 7.14 BaU – Estimated average electricity consumption of units sold (kWh/year)

	BaU - Estimated electricity consumption of units sold (kWh/year)				
	Category 1	Category 2	Category 3	Category 4	Average
1990	539	-	-	-	539
1995	513	-	-	-	513
2000	488	-	-	-	488
2005	464	-	-	367	464
2010	446	307	-	344	421
2015	446	282	272	326	364
2020	446	259	249	283	338
2025	446	247	237	269	319
2030	446	234	225	256	299
2035	446	223	214	244	278
2040	446	212	204	232	257
2045	446	202	194	220	235
2050	446	192	184	210	212

The environmental impacts created in the EoL phase have been calculated using the inputs for the Base Cases as per Task 5.

7.2.1.4 Minimum Energy Performance Standards – MEPS Scenario

The MEPS are assumed to be implemented in two tiers. Based on the timings of other Ecodesign regulations, the time gap between Tiers is typically 3-5 years. In this case, a 3-year interval between Tiers has been selected as being optimal. In the modelling, Tier 1 is assumed to come into force in 2024 and Tier 2 in 2027. Between 1990 and 2023, there is no difference between the BaU and the MEPS scenario. In 2024 and then again in 2027, the MEPS are assumed to affect the average standby energy consumption, the average cycle length and the average energy consumption per drying cycle.

Table 7.15 Key Inputs for calculating energy consumption of hand dryers in 2024 and 2027 (Tier 2) when the MEPS are implemented

Input	Category 1	Category 2	Category 3	Category 4
Cycle duration (s/cycle) – Tier 1	15.1	14.3	13.6	12.4
Cycle duration (s/cycle) – Tier 2	14.7	14.2	13.2	12.0
Electricity consumption per cycle (Wh/cycle) – Tier 1	5.28	4.06	4.24	4.66
Electricity consumption per cycle (Wh/cycle) – Tier 2	4.19	4.02	3.52	4.27
Electricity consumption on standby (Wh/h) – Tier 1	0.50	0.52	0.50	0.85
Electricity consumption on standby (Wh/h) – Tier 2	0.50	0.50	0.50	0.50

There are five aspects of the proposed measures which affect the energy consumption of hand dryers, and a brief explanation on their effect is presented below. Although the proposed measures do not exactly match each of the design options (DOs) modelled in Task 6, there are more details on how each of these measures affects the energy consumption of the Base Cases on the Task 6 report, where each DO is implemented individually.

- Standby consumption

The two tiers proposed in the standby power consumption measure affect the average electricity consumption on standby for all category driers. In 2024, when Tier 1 comes into force, the average standby consumption is still above 0.5W to allow for the 1W threshold where an information/status display is included in the product. In 2027, when Tier 2 comes into force, all hand dryers are assumed to have a standby power consumption of 0.5W

- Sensor only

The sensor only measure is assumed to affect only Category 1 products, as 100% of units from the other categories are assumed to operate with a sensor in the BaU scenario already. This measure decreases the average cycle duration and the average Wh/cycle of conventional hand dryers.

- Run-on time

The run-on time measure is expected to affect all hand dryers as the average run-on time modelled in Task 5 and in the BaU scenario is 1.5 seconds for all Categories. In the MEPS scenario, the average run-on time is limited to 1.0 seconds, thus reducing average cycle length and consequently Wh/cycle for all hand dryers.

- Energy consumption

The energy consumption measure limits the consumption per cycle. Tier 1 does not significantly affect Category 2, 3 and 4 dryers, because nearly all the products within these categories meet the 10Wh/cycle requirement. However, as a result of the measure, the average Wh/cycle of Category 1 units sold is reduced.

When Tier 2 comes into force with the 7.5 Wh/cycle requirement, the Wh/cycle of Category 1 products reduces further and the average Wh/cycle of Category 2, 3 and 4 products also decreases.

- Heating element

The proposed limitation of the power of the heating elements is assumed to reduce electricity consumption per cycle and to slightly increase the drying time for Category 2, 3 and 4 hand dryers. The measure does not apply to Category 1 units.

Table 7.16 summarises the effect of each of the proposed measures to the inputs used to estimate the average electricity consumption of products from each of the four categories.

Table 7.16 Effect of proposed measures to the inputs used to estimate the average electricity consumption of a unit

	Category 1	Category 2	Category 3	Category 4
Standby power consumption	↓ standby consumption (Tiers 1 and 2)			
Sensor only	↓ cycle duration ↓ kWh/cycle	No effect		
Run-on time	↓ cycle duration ↓ electricity consumption per cycle			
Energy consumption	↓ kWh/cycle (Tiers 1 and 2)	↓ kWh/cycle (Tier 2 only)		
Heating element	No effect	↑ drying time ↓ kWh/cycle		

No further technical improvements are assumed after the policy is implemented, meaning that the average electricity consumption of a unit sold in 2024 remains constant until 2027 – when it is affected by Tier 2 – and then constant again from 2028 onwards. However, the average electricity consumption of Category 2, 3 and 4 products in the BaU scenario catches up with the MEPS scenario in 2035, 2044 and 2038 respectively. From these points onwards, the electricity consumption of units sold is the same in the MEPS and BaU scenario, and is calculated based on the average assumed 1% yearly improvement. For Category 1 dryers this is not the case, since no reduction in the average electricity consumption is accounted for in the BaU scenario.

Table 7.17 presents the estimated average electricity consumption of units sold between 2020 and 2050. The 1990-2020 figures in the MEPS scenario are the same as those presented in Table 7.14 for the BaU scenario. In the MEPS scenario, the average electricity consumption of a unit sold is 33% lower in 2030 and 42% lower in 2050 when compared to 2020.

Table 7.17 MEPS – Estimated average annual electricity consumption per Hand Dryer unit sold (kWh/year)

	MEPS - Estimated electricity consumption of units sold (kWh/year)				
	Category 1	Category 2	Category 3	Category 4	Average
2025	293	227	236	262	254
2030	234	224	197	238	227
2035	234	223	197	238	226
2040	234	212	197	232	218
2045	234	202	194	220	208
2050	234	192	184	210	197

Table 7.18 MEPS – Estimated change in annual average electricity consumption of units sold (%)

	MEPS - Estimated change in electricity consumption of units sold (%)				
	Category 1	Category 2	Category 3	Category 4	Average
BaU 2020 (kWh/year)	446	259	249	283	338
2025	-34%	-13%	-5%	-7%	-25%
2030	-48%	-13%	-21%	-16%	-33%
2035	-48%	-14%	-21%	-16%	-33%
2040	-48%	-18%	-21%	-18%	-36%
2045	-48%	-22%	-22%	-22%	-39%
2050	-48%	-26%	-26%	-26%	-42%

Finally, proposed measures are expected to increase the rate of repair of hand dryers and the fraction of electronic components that is recycled from 10% to 29%, as modelled in T6 DO5. This has an effect on the average lifespan of products and on the environmental impacts calculated in the EoL phase.

7.2.1.5 Labelling Scenario

The Energy Label is assumed to be implemented in 2024. Between 1990 and 2023, there is no difference between the BaU and the Labelling scenario. From 2024 onwards, the Labelling system is assumed to accelerate improvements in efficiency over time.

Table 7.19 compares the estimated yearly percentage reduction in the average electricity consumption used in the BaU and MEPS scenarios. Although there is significant uncertainty associated to these percentages, they are based on the methodology used in the Ecodesign preparatory study for professional refrigeration products[206]. Specifically, this approach applies a similar difference between the BaU and the Labelling scenario used to model to effect of an energy label on the market of professional refrigeration products. The professional refrigeration approach has been replicated because these products are also sold in the business-to-business (B2B) market.

[206] Available at: https://ec.europa.eu/smart-regulation/impact/ia_carried_out/docs/ia_2015/swd_2015_0097_en.pdf.

Table 7.19 Labelling versus BaU: estimated effects in percentage reduction year on year in the average annual electricity consumption of a hand dryer over time

	BaU	Labelling
2020	0% for Category 1 1% for Categories 2 3 and 4	Same as BaU
2021		
2022		
2023		
2024		3% for all Categories
2025		4% for all Categories
2026		3% for all Categories
2027		2% for all Categories
2028-2050		1% for all Categories

In the BaU scenario the average electricity consumption of a unit is expected to decrease by 0% (Category 1) or 1% (for Category 2, 3 and 4 products) per year. In the Labelling scenario a reduction of 3% has been assumed for the year when the label is implemented (2024). Subsequently, a further 4% reduction is accounted for in year 2 (2025) as the competitive market for energy issues takes hold followed by further 3% (in 2026) and 2% (in 2027) reductions. From 2028 onwards, the annual improvement rate of electricity consumption is set at 1% for all Categories.

Table 7.20 presents the estimated average electricity consumption of units sold between 2020 and 2050. The 1990-2020 figures in the Labelling scenario are not shown as they would be the same as those presented in Table 7.14 for the BaU scenario. In the Labelling scenario, the average electricity consumption of a unit sold is 21% lower in 2030 and 44% lower in 2050 when compared to 2020.

Table 7.20 Labelling – Estimated annual average electricity consumption per unit sold (kWh/year)

	Labelling - Estimated electricity consumption of units sold (kWh/year)				
	Category 1	Category 2	Category 3	Category 4	Average
2025	416	234	225	256	300
2030	383	216	208	236	268
2035	365	205	198	225	246
2040	347	195	188	214	225
2045	330	186	179	203	207
2050	314	177	170	193	189

Table 7.21 Labelling – Estimated change in annual average electricity consumption of units sold (%)

	Labelling - Estimated change in electricity consumption of units sold (%)				
	Category 1	Category 2	Category 3	Category 4	Average
BaU 2020 (kWh/year)	446	259	249	283	338
2025	-7%	-10%	-10%	-10%	-11%
2030	-14%	-17%	-17%	-17%	-21%
2035	-18%	-21%	-21%	-21%	-27%
2040	-22%	-25%	-25%	-25%	-33%
2045	-26%	-28%	-28%	-28%	-39%
2050	-30%	-32%	-32%	-32%	-44%

Similar to the approach taken in BaU scenario, in the Labelling scenario the environmental impacts created in the EoL phase have been calculated using the inputs for the Base Cases as per Task 5.

7.2.1.6 MEPs and Labelling

In this scenario, both the MEPs and the Labelling system are assumed to be implemented in 2024. Between 1990 and 2023, there is no difference between the BaU and the MEPS + Labelling scenario. In 2024 and 2027, when the proposed measures come into force, the energy consumption of hand dryers is calculated as in the MEPS scenario, using the inputs presented in Table 7.15. In 2025 and 2026 and from 2028 onwards, the energy label is assumed to accelerate improvements in efficiency over time as per the inputs presented in Table 7.19.

Table 7.22 presents the estimated average electricity consumption of units sold between 2020 and 2050. The 1990-2020 figures in the MEPS + Labelling scenario are the same as those presented in Table 7.14 for the BaU scenario. In the MEPS + Labelling scenario, the average electricity consumption of a unit sold is 38% lower in 2030 and 50% lower in 2050 when compared to 2020.

Table 7.22 MEPS + Labelling. – Estimated annual average electricity consumption per unit sold (kWh/year)

	MEPS + Labelling - Estimated electricity consumption of units sold (kWh/year)				
	Category 1	Category 2	Category 3	Category 4	Average
2025	282	218	227	252	244
2030	227	201	191	231	211
2035	216	191	182	220	200
2040	205	182	173	209	189
2045	195	173	164	199	179
2050	185	164	156	189	170

Table 7.23 MEPS +Labelling – Estimated change in annual average electricity consumption of units sold (%)

	MEPS + Labelling - Estimated change in electricity consumption of units sold (%)				
	Category 1	Category 2	Category 3	Category 4	Average
BaU 2020 (kWh/year)	446	259	249	283	338
2025	-37%	-16%	-9%	-11%	-28%
2030	-49%	-23%	-23%	-18%	-38%
2035	-52%	-26%	-27%	-22%	-41%
2040	-54%	-30%	-31%	-26%	-44%
2045	-56%	-33%	-34%	-30%	-47%
2050	-58%	-37%	-37%	-33%	-50%

Similar to the approach taken in the MEPS scenario, proposed measures are expected to increase the rate of repair of hand dryers and the fraction of electronic components that is recycled from 10% to 29%, as modelled in T6 DO5. This has an effect on the average lifespan of products and on the environmental impacts calculated in the EoL phase.

7.2.2 Results

The energy consumption of the stock of hand dryers in the EU for the four different scenarios is presented in Table 7.24. Table 7.25 and Figure 7.6 present the primary energy consumption in the same scenarios, taking into account the average EU Primary Energy Factor ("PEF") of 2.1 for electricity generation, and thus how much primary energy is used to generate the electricity consumed by hand dryers.

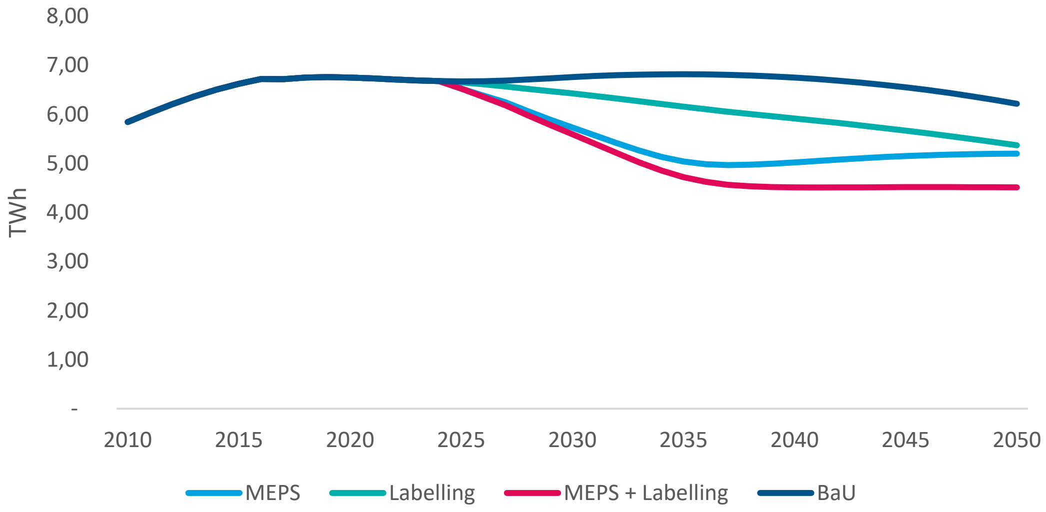
Table 7.24 Hand Dryers' Total Annual Final Energy Consumption in the EU28 for all scenarios (TWh/year)

	Annual energy consumption (TWh/year)			
	BaU	MEPS	Labelling	MEPS + Labelling
1990	0.74	0.74	0.74	0.74
1995	1.03	1.03	1.03	1.03
2000	1.44	1.44	1.44	1.44
2005	2.09	2.09	2.09	2.09
2010	2.78	2.78	2.78	2.78
2015	3.15	3.15	3.15	3.15
2020	3.21	3.21	3.21	3.21
2025	3.17	3.11	3.17	3.11
2030	3.22	2.73	3.06	2.66
2035	3.24	2.40	2.93	2.25
2040	3.21	2.39	2.82	2.15
2045	3.12	2.45	2.70	2.15
2050	2.96	2.47	2.56	2.15

Table 7.25 Hand Dryers' Total Annual Primary Energy Consumption in the EU28 for all scenarios (TWh/year)

	Annual primary energy consumption (TWh/year)			
	BaU	MEPS	Labelling	MEPS + Labelling
1990	1.54	1.54	1.54	1.54
1995	2.16	2.16	2.16	2.16
2000	3.02	3.02	3.02	3.02
2005	4.38	4.38	4.38	4.38
2010	5.84	5.84	5.84	5.84
2015	6.62	6.62	6.62	6.62
2020	6.75	6.75	6.75	6.75
2025	6.67	6.52	6.65	6.52
2030	6.76	5.73	6.42	5.59
2035	6.81	5.04	6.15	4.72
2040	6.75	5.02	5.91	4.51
2045	6.55	5.15	5.67	4.51
2050	6.21	5.20	5.37	4.51

Figure 7.6 Hand Dryers' Annual Primary Energy Consumption in the EU28 for all scenarios (TWh)



In the BaU scenario, the energy consumption remains roughly steady between 2020 and 2050 as the market transitions from Category 1 to Category 2, 3 and 4 products – which tend to be more efficient. Even with the stock of hand-dryers increasing over time, the reduced share of conventional products and the higher share of high-speed units leads to the average energy consumption of a unit in stock reducing over time. Consequently, the annual primary energy consumption in the EU28 remains roughly constant ranging between 6.2 - 6.8 TWh/ year over the period.

This means that the BaU scenario is especially sensitive to the split per categories of sales and stock over time. Table 7.26 and Table 7.27 present the estimated average energy consumption (kWh/year) of a unit sold and in stock respectively.

Both the Labelling and MEPs scenarios are expected to speed up the uptake of more efficient products and consequently lower energy consumption over time. The MEPS + Labelling scenario is the more ambitious case (Table 7.25), reducing annual primary energy consumption by 17% in 2030 and 27% in 2050 compared to the BaU scenario.

In the MEPS scenario, the annual primary energy consumption decreases from 2024 (when the proposed measures are implemented) until around 2037, when the curve bounces back and begins to approach the BaU curve. This happens because as described in Sections 7.2.1.3 and 7.2.1.4, the average electricity consumption of a unit is assumed to improve over time in the BaU and eventually catch up with the electricity consumption of a MEPS compliant unit (for Categories 2, 3 and 4). The MEPS scenario is assumed to accelerate improvements in product efficiency that would naturally occur in the BaU scenario in the long-term, thus leading to energy savings. However, over time, the MEPS scenario curve begins to slowly approach the BaU scenario curve, which explain the slight upward inclination presented in the graph between 2037 and 2050.

NB It should be noted that the above situation necessarily assumes that neither the MEPS nor the Energy Labelling requirements are progressively revised over time. In reality, if Ecodesign and/ or Energy Labelling regulations were to be approved for the Hand Dryers product group, then they would be subject to periodic reviews, to verify that they were up to date and still rewarded technological progress. In this way, the momentum of continuous progress should be maintained rather than restrained. In addition, the responsiveness of the regulation(s) to actual end-consumer use of the products, market surveillance reporting from Member States and manufacturers' and stakeholders' feedback would be taken into account.

Table 7.26 Average annual final energy consumption per unit sold (kWh/year)

	Average kWh/year per unit sold			
	BaU	MEPS	Labelling	MEPS + Labelling
1990	539	539	539	539
1995	513	513	513	513
2000	488	488	488	488
2005	464	464	464	464
2010	421	421	421	421
2015	364	364	364	364
2020	338	338	338	338
2025	319	254	300	244
2030	299	227	268	211
2035	278	226	246	200
2040	257	218	225	189
2045	235	208	207	179
2050	212	197	189	170

Table 7.27 Average annual final energy consumption per unit in stock (kWh/year)

	Average kWh/year per unit in stock			
	BaU	MEPS	Labelling	MEPS + Labelling
1990	569	569	569	569
1995	541	541	541	541
2000	515	515	515	515
2005	489	489	489	489
2010	462	462	462	462
2015	426	426	426	426
2020	388	388	388	388
2025	361	353	360	353
2030	342	290	325	283
2035	322	242	291	227
2040	301	227	264	204
2045	278	219	241	192
2050	253	210	219	182

GHG emissions in all four scenarios are presented in Table 7.28 and Figure 7.7. Note that projected GHG emissions decrease over time also in the BaU scenario. This reduction arises because the average EU electricity mix-related GWP emission factor goes down over time, as the EU28 makes a transition to a low carbon economy, and increasingly produces electricity from renewables. That noted, all policy scenarios modelled still bring associated additional emission savings against the BaU, with annual GHG emissions being reduced by 17% and 28% in 2030 and 2050 respectively in the MEPs + Labelling scenario (Table 7.28). In the MEPS scenario, there is a visible change in the slope of the curve around 2037, which is in line with the trend presented in Figure 7.6.

The key factor driving the savings in emissions created in the scenarios is the difference in energy consumption presented in Table 7.24. The results presented here also account for the effects of the increased rate of repair of hand dryers and the higher fraction of electronic components that is recycled in both the MEPS and MEPS + Labelling scenario.

The improved repair rates are presented in Table 7.4 in Section 7.1.4.6. These higher rates lead to a slight increase in the average lifespan of a unit, which affects the stock of hand-dryers and consequently the average electricity consumption of a unit in stock. In the Task 6 report, the design options are modelled individually and there is further detail on how the improved design requirements affect resource use and environmental impacts.

Generally, the contribution of the EoL to the total environmental impacts is very marginal. Although the size of the effect varies for different scenarios, years and impacts (e.g. GHG emissions, heavy metals) it is usually low (i.e. corresponds to less than 1% of the impacts) and positive (i.e. bringing net emission savings when the savings generated in recycling and recovering components is be greater than the emissions generated in incinerating components). More detailed results of the savings created only in the EoL phase is available at the Annex.

The results from estimating the other environmental impacts created in the use and EoL phase are presented in Figure 7.8.

Table 7.28 Hand Dryers' Annual GHG Emissions in the EU28 for all scenarios (MtCO2e/year)

	Annual GHG emissions in the EU (MtCO2e)			
	BaU	MEPS	Labelling	MEPS + Labelling
1990	0.37	0.37	0.37	0.37
1995	0.49	0.49	0.49	0.49
2000	0.65	0.65	0.65	0.65
2005	0.90	0.90	0.90	0.90
2010	1.14	1.14	1.14	1.14
2015	1.24	1.24	1.24	1.24
2020	1.22	1.22	1.22	1.22
2025	1.14	1.11	1.13	1.11
2030	1.09	0.92	1.03	0.90
2035	1.03	0.76	0.93	0.71
2040	0.96	0.71	0.84	0.64
2045	0.87	0.68	0.75	0.60
2050	0.76	0.64	0.66	0.55

Figure 7.7 Hand Dryers' Annual GHG Emissions in the EU28 for all scenarios

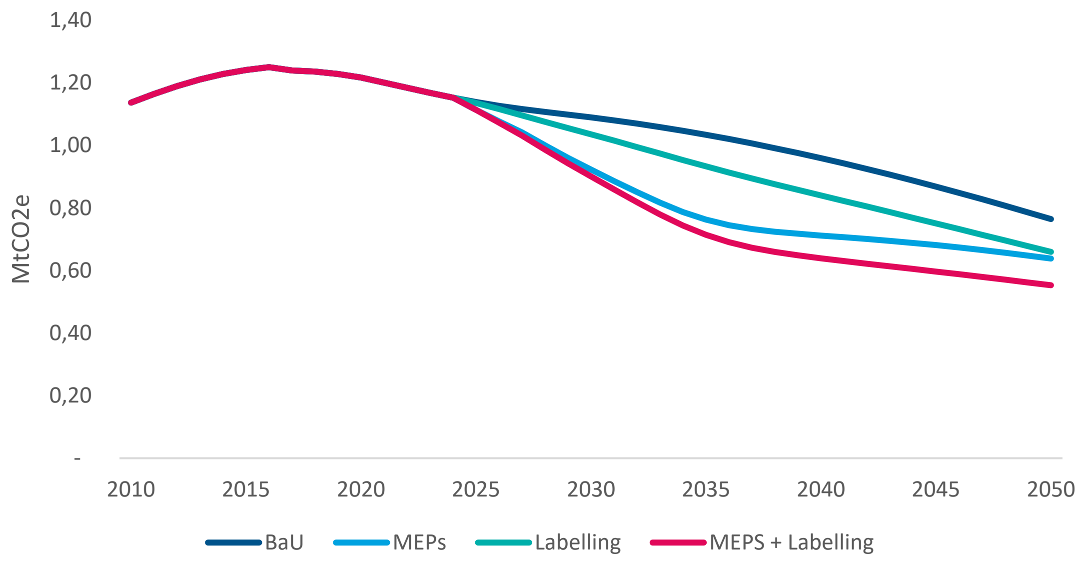
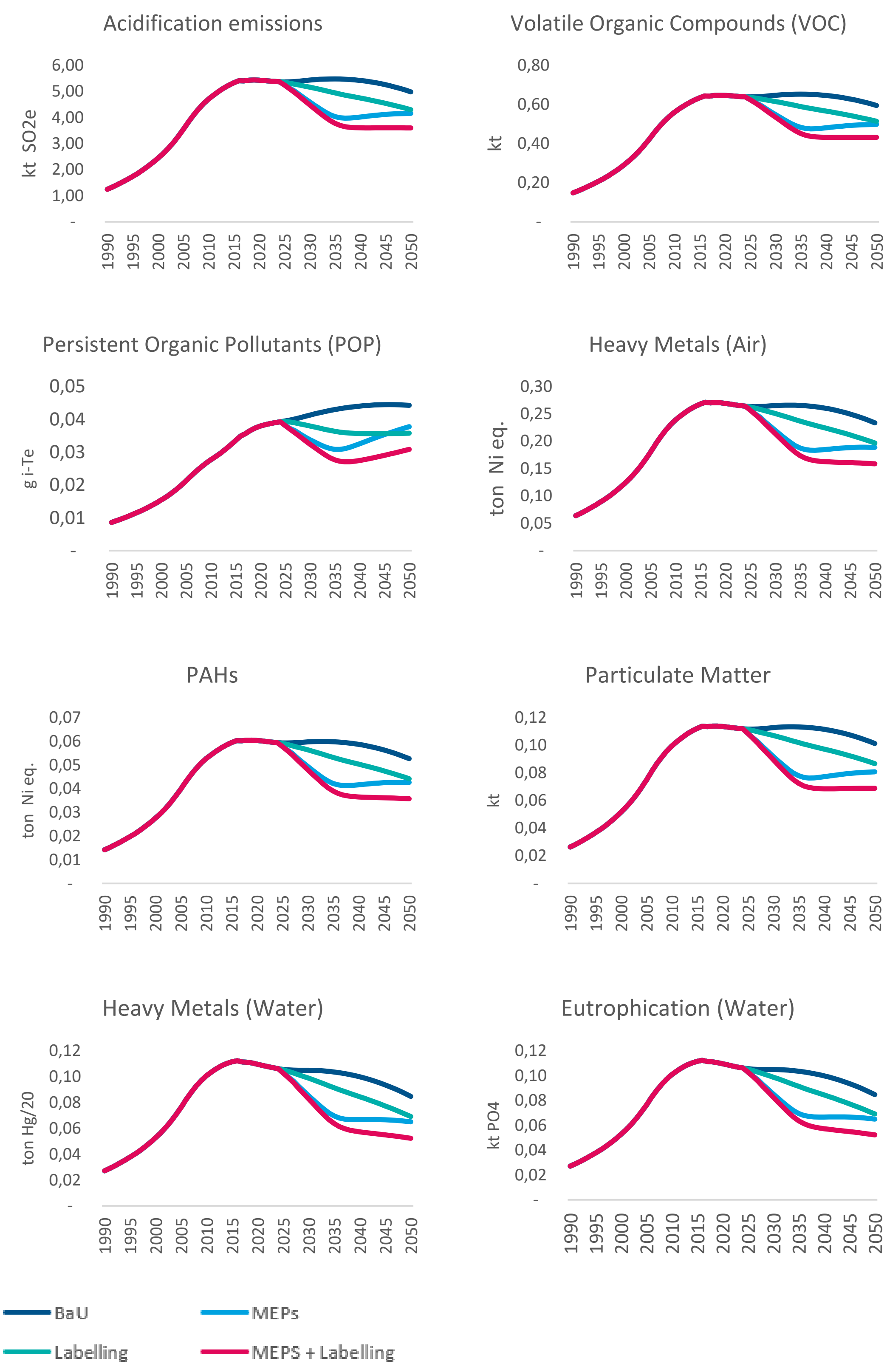


Figure 7.8 Environmental Impacts in the EU28 for all scenarios



7.3 SCENARIO ANALYSIS – SOCIO-ECONOMIC IMPACTS

The objective of this sub-task is to discuss the socio-economics impacts created by the different policy scenarios proposed (i.e. BaU, MEPS, Labelling and MEPS + Labelling).

The same sales and stock model used previously to calculate resource use and environmental impacts – which is described in Section 7.2.1.1 – is used to estimate the following outputs in all four scenarios:

- Consumer expenditure with purchase and installation of hand dryers
- Running costs to the consumer, including cost of consumables (i.e. filters), cost of electricity, cost of repair, and maintenance cost
- Societal costs of the environmental impacts created

The inputs and assumptions used in the modelling as well as the results are presented in the following sub-sections.

7.3.1 Inputs and Assumptions

7.3.1.1 Purchase Price

Using a similar approach to that in section 7.2, the purchase price inputs for the BaU scenario were used as per the Base Case models from Task 5 for the whole 1990-2050 period.

In the **Labelling scenario**, the purchase prices of units are similar to those in the BaU scenario. The rationale behind this assumption is that the label per se does not directly affect the price of products on the market. However, it must be noted that Energy Labelling, without having MEPS set as a "base line", is unusual to date in EU product policy-making.

In the **MEPS scenario**, and in the **MEPS + Labelling scenario**, the average price per unit is expected to increase in 2024 for all Categories due to the proposed measures. The different aspects of the effect of the MEPS to the unit price are detailed below:

- To comply with the standby consumption improvement criteria, as modelled in Task 6 DO2 based on manufacturer feedback, the cost of improvement is estimated to increase the unit price by €8, due to redesigning efforts.
- To comply with the sensor only measure, as modelled in T6 DO3, a €2.73 cost increase is estimated for Category 1 hand dryers as push-button operated products are replaced by sensor operated products.
- Shortening run-on time from 1.5 to 1 second has been assumed not to bring a cost increase to the products.
- The minimum efficiency criteria of Tier 1 (10Wh/cycle) and Tier 2 (7.5Wh/cycle) are assumed to not have an influence in the price per unit. However, these have an effect on sales, as detailed in 7.2.1.1.
- The limitation of the heating component is assumed not to bring a cost increase to the products.
- The circular economy measures described in 7.1.4.5 relate to spare part availability, providing repair and maintenance information, WEEE separation and marking of plastics. Manufacturer feedback has indicated that most products already comply with these measures and hence it is assumed there is no cost increase associated with them.
- The improved design criteria, as detailed in Task 6 DO5, is estimated to increase the total price of each product by 5%.
- The Neodymium and critical raw material criteria is assumed not to bring a cost increase to the products.

The purchase price of units used in the scenarios are detailed in Table 7.29 below.

Table 7.29 Purchase price inputs

Category	BaU and Labelling purchase price	Standby consumption price increase	Sensor only price increase	Improved design price increase	MEPS and MEPS + Labelling purchase price (2024)
Category 1	**€188**	€8	€2.73	+5%	**€209**
Category 2	**€351**	€8	€0	+5%	**€377**
Category 3	**€351**	€8	€0	+5%	**€377**
Category 4	**€715**	€8	€0	+5%	**€759**

As described in Section 7.2.1.4, over time the average electricity consumption of Category 2, 3 and 4 products in the BaU scenario catches up with the MEPS scenario in 2035, 2044 and 2038 respectively. From these points onwards, the electricity consumption of units sold is the same in the MEPS and BaU scenario.

In the modelling, it is assumed that the difference in the purchase price of a MEPS compliant unit also catches up with the BaU. This means that in 2035, 2044 and 2038 the price of Category 2, 3 and 4 products in the MEPS and MEPS + Labelling scenario is the same as the price in the BaU scenario. For the years between 2024 and when the policy catches up, a linear decrease in price is assumed.

In the case of Category 4 products for example, in the MEPS and MEPS + Labelling scenarios the purchase price is €715 for all years until 2023, before the MEPS come into force. Then, it is set at €759 in 2024 when the MEPS are implemented, decreasing linearly until 2038, when it reaches €715 and it is then kept constant from then onwards.

7.3.1.2 Installation Cost

The installation cost inputs for the BaU scenario were used as per the Base Case models from Task 5 for the whole 1990-2050 period in all four scenarios and set at €100.

7.3.1.3 Cost of consumables

The cost of consumables inputs for the BaU scenario were used as per the Base Case models from Task 5. The filter price is set at €20 and the percentage of units assumed to operate with a filter that is exchanged on average once per year is 0%, 30%, 30% and 100% for Categories 1, 2, 3 and 4 respectively. These inputs are used for the whole 1990-2050 period in all four scenarios.

7.3.1.4 Maintenance and Repair

The repair and maintenance cost inputs for the BaU scenario were used as per the Base Case models from Task 5. As detailed in T6 DO5, the improved design criteria is expected to decrease the repair labour costs from €125.58 to €87.25. However, the cheaper repair price is estimated to increase the rate of repair by 50% as detailed in Section 7.1.4.6, which leads to a net increase to the average repair price per unit as presented in Table 7.30.

Table 7.30 Average Lifetime Maintenance and Repair costs per unit

Category	BaU & Labelling	MEPS & MEPS + Labelling
Category 1	€38.96	€42.94
Category 2	€56.69	€65.37
Category 3	€56.69	€65.37
Category 4	€236.56	€247.06

7.3.1.5 Electricity cost

The cost with electricity is calculated based on the annual electricity consumption of the EU28 stock presented in Table 7.24 for the four scenarios and on the year specific electricity prices for the services sector presented in Table 7.31.

Table 7.31 Electricity Prices (Source: PRIMES REF 2015f)

Year	Electricity Prices (€/kWh)
2005	0.127
2010	0.148
2015	0.157
2020	0.171
2025	0.176
2030	0.179
2035	0.184
2040	0.182
2045	0.180
2050	0.178

7.3.1.6 Cost of Externalities

The societal cost of the environmental impacts created as a consequence of use and end of life phases of the lifecycle of hand dryer units was calculated using the default rates from MEErP and the EcoReport Tool, as presented in Table 7.32.

Table 7.32 External marginal cost to society rates (Source: EcoReport Tool)

	Externalities rates	
Greenhouse Gases in GWP100	0.014	€ per kg CO2 eq.
Acidification, emissions	0.0085	€ per g SO2 eq.
Volatile Organic Compounds (VOC)	0.00076	€ per g
Persistent Organic Pollutants (POP)	0.000027	€ per ng i-Teq
Heavy Metals	0.0003	€ per mg Ni eq.
PAHs	0.001279	€ per mg Ni eq.
Particulate Matter (PM, dust)	0.01546	€ per g

7.3.1.7 Inflation

Socio-economic impacts were first calculated net of inflation to allow for an analysis of the effect of the assumptions and policies in terms of real value (i.e. current €). The 4% MEErP inflation was then used to estimate the socio-economic impacts in terms of nominal value.

7.3.2 Results

Total annual costs of the stock of hand dryers in the EU for the four different scenarios is presented net of inflation in Table 7.33 and Figure 7.9.

From 1990 to 2023 there is no difference between the different scenarios. Between 2024 and 2027, the increased purchase prices lead to greater annual costs in the MEPS and MEPS + Labelling scenario. However, after 2028 the energy savings caused by the implementation of the proposed measures begins to create cost savings and total cost is reduced by 5% in 2030 and 9% in 2050 in the MEPS + Labelling scenario versus the BaU.

In the Labelling scenario, no increases are assumed regarding the purchase cost per se, which leads to cost savings begin to being accrued already in 2025 due to improved product efficiency and consequent energy savings.

Figure 7.10 and Figure 7.11 provide further detail on the breakdown of the total cost between the sales & installation of new products, the running costs of products in stock, and the cost of externalities for 2030 and 2050.

Table 7.33 Total annual costs of Hand Dryer Stocks in the EU (Million €, net of inflation)

	Annual costs in the EU (Million €)			
	BaU	MEPS	Labelling	MEPS + Labelling
1990	170	170	170	170
1995	244	244	244	244
2000	359	359	359	359
2005	509	509	509	509
2010	721	721	721	721
2015	1,031	1,031	1,031	1,031
2020	1,172	1,172	1,172	1,172
2025	1,270	1,293	1,269	1,293
2030	1,373	1,316	1,341	1,303
2035	1,481	1,334	1,417	1,303
2040	1,561	1,413	1,481	1,364
2045	1,630	1,510	1,546	1,450
2050	1,692	1,605	1,613	1,540

Figure 7.9 Total annual costs attributed to Hand Dryer Stocks in the EU (Million €, net of inflation)

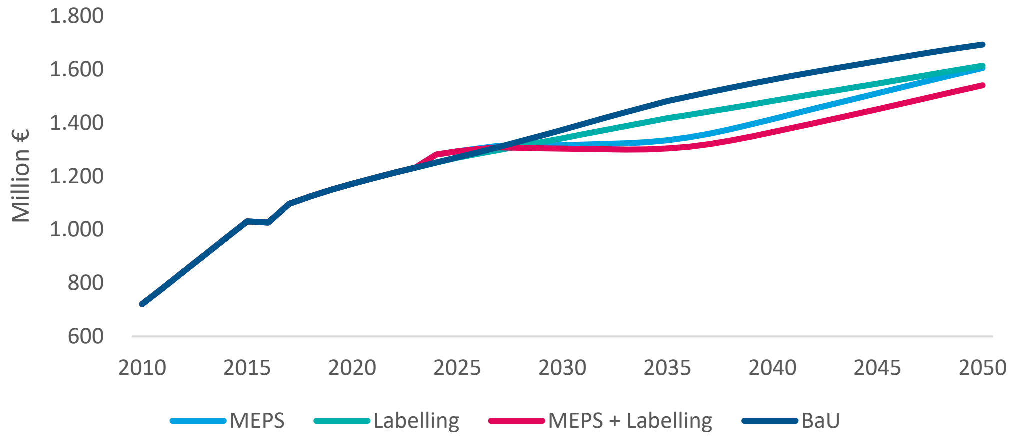


Figure 7.10 Breakdown of the total costs attributed to Hand Dryer Stocks in the EU in 2030 (Million €, net of inflation)

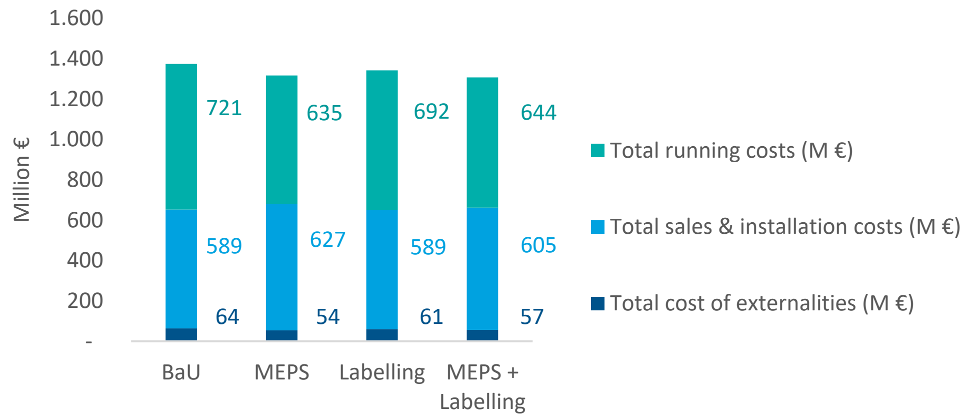
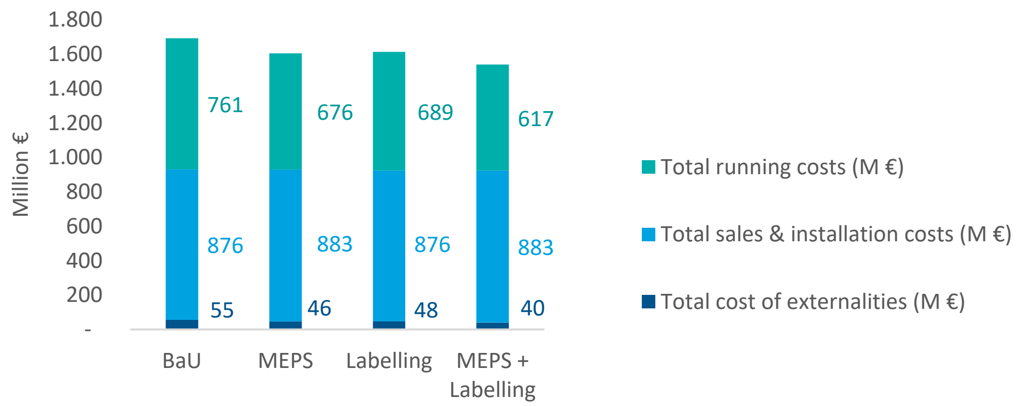
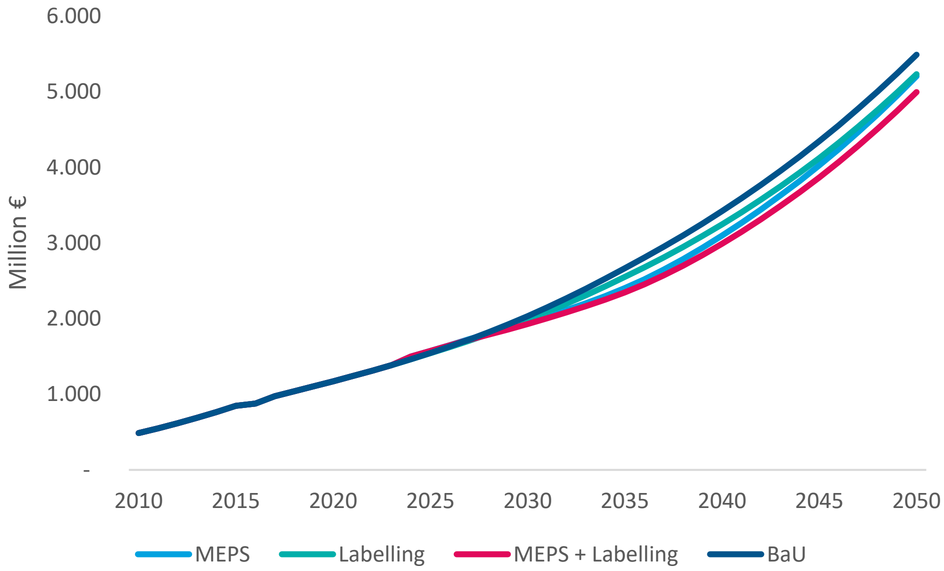


Figure 7.11 Breakdown of the total costs attributed to Hand Dryer Stocks in the EU in 2050 (Million €, net of inflation)



The total annual costs of the stock of hand dryers in the EU for the four different scenarios is presented accounting for inflation in Figure 7.12. Although savings are still seen in the graph, the effect of inflation dominates the results presented.

Figure 7.12 Total annual costs attributed to Stocks of Hand Dryers in the EU (Million €, inflated)



7.3.3 Additional Information

The data gathered for this preparatory study indicates that there is not a simple relation between the price of products and their performance in terms of energy use. There are a number of efficient cheaper products and some inefficient expensive products on the market. In other words, the price elasticity for indicator target levels has not been defined, since it is not feasible or coherent to be able to forecast/ pre-empt this with the evidence available, and taking into account the assumptions behind the models.

Furthermore, due to a lack of data from manufacturers regarding production costs, turnover/employee, margins and overhead, it was not possible to model the detailed effects of the different policy scenarios in relation to these socio-economic aspects.

Currently, the market is mostly made of SME companies with small market shares. There is no evidence to indicate that the policy scenarios proposed will have a significant effect to this configuration.

The regulation should remove poorer-performing products from the market. While in the modelling it was assumed that these products are merely substituted by similar products (i.e. more efficient dryers within the same price range), manufacturers have pointed out that there is some risk of technology substitution attached to the proposed measures. That is, there may be some associated decreases in the sales of hand dryers if a number of consumers instead choose to buy cheaper purchase price alternatives (e.g., paper towels/ paper-based solutions). However, this is outside the scope of the present analysis, which focuses on electric hand dryer technology design options. Full whole life cycle comparisons with competing technology alternative solutions would need to be carried out, including apportioning environmental externalities, in order to appreciate these issues in full.

7.4 SENSITIVITY ANALYSIS

The objective of this sub-task is to conduct a sensitivity analysis, covering the relevant factors (such as the price of electricity, the purchase price) and, where appropriate, external environmental costs, and presents their outputs relevant to the policy scenarios.

The inputs included in the sensitivity analysis are:

- Electricity prices

- Purchase price of hand dryers
- Primary Energy Factor (PEF)
- Cost of externalities
- Inflation
- Number of cycles per day

7.4.1 Electricity Prices

The socio-economic impacts presented in Section 7.3.2 are very sensitive to the electricity prices because most of the cost savings created in the policy scenarios are a result of the lower use phase electricity consumption and consequent lower running expenditures.

Table 7.34 and Figure 7.13 present the estimated total annual costs in the EU with electricity prices 50% lower than those used in the model for the whole period. Table 7.35 presents the total annual cost savings, which are 71% and 47% lower in the MEPS + Labelling scenario in 2030 and 2050 respectively. Figure 7.14 shows how the decreased electricity prices affect the split of total costs in 2030, with running costs corresponding to a reduced fraction of the total cost.

Table 7.34 Total annual costs in the EU – Lower electricity prices (Million €, net of inflation)

Annual costs (Million €)	2020	2025	2030	2035	2040	2045	2050
BaU	897	991	1,085	1,183	1,268	1,349	1,429
MEPS	897	1,020	1,072	1,114	1,195	1,290	1,384
Labelling	897	990	1,067	1,148	1,224	1,304	1,385
MEPS + Labelling	897	1,020	1,064	1,097	1,169	1,257	1,349

Table 7.35 Total annual savings in the EU compared to the BaU scenario – Lower electricity prices (Million €, net of inflation)

Annual savings (Million €/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	-29	13	69	73	60	45
Labelling	-	1	17	35	44	46	43
MEPS + Labelling	-	-29	20	86	100	93	80

Figure 7.13 Total annual costs in the EU – Lower electricity prices (Million €, net of inflation)

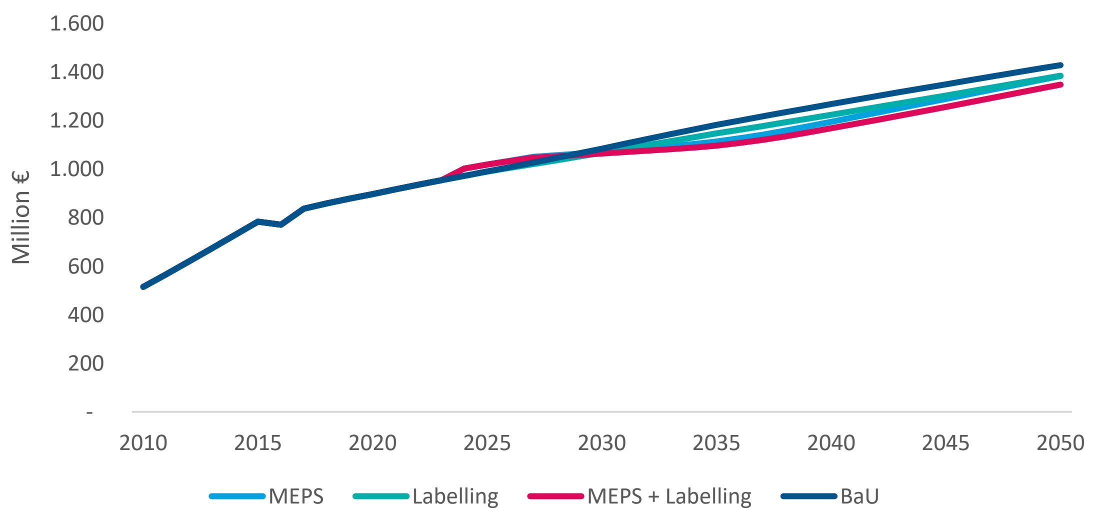


Figure 7.14 Breakdown of the total costs attributed to Hand Dryer Stocks in the EU in 2030 – Lower electricity prices (Million €, net of inflation)

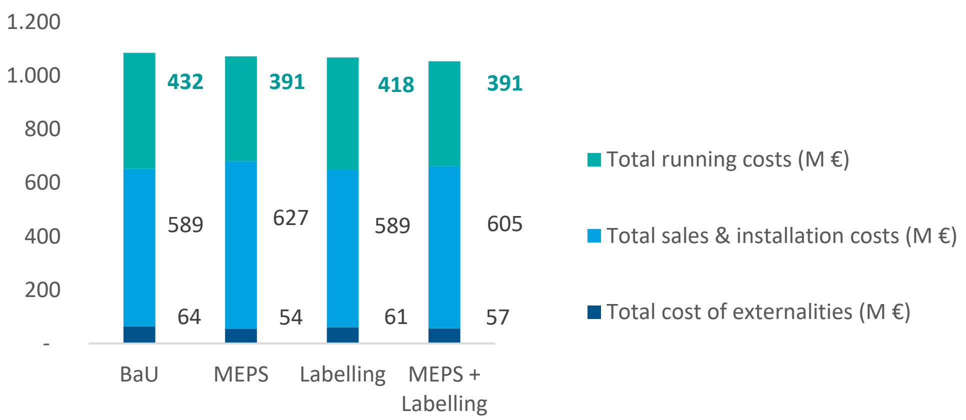


Table 7.36 and Figure 7.15 present the estimated total annual costs in the EU with electricity prices 50% higher than those used in the model for the whole period. Table 7.37 presents the total annual cost savings, which are 71% and 48% higher in the MEPS + Labelling scenario in 2030 and 2050 respectively. Figure 7.16 shows how the increased electricity prices affect the split of total costs in 2030, with running costs corresponding to a larger fraction of the total cost.

Table 7.36 Total annual costs in the EU – Higher electricity prices (Million €, net of inflation)

Annual costs (Million €)	2020	2025	2030	2035	2040	2045	2050
BaU	1,446	1,550	1,661	1,779	1,854	1,910	1,956
MEPS	1,446	1,566	1,560	1,555	1,631	1,731	1,825
Labelling	1,446	1,547	1,615	1,686	1,738	1,789	1,841
MEPS + Labelling	1,446	1,566	1,541	1,510	1,560	1,643	1,731

Table 7.37 Total annual savings in the EU – Higher electricity prices (Million €, net of inflation)

Annual savings (Million €/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	-16	101	224	223	180	131
Labelling	-	2	46	93	116	121	115
MEPS + Labelling	-	-16	120	269	294	267	225

Figure 7.15 Total annual costs in the EU – Higher electricity prices (Million €, net of inflation)

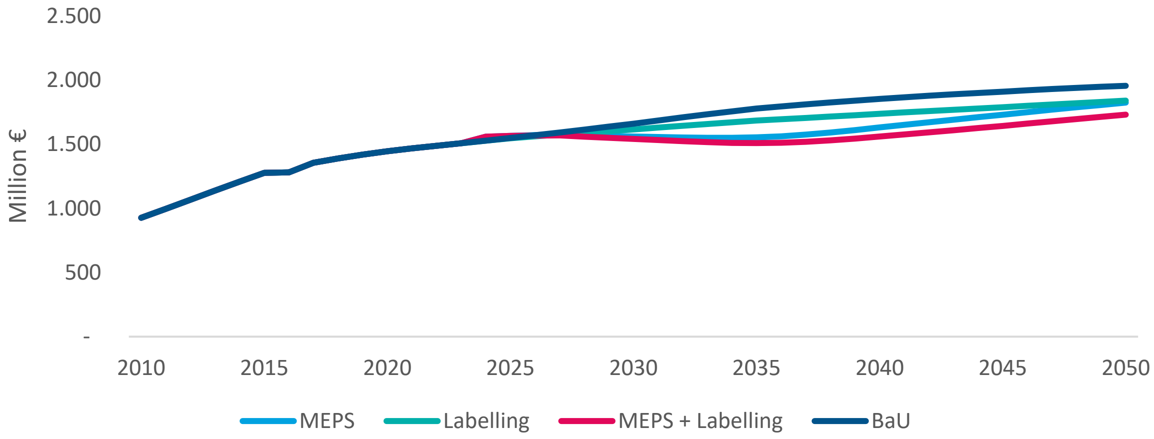
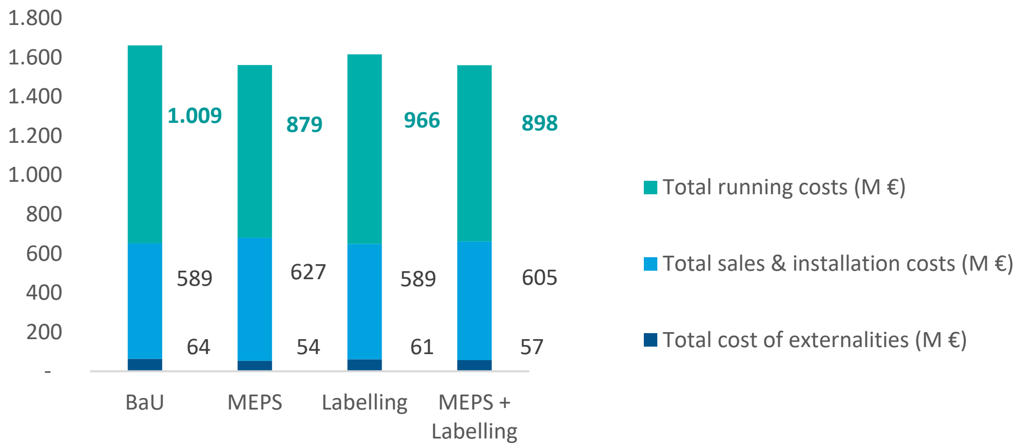


Figure 7.16 Breakdown of the total costs attributed to Hand Dryer Stocks in the EU in 2030 – Higher electricity prices (Million €, net of inflation)



7.4.2 Purchase Price

Table 7.38 and Figure 7.17 present the estimated total annual costs in the EU with purchase prices 50% lower than those used in the model for the whole period. Table 7.39 presents the total annual cost savings, which are 23% and 3% higher in the MEPS + Labelling scenario in 2030 and 2050 respectively. Figure 7.20 shows how the decreased purchase prices affect the split of total costs in 2030, with sales and installation costs corresponding to a reduced fraction of the total cost.

Table 7.38 Total annual costs in the EU – Lower purchase prices (Million €, net of inflation)

Annual costs (Million €)	2020	2025	2030	2035	2040	2045	2050
BaU	994	1,066	1,141	1,221	1,272	1,309	1,340
MEPS	994	1,075	1,068	1,064	1,116	1,184	1,249
Labelling	994	1,064	1,109	1,157	1,192	1,226	1,260
MEPS + Labelling	994	1,075	1,055	1,033	1,068	1,124	1,184

Table 7.39 Total annual savings in the EU – Lower purchase prices (Million €, net of inflation)

Annual savings (Million €/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	-10	73	157	155	125	91
Labelling	-	2	32	64	80	84	79
MEPS + Labelling	-	-10	86	188	204	185	156

Figure 7.17 Total annual costs in the EU – Lower purchase prices (Million €, net of inflation)

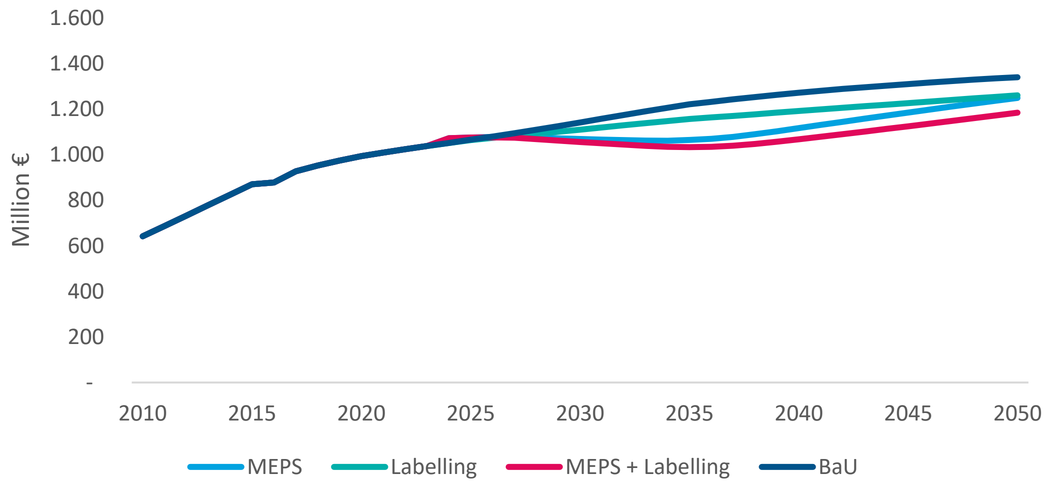


Figure 7.18 Breakdown of the total costs attributed to Hand Dryer Stocks in the EU in 2030 – Lower purchase prices (Million €, net of inflation)

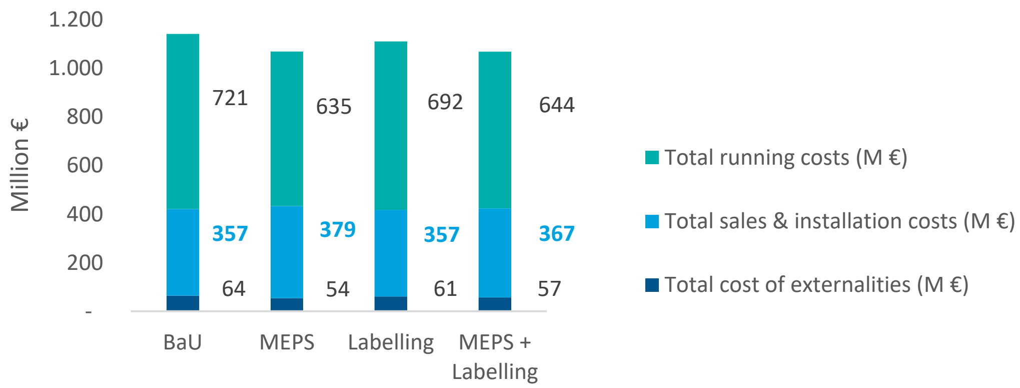


Table 7.40 and Figure 7.19 present the estimated total annual costs in the EU with purchase prices 50% higher than those used in the model for the whole period. Table 7.41 presents the total annual cost savings, which are 23% and 2% lower in the MEPS + Labelling scenario in 2030 and 2050 respectively. Figure 7.20 shows how the increased purchase prices affect the split of total costs in 2030, with sales and installation costs corresponding to an increased fraction of the total cost.

Table 7.40 Total annual costs in the EU – Higher purchase prices (Million €, net of inflation)

Annual costs (Million €)	2020	2025	2030	2035	2040	2045	2050
BaU	1,349	1,475	1,605	1,741	1,851	1,951	2,045
MEPS	1,349	1,510	1,563	1,604	1,710	1,836	1,960
Labelling	1,349	1,473	1,573	1,677	1,771	1,867	1,966
MEPS + Labelling	1,349	1,510	1,550	1,573	1,661	1,776	1,896

Table 7.41 Total annual savings in the EU – Higher purchase prices (Million €, net of inflation)

Annual savings (Million €/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	-35	42	136	140	114	85
Labelling	-	2	32	64	80	84	79
MEPS + Labelling	-	-35	54	167	189	175	149

Figure 7.19 Total annual costs in the EU – Higher purchase prices (Million €, net of inflation)

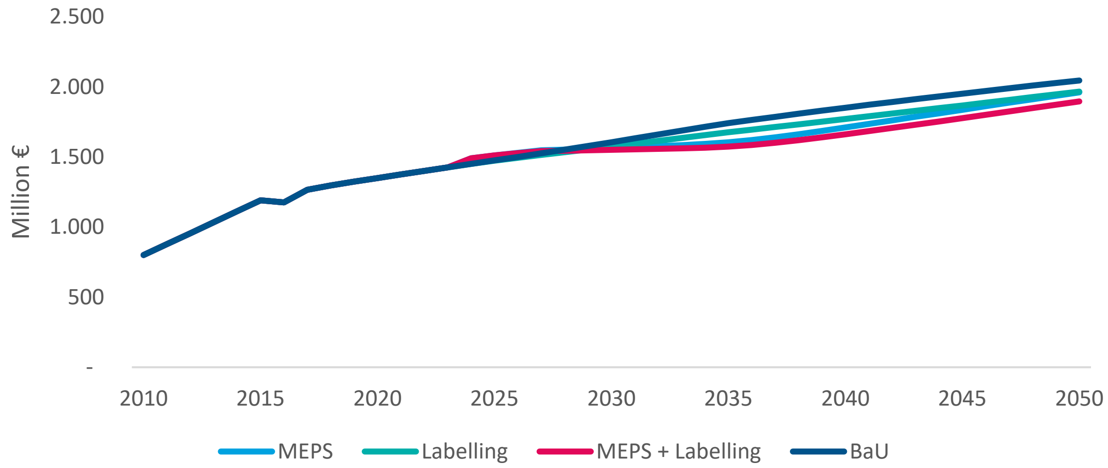
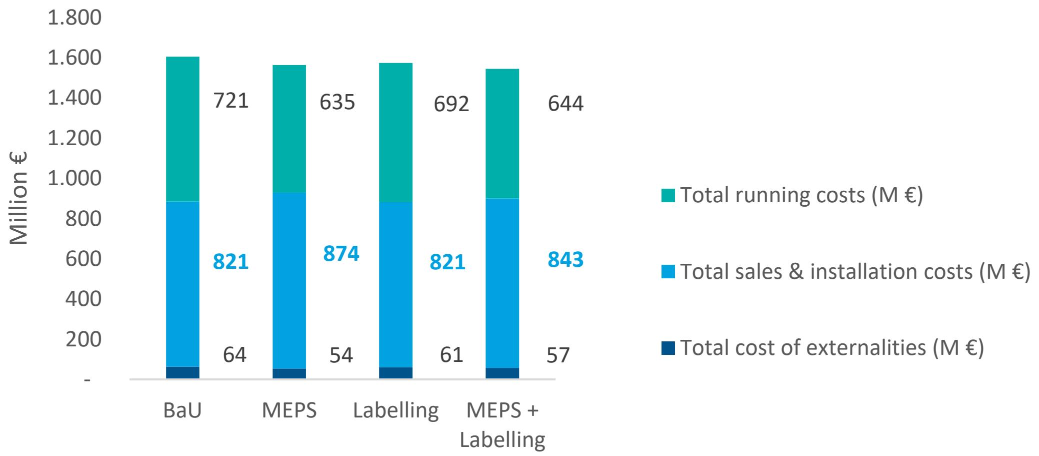


Figure 7.20 Breakdown of the total costs attributed to Hand Dryer Stocks in the EU in 2030 – Higher purchase prices (Million €, net of inflation)



7.4.3 Primary Energy Factor

The Primary Energy Factor (PEF) indicates how much primary energy is used to generate a unit of electricity. In the model, the default PEF is 2.1, meaning that 2.1 MWh of primary energy are used to generate each 1 MWh of electricity used.

Whilst a lower PEF – of 1.6 – will reduce the annual primary energy savings created in the MEPS + Labelling scenario by 23%, a higher PEF – of 2.5 – will increase the annual primary energy savings by 20%.

Table 7.42 Total annual primary energy consumption in the EU – Lower PEF (TWh/year)

Annual primary energy consumption (TWh/year)	2020	2025	2030	2035	2040	2045	2050
BaU	5.14	5.08	5.15	5.19	5.14	4.99	4.73
MEPS	5.14	4.97	4.36	3.84	3.82	3.92	3.96
Labelling	5.14	5.07	4.89	4.69	4.50	4.32	4.09
MEPS + Labelling	5.14	4.97	4.26	3.59	3.44	3.44	3.43

Table 7.43 Total annual primary energy savings in the EU – Lower PEF (TWh/year)

Annual primary energy savings (TWh/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	0.11	0.78	1.35	1.32	1.07	0.77
Labelling	-	0.01	0.25	0.50	0.63	0.67	0.64
MEPS + Labelling	-	0.11	0.89	1.60	1.70	1.55	1.30

Figure 7.21 Total annual primary energy consumption in the EU – Lower PEF (TWh/year)

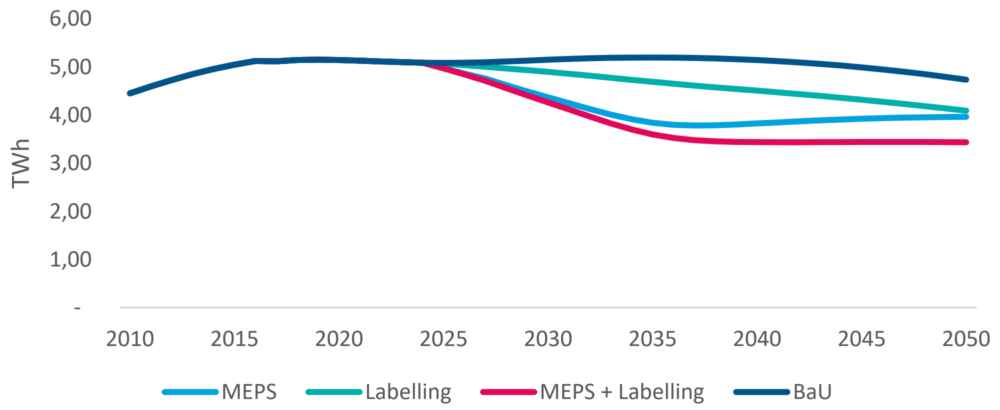


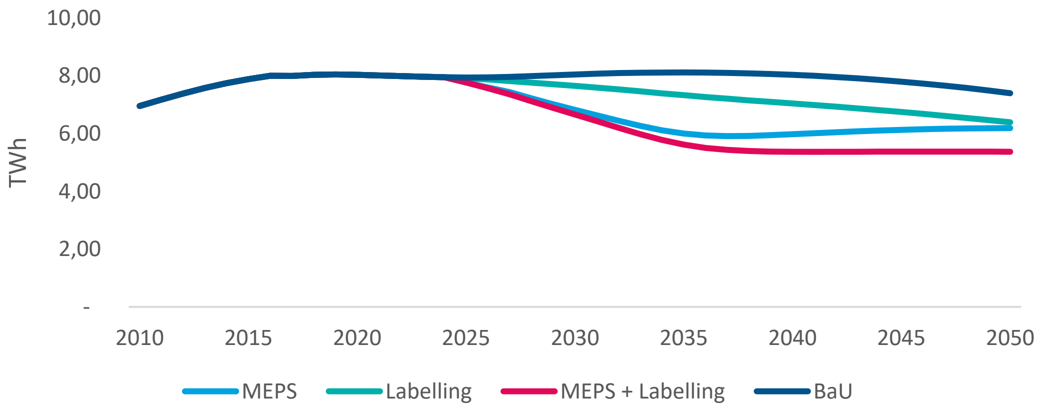
Table 7.44 Total annual primary energy consumption in the EU – Higher PEF (TWh/year)

Annual primary energy consumption (TWh/year)	2020	2025	2030	2035	2040	2045	2050
BaU	8.03	7.94	8.04	8.11	8.03	7.79	7.40
MEPS	8.03	7.76	6.82	6.00	5.97	6.13	6.19
Labelling	8.03	7.92	7.65	7.33	7.04	6.74	6.39
MEPS + Labelling	8.03	7.76	6.66	5.62	5.37	5.37	5.37

Table 7.45 Total annual primary energy savings in the EU – Higher PEF (TWh/year)

Annual primary energy savings (TWh/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	0.17	1.22	2.11	2.06	1.67	1.21
Labelling	-	0.02	0.40	0.79	0.99	1.05	1.01
MEPS + Labelling	-	0.17	1.39	2.50	2.66	2.42	2.03

Figure 7.22 Total annual primary energy savings in the EU – Higher PEF (TWh/year)



7.4.4 Cost of Externalities

Recent research suggests that the default societal cost rates in the MEErP and the EcoReport template might be outdated and underestimated. Specifically, the Environmental Prices Handbook published in 2017 by CE Delft proposes environmental prices as external costs to be used in Life Cycle Assessments.

To understand what would be the effect of using more recent rates for externalities on the economic impacts, the marginal societal costs of environmental impacts which were adjusted based on the Environmental Prices Handbook as presented in Table 7.46.

Table 7.46 External marginal cost to society rates – EcoReport Default vs. Environmental Prices Handbook

	Rate external marginal costs to society (€)		
Environmental Impact	**EcoReport Default**	**Environmental Prices Handbook**	**Unit**
GHG	0.014	0.057	€/kg CO2 eq.
Acidification	0.0085	0.0054	€/g SO2 eq.
Volatile Organic Coumpounds	0.00076	0.0021	€/g
Particulate Matter	0.01546	0.069	€/g

Using these rates in the model, leads to an 10% increase to the annual cost savings estimated for 2030 in the MEPS + Labelling scenario. Figure 7.23 shows how the increased purchase prices affect the split of total costs in 2030, with the cost of externalities corresponding to an increased fraction of the total cost.

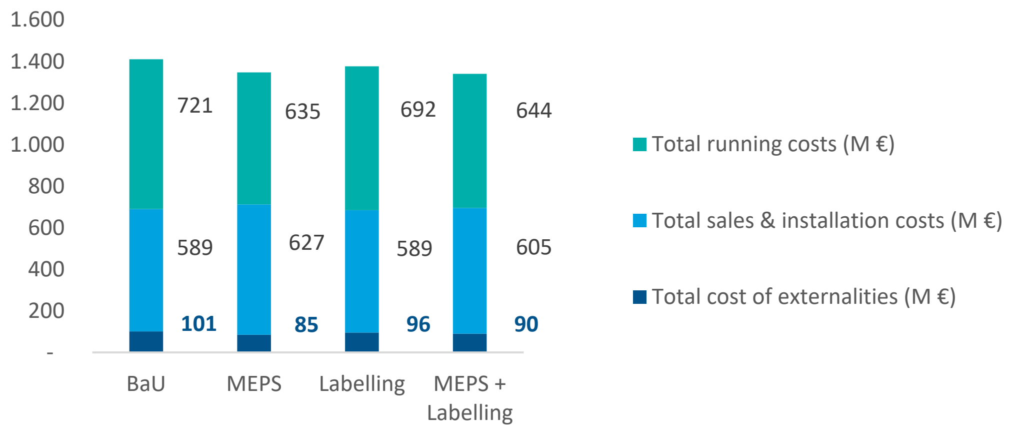
Table 7.47 Total annual costs in the EU – Updated externalities' costs (Million €, net of inflation)

Annual costs (Million €)	2020	2025	2030	2035	2040	2045	2050
BaU	1,214	1,309	1,410	1,515	1,593	1,658	1,716
MEPS	1,214	1,331	1,347	1,359	1,436	1,532	1,624
Labelling	1,214	1,308	1,376	1,448	1,509	1,570	1,633
MEPS + Labelling	1,214	1,331	1,333	1,327	1,385	1,469	1,557

Table 7.48 Total annual savings in the EU – Updated externalities' costs (Million €, net of inflation)

Annual savings (Million €/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	-22	63	156	156	126	92
Labelling	-	2	33	67	84	87	83
MEPS + Labelling	-	-22	77	188	208	189	159

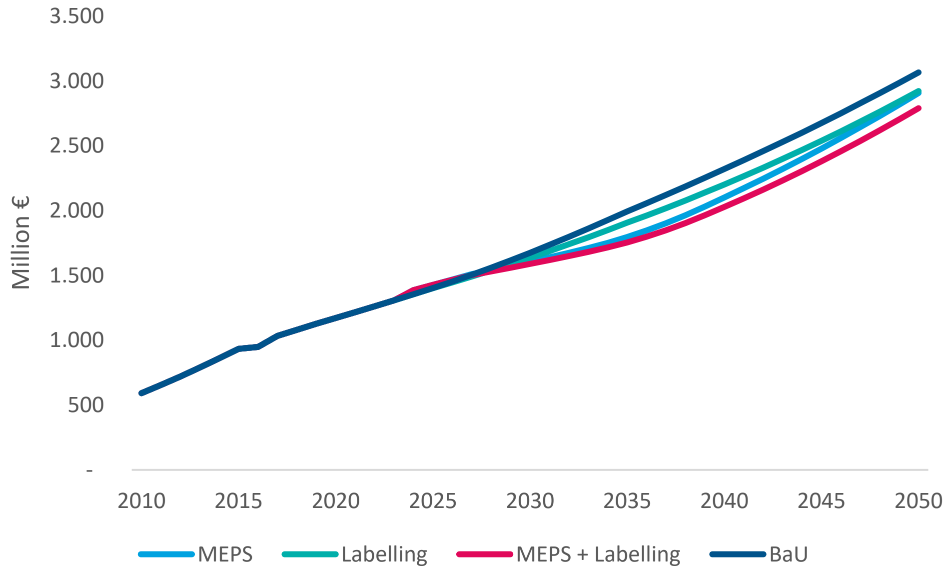
Figure 7.23 Breakdown of the total costs attributed to Hand Dryer Stocks in the EU in 2030 – Updated externalities' costs (Million €, net of inflation)



7.4.5 Annual Inflation Rate

The default inflation rate from the MEErP of 4% is used in the model. However, there is evidence suggesting that this rate can be overestimated. Figure 7.24 presents the inflated costs when the inflation is reduced by 50% to a 2% figure. Although there is no significant change to the trends presented in the graph and the difference between the scenarios, the absolute nominal value of costs decreases significantly in the period for all scenarios.

Figure 7.24 Total annual costs in the EU (Million €, inflated) – Adjusted to a Forecast of 2% per annum increase



7.4.6 Number of cycles per day

The resource use and environmental impacts presented in Section 7.2.2 are very sensitive to the average number of cycles per day of hand-dryers because most of the energy savings created in the policy scenarios are a result of the associated lower electricity consumption.

Discussions with stakeholders and data from previous tasks suggests that the 150 assumed average cycles per day figure might be underestimated. Thus, a higher figure was calculated, assuming a more intensive use of hand dryers to analyse the sensitivity of key outputs.

The revised figure estimated for this analysis was a 361 cycles/day average, calculated by assuming that 80% of products have a 163 cycles/day usage, 15% of products have a medium 750 cycles/day usage, and the remaining 5% a high 2,355 usage.

The increased usage intensity leads to a 132% increase to the annual primary energy savings and a consequent 207% increase to the total cost savings in 2030 in the MEPS + Labelling scenario.

Table 7.49 Total annual primary energy savings in the EU – Higher number of cycles/day (TWh/year)

Annual primary energy savings (TWh/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	0.33	2.36	4.11	4.03	3.30	2.40
Labelling	-	0.04	0.79	1.56	1.97	2.08	2.00
MEPS + Labelling	-	0.33	2.69	4.86	5.19	4.70	3.92

Table 7.50 Total annual final energy savings in the EU – Higher number of cycles/day (TWh/year)

Annual final energy savings (TWh/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	0.16	1.13	1.96	1.92	1.57	1.14
Labelling	-	0.02	0.37	0.74	0.94	0.99	0.95
MEPS + Labelling	-	0.16	1.28	2.32	2.47	2.24	1.87

Table 7.51 Total cost savings in the EU – Higher number of cycles/day (Million €/year, net of inflation)

Annual savings (Million €/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	-5	184	372	370	300	218
Labelling	-	4	75	151	189	197	188
MEPS + Labelling	-	-5	215	445	481	433	360

Figure 7.25 Total annual primary energy consumption in the EU – Higher number of cycles/day (TWh/year)

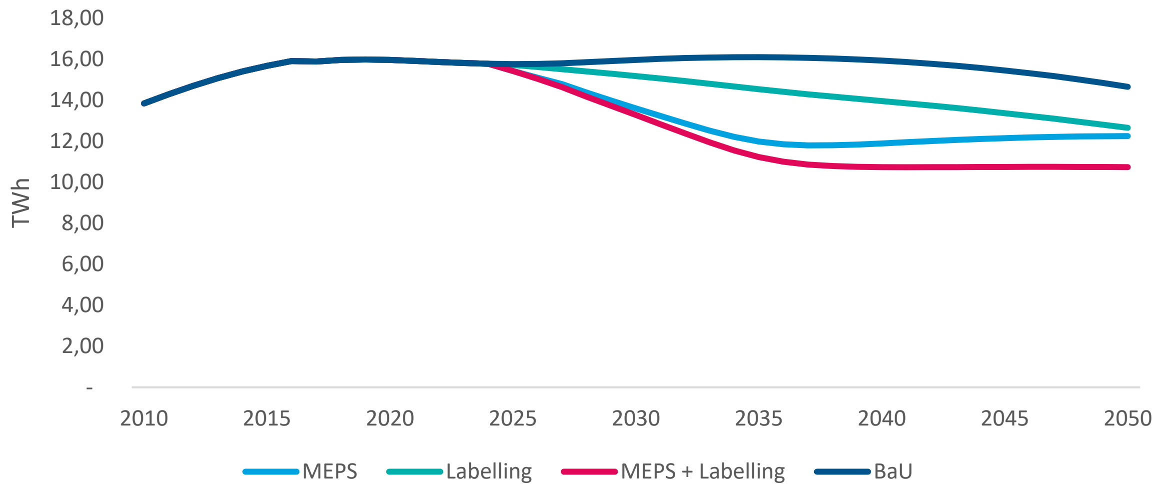


Figure 7.26 Total cost savings in the EU – Higher number of cycles/day (Million €/year, net of inflation)

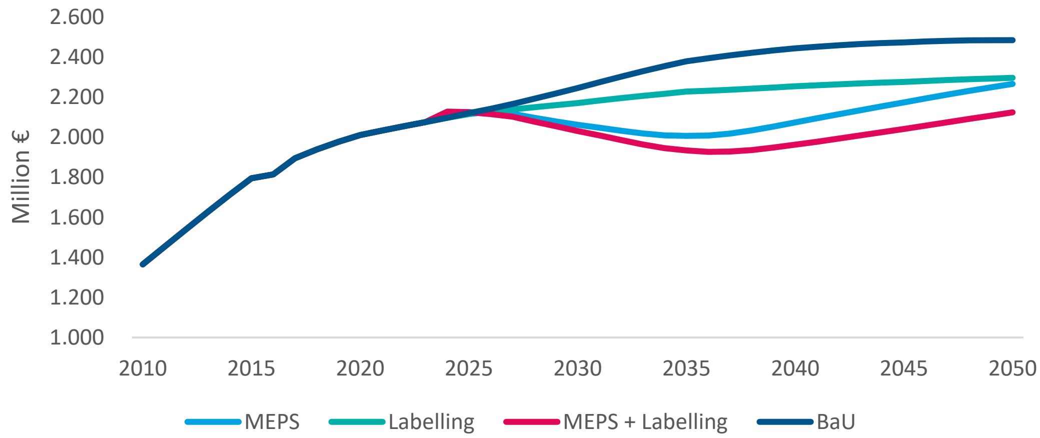


Table 7.52 presents the annual cost savings when the higher number of cycles per day is combined with the updated externalities costs as per Section 7.4.4, bringing a 229% increase to cost savings accrued in 2030 when comparing to the scenarios modelled in Sections 7.2 and 7.3.

Table 7.52 Total cost savings in the EU – Higher number of cycles/day and Updated externalities cost (Million €/year, net of inflation)

Annual savings (Million €/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	-3	197	393	389	314	227
Labelling	-	4	79	159	198	206	195
MEPS + Labelling	-	-3	229	470	505	453	375

7.5 SUMMARY

This section provides a summary of the work undertaken in the above sub-tasks and an overview of the policy options investigated. It includes a summary of the annual and accumulative scenario outcomes for 2030 and 2050 and a consideration of possible negative impacts on competitiveness, employment, trade, health and safety.

7.5.1 Policy Scenarios

The following policy scenarios were proposed in Section 7.2:

- **Minimum Energy Performance Standards (MEPS)** – Implementation of minimum performance standards for hand dryers sold in the EU, as described in Section 7.1.4. This regulation aims at removing worst performing products from the market. The proposed measures cover:
    - Standby power consumption
    - Sensor use
    - Run-on time
    - Energy consumption
    - Heating elements
    - Circular economy aspects
    - Improved design
    - Use of Critical Raw Materials
- **Labelling** – Implementation of a labelling scheme to rank hand dryers by their energy performance compared to the average performance on the market, as described in Section 7.1.5. This regulation aims at incentivising consumers to buy more efficient products.
- **MEPS + Labelling** – A combined policy scenario in which both the MEPS and the energy label are implemented. This is the most ambitious policy scenario for the three considered.

Resource use and environmental impacts of these scenarios have been modelled and compared to the business-as-usual (BaU) scenario in Section 7.2. A similar analysis was presented in Section 7.3 for the socio-economic impacts. The key results are summarised below in Section 7.5.2.

7.5.2 Key Results

7.5.2.1 Energy Consumption

Figure 7.27 presents the annual primary energy consumption of hand dryers in the EU between 2010 and 2050 for the different scenarios. Table 7.53 and Table 7.54 present annual and cumulative primary energy savings accrued when implementing the proposed policies.

In the BaU scenario, the energy consumption remains roughly steady between 2020 and 2050 ranging between 6.2 TWh/ year and 6.8 TWh/ year over the period, as the market transitions from conventional to high-speed products (which tend to be more efficient).

The MEPS scenario is more ambitious than the Labelling scenario in the short and medium-term. As the average electricity consumption in the BaU scenario catches up with the MEPS, less annual savings begin to be accrued and the distance between these two curves decreases over time.

The MEPS + Labelling scenario is the more ambitious, reducing annual primary energy consumption by 17% in 2030 and 27% in 2050 compared to the BaU scenario. Cumulative energy savings accrued in this scenario add up to 3.81 TWh by 2030 and reach 43.66 TWh by 2050.

Figure 7.27 Total annual primary energy consumption in the EU (TWh/year)

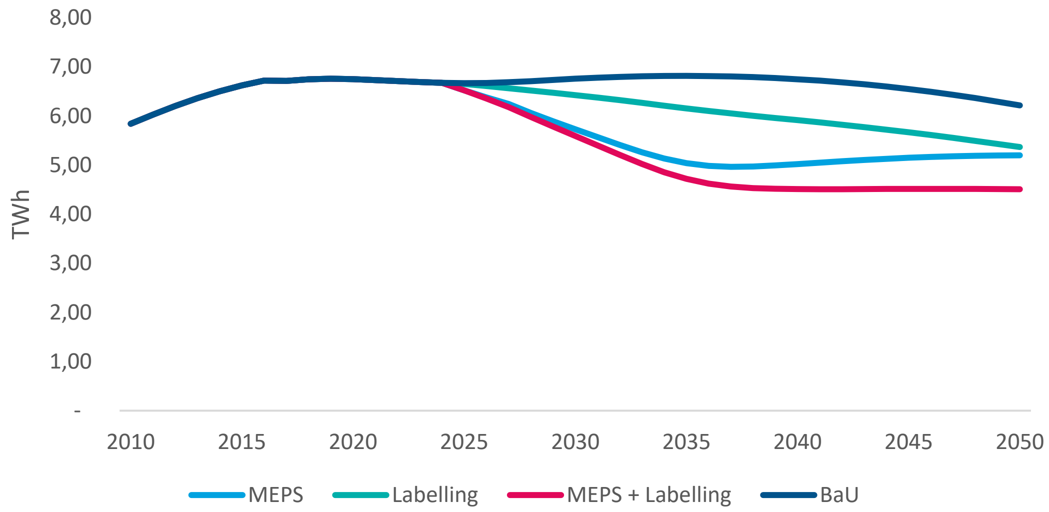


Table 7.53 Total annual primary energy savings in the EU (TWh/year)

Annual primary energy savings (TWh/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	0.15	1.03	1.78	1.73	1.40	1.02
Labelling	-	0.02	0.33	0.66	0.83	0.88	0.85
MEPS + Labelling	-	0.15	1.16	2.10	2.24	2.03	1.70

Table 7.54 Total cumulative primary energy savings in the EU (TWh)

Cumulative primary energy savings (TWh)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	0.15	3.40	10.99	19.98	27.67	33.54
Labelling	-	0.02	0.99	3.67	7.57	11.91	16.25
MEPS + Labelling	-	0.15	3.81	12.62	23.80	34.43	43.66

7.5.2.2 GHG Emissions

Figure 7.28 presents the annual GHG emissions generated by the electricity consumption (use phase) and the disposal (end-of-life phase) of hand dryers in the EU between 2010 and 2050 for the different scenarios. Table 7.55 and Table 7.56 present annual and cumulative emissions savings accrued when implementing the proposed policies.

In the BaU scenario, GHG emissions reduce over time mostly because the GWP EU average electricity generating mix emissions factor is assumed to go down in the future, as the EU28 transitions to a low carbon economy and increasingly produces electricity from renewables.

Still, all policy scenarios modelled bring emission savings against the BaU, with annual GHG emissions being reduced by 17% and 28% in 2030 and 2050 respectively in the MEPs + Labelling scenario. Cumulative GHG emission savings accrued in this scenario add up to 4.33 MtCO2e by 2030, and reach 13.46 MtCO2e by 2050.

Figure 7.28 Total annual GHG emissions in the EU (MtCO2e/year)

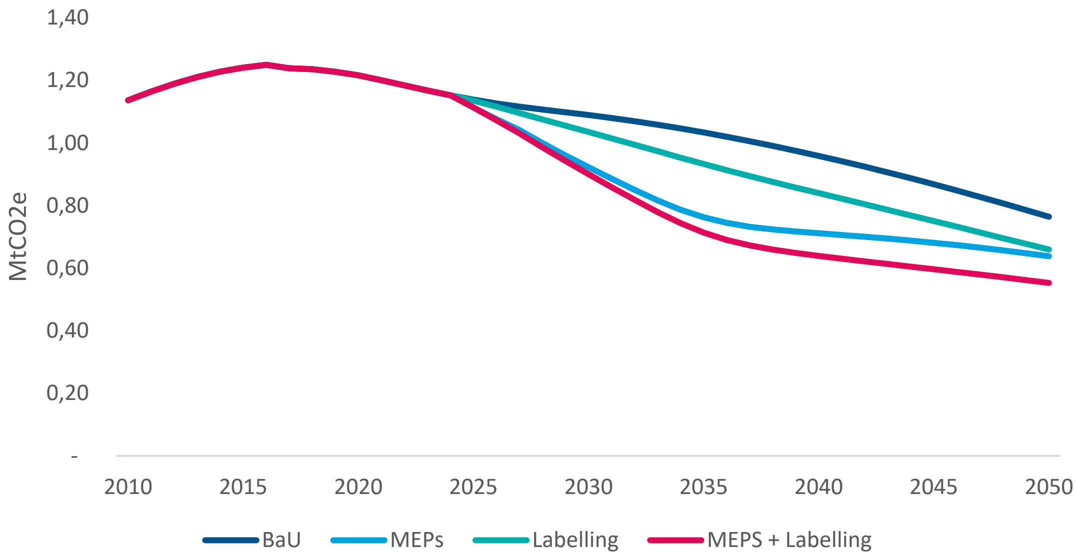


Table 7.55 Total annual GHG savings in the EU (MtCO2e/year)

Annual GHG emission savings (MtCO2e/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	0.03	0.17	0.27	0.25	0.19	0.13
Labelling	-	0.00	0.05	0.10	0.12	0.12	0.10
MEPS + Labelling	-	0.03	0.19	0.32	0.32	0.27	0.21

Table 7.56 Total cumulative GHG savings in the EU (MtCO2e)

Cummulative GHG emission savings (MtCO2e)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	0.03	0.56	1.75	3.07	4.12	4.87
Labelling	-	0.03	0.72	2.33	4.22	5.87	7.18
MEPS + Labelling	-	0.05	1.35	4.33	7.86	10.97	13.46

7.5.2.3 Costs

Figure 7.29 presents the total annual cost of hand dryers in the EU between 2010 and 2050 for the different scenarios, including the purchase and installation costs, running costs and the societal cost of externalities. Table 7.57 and Table 7.58 present annual and cumulative cost savings accrued when implementing the proposed policies.

Between 2024 and 2027, the increased purchase prices lead to greater annual costs in the MEPS and MEPS + Labelling scenario. However, after 2028 the energy savings caused by the implementation of the policies begins to create cost savings and total cost is reduced by 5% in 2030 and 9% in 2050 in the MEPS + Labelling scenario versus BaU. Cumulative cost savings accrued in this scenario add up to € 78 Million by 2030, and reach € 3.5 Billion by 2050.

Figure 7.29 Total annual costs in the EU (Million €, net of inflation)

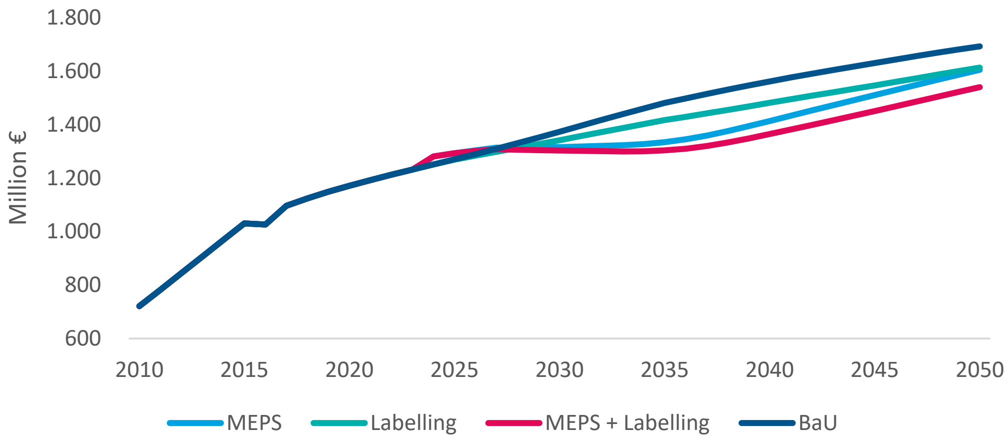


Table 7.57 Total annual cost savings in the EU (Million €/year, net of inflation)

Annual savings (Million €/year)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	-23	57	146	148	120	88
Labelling	-	2	32	64	80	84	79
MEPS + Labelling	-	-23	70	177	197	180	152

Table 7.58 Total cumulative cost savings in the EU (Million €, net of inflation)

Cummulative savings (Million €)	2020	2025	2030	2035	2040	2045	2050
MEPS	-	-53	39	609	1,373	2,031	2,536
Labelling	-	2	93	351	727	1,141	1,549
MEPS + Labelling	-	-53	78	765	1,739	2,679	3,500

7.5.3 Additional Information

The data gathered for this preparatory study indicates that there is not a simple relation between the price of products and their performance in terms of energy use. Efficient cheap products and relatively inefficient expensive products currently exist on the market. Furthermore, due to the lack of data regarding production costs, turnover/employee, margins and overhead, it was not possible to model the detailed effect of the different policy scenarios with regard to more granular socio-economic aspects.

All of the proposed policy scenarios should contribute towards creating energy, emissions and cost savings in the long-term by removing poorer-performing products from the market. While the model assumes that these products are merely substituted by similar products (i.e. more efficient dryers within the same price range), manufacturers have argued that the proposed measures could decrease the sales of hand dryers, if some technology transfer occurs, and i.e., if instead some consumers chose to buy cheaper purchase price alternatives (e.g. paper towels). Section 7.3.3 has already made reference to the complexities surrounding this issue, which lie outside the scope of the present Ecodesign and Energy Labelling Preparatory Study.

Currently, the market is mostly made of SME companies with small market shares. There is no evidence to indicate that the policy scenarios proposed will have a significant effect to this configuration.

7.5.4 Harmonised Standard

In order for the proposed policy measures to be successfully implemented there is a need for a harmonised testing standard for measuring the energy consumption of a hand dryer in order to achieve a remaining moisture content target (0.25g) over a defined period of time.

The existence of such a standard is assumed as a necessary precursor for the implementation of the energy consumption MEPS and associated Energy Label classification. Consequently, it is recommended that the European Commission issue a mandate to the European Standards Organisations, in order to expedite the delivery of this harmonised testing standard(s). Detailed information on the existing measurement standards have been described in Task 1 of this Preparatory Study.

Such a harmonised standard would help to ensure that manufacturers declared consistent information to users and public procurers; it would also importantly ensure a consistent playing field for SMEs and other manufacturers.

Annex 1 Task 7 Energy consumption

Table A1.1 BaU scenario annual emissions (Use + EoL phases)

Annual energy consumption	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Category 1	2.32	2.25	2.19	2.14	2.09	2.06	2.03	2.00	1.98	1.96	1.94	1.91	1.89	1.86	1.83	1.80	1.76	1.73	1.69	1.65	1.60	1.56	1.51	1.45	1.40	1.34	1.29	1.22	1.16	1.09	1.02
Category 2	0.46	0.49	0.53	0.55	0.58	0.61	0.63	0.66	0.68	0.71	0.73	0.76	0.78	0.81	0.83	0.86	0.88	0.91	0.93	0.96	0.98	1.01	1.03	1.06	1.08	1.11	1.13	1.16	1.19	1.21	1.24
Category 3	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Category 4	0.35	0.37	0.39	0.40	0.41	0.42	0.43	0.43	0.44	0.45	0.45	0.46	0.47	0.48	0.49	0.49	0.50	0.51	0.51	0.52	0.53	0.54	0.54	0.55	0.56	0.56	0.57	0.58	0.58	0.59	0.60
All hand dryers	3.21	3.20	3.19	3.19	3.18	3.17	3.18	3.18	3.19	3.21	3.22	3.23	3.24	3.24	3.24	3.24	3.24	3.24	3.23	3.22	3.21	3.20	3.18	3.16	3.14	3.12	3.09	3.06	3.03	3.00	2.96
Annual primary energy consumption	6.75	6.73	6.71	6.69	6.67	6.67	6.67	6.68	6.71	6.73	6.76	6.78	6.79	6.81	6.81	6.81	6.81	6.80	6.79	6.77	6.75	6.72	6.68	6.64	6.60	6.55	6.49	6.43	6.36	6.29	6.21

Table A1.2 MEPS scenario Annual energy consumption (TWh/year)

Annual energy consumption	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Category 1	2.32	2.25	2.19	2.14	2.09	2.00	1.89	1.78	1.65	1.52	1.40	1.27	1.14	1.02	0.91	0.82	0.74	0.69	0.65	0.62	0.59	0.57	0.55	0.53	0.51	0.49	0.47	0.45	0.42	0.40	0.37
Category 2	0.46	0.49	0.53	0.55	0.58	0.60	0.63	0.67	0.71	0.76	0.80	0.85	0.89	0.93	0.97	1.01	1.04	1.08	1.11	1.13	1.16	1.18	1.21	1.23	1.25	1.27	1.29	1.31	1.33	1.35	1.37
Category 3	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.11
Category 4	0.35	0.37	0.39	0.40	0.41	0.42	0.42	0.43	0.43	0.43	0.44	0.45	0.46	0.47	0.47	0.48	0.49	0.51	0.52	0.53	0.54	0.55	0.56	0.57	0.58	0.59	0.59	0.60	0.61	0.62	0.62
All hand dryers	3.21	3.20	3.19	3.19	3.18	3.11	3.04	2.97	2.89	2.81	2.73	2.65	2.58	2.51	2.44	2.40	2.37	2.36	2.37	2.38	2.39	2.40	2.42	2.43	2.44	2.45	2.46	2.47	2.47	2.47	2.47
Annual primary energy consumption	6.75	6.73	6.71	6.69	6.67	6.52	6.38	6.24	6.06	5.89	5.73	5.57	5.41	5.26	5.13	5.04	4.98	4.96	4.97	4.99	5.02	5.05	5.08	5.10	5.13	5.15	5.16	5.18	5.19	5.19	5.20
Annual primary energy savings	-	-	-	-	-	0.15	0.29	0.44	0.65	0.84	1.03	1.21	1.38	1.55	1.68	1.78	1.83	1.84	1.82	1.78	1.73	1.67	1.61	1.54	1.47	1.40	1.33	1.25	1.18	1.10	1.02
Cumulative energy savings	-	-	-	-	-	0.15	0.44	0.88	1.53	2.37	3.40	4.61	5.99	7.53	9.22	10.99	12.82	14.66	16.48	18.26	19.98	21.65	23.26	24.80	26.27	27.67	29.00	30.25	31.43	32.52	33.54

Table A1.3 Labelling scenario Annual energy consumption (TWh/year)

Annual energy consumption	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Category 1	2.32	2.25	2.19	2.14	2.09	2.05	2.01	1.97	1.92	1.88	1.84	1.80	1.75	1.70	1.64	1.59	1.54	1.49	1.43	1.38	1.33	1.28	1.23	1.17	1.12	1.06	1.01	0.95	0.89	0.83	0.77
Category 2	0.46	0.49	0.53	0.55	0.58	0.61	0.63	0.64	0.66	0.68	0.70	0.71	0.73	0.75	0.77	0.79	0.82	0.84	0.86	0.88	0.91	0.93	0.95	0.98	1.00	1.02	1.05	1.07	1.09	1.12	1.14
Category 3	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10
Category 4	0.35	0.37	0.39	0.40	0.41	0.42	0.42	0.43	0.43	0.43	0.43	0.44	0.44	0.45	0.45	0.46	0.46	0.47	0.47	0.48	0.49	0.49	0.50	0.51	0.51	0.52	0.52	0.53	0.54	0.54	0.55
All hand dryers	3.21	3.20	3.19	3.19	3.18	3.17	3.15	3.13	3.10	3.08	3.06	3.03	3.01	2.98	2.96	2.93	2.90	2.88	2.86	2.84	2.82	2.79	2.77	2.75	2.72	2.70	2.67	2.64	2.62	2.59	2.56
Annual primary energy consumption	6.75	6.73	6.71	6.69	6.67	6.65	6.61	6.56	6.52	6.47	6.42	6.37	6.32	6.26	6.21	6.15	6.10	6.05	6.00	5.96	5.91	5.87	5.82	5.77	5.72	5.67	5.61	5.55	5.49	5.43	5.37
Annual primary energy savings	-	-	-	-	-	0.02	0.06	0.12	0.19	0.26	0.33	0.40	0.47	0.54	0.60	0.66	0.71	0.75	0.79	0.81	0.83	0.85	0.86	0.87	0.88	0.88	0.88	0.88	0.87	0.86	0.85
Cumulative primary energy savings	-	-	-	-	-	0.02	0.08	0.20	0.39	0.65	0.99	1.39	1.87	2.41	3.01	3.67	4.39	5.14	5.92	6.73	7.57	8.42	9.28	10.15	11.03	11.91	12.79	13.67	14.54	15.40	16.25

Table A1.4 MEPS + Labelling scenario Annual energy consumption (TWh/year)

Annual energy consumption	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Category 1	2.32	2.25	2.19	2.14	2.09	2.00	1.89	1.77	1.64	1.51	1.38	1.25	1.13	1.00	0.89	0.79	0.72	0.66	0.62	0.58	0.56	0.53	0.51	0.48	0.46	0.44	0.42	0.39	0.37	0.34	0.32
Category 2	0.46	0.49	0.53	0.55	0.58	0.60	0.62	0.65	0.69	0.73	0.76	0.79	0.82	0.85	0.88	0.90	0.92	0.95	0.97	0.99	1.00	1.02	1.04	1.06	1.07	1.09	1.11	1.12	1.14	1.16	1.17
Category 3	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Category 4	0.35	0.37	0.39	0.40	0.41	0.42	0.42	0.42	0.42	0.43	0.43	0.44	0.44	0.45	0.46	0.47	0.47	0.48	0.49	0.49	0.50	0.50	0.51	0.52	0.52	0.53	0.54	0.54	0.55	0.56	0.56
All hand dryers	3.21	3.20	3.19	3.19	3.18	3.11	3.03	2.94	2.85	2.75	2.66	2.57	2.48	2.39	2.31	2.25	2.20	2.17	2.16	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
Annual primary energy consumption	6.75	6.73	6.71	6.69	6.67	6.52	6.35	6.18	5.98	5.78	5.59	5.40	5.21	5.02	4.85	4.72	4.62	4.56	4.53	4.52	4.51	4.51	4.51	4.51	4.51	4.51	4.51	4.51	4.51	4.51	4.51
Annual primary energy savings	-	-	-	-	-	0.15	0.32	0.51	0.73	0.95	1.16	1.38	1.59	1.79	1.96	2.10	2.19	2.24	2.26	2.25	2.24	2.21	2.17	2.13	2.09	2.03	1.98	1.92	1.85	1.78	1.70
Cumulative energy savings	-	-	-	-	-	0.15	0.46	0.97	1.70	2.65	3.81	5.19	6.78	8.56	10.52	12.62	14.81	17.05	19.30	21.56	23.80	26.01	28.18	30.31	32.40	34.43	36.41	38.32	40.17	41.95	43.66

Annex 2 Task 7 Environmental Impacts

Table A2.1 BaU scenario annual emissions (Use + EoL phases)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Air emissions																															
Greenhouse Gases in GWP100 (Mt CO2e)	1.22	1.20	1.18	1.17	1.15	1.14	1.13	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.03	1.02	1.01	0.99	0.97	0.96	0.94	0.92	0.91	0.89	0.87	0.85	0.83	0.81	0.79	0.76
Acidification, emissions (kt SO2 eq.)	5.43	5.41	5.40	5.38	5.37	5.36	5.36	5.37	5.39	5.41	5.43	5.45	5.46	5.47	5.47	5.47	5.47	5.46	5.45	5.44	5.42	5.39	5.36	5.33	5.29	5.25	5.21	5.16	5.10	5.04	4.98
Volatile Organic Compounds (VOC) (kt)	0.65	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.64	0.64	0.64	0.63	0.63	0.62	0.62	0.61	0.60	0.59
Persistent Organic Pollutants (POP) (g i-Teq)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Heavy Metals (ton Ni eq.)	0.27	0.27	0.27	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.27	0.27	0.27	0.27	0.27	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.25	0.25	0.25	0.24	0.24	0.24	0.23
PAHs (ton Ni eq.)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05
Particulate Matter (PM, dust) (kt)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.10
Water emissions																															
Heavy Metals (ton Hg/20)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.08
Eutrophication (kt PO4)	5.46	5.45	5.43	5.41	5.40	5.40	5.40	5.41	5.43	5.45	5.47	5.49	5.50	5.51	5.52	5.52	5.51	5.51	5.50	5.48	5.46	5.44	5.41	5.38	5.34	5.30	5.25	5.21	5.15	5.09	5.03

Table A2.2 MEPS scenario annual emissions (Use + EoL phases)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Air emissions																															
Greenhouse Gases in GWP100 (Mt CO2e)	1.22	1.20	1.18	1.17	1.15	1.11	1.08	1.04	1.00	0.96	0.92	0.89	0.85	0.82	0.79	0.76	0.74	0.73	0.72	0.72	0.71	0.71	0.70	0.69	0.69	0.68	0.67	0.66	0.66	0.65	0.64
Acidification, emissions (kt SO2 eq.)	5.43	5.41	5.40	5.38	5.37	5.24	5.12	5.01	4.87	4.73	4.59	4.46	4.34	4.21	4.11	4.03	3.99	3.97	3.97	3.99	4.01	4.04	4.06	4.08	4.10	4.12	4.13	4.14	4.15	4.15	4.15
Volatile Organic Compounds (VOC) (kt)	0.65	0.64	0.64	0.64	0.64	0.62	0.61	0.60	0.58	0.56	0.55	0.53	0.52	0.50	0.49	0.48	0.48	0.47	0.48	0.48	0.48	0.48	0.49	0.49	0.49	0.49	0.49	0.50	0.50	0.50	0.50
Persistent Organic Pollutants (POP) (g i-Teq)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04
Heavy Metals (ton Ni eq.)	0.27	0.27	0.27	0.26	0.26	0.26	0.25	0.24	0.24	0.23	0.22	0.21	0.20	0.20	0.19	0.19	0.18	0.18	0.18	0.18	0.18	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
PAHs (ton Ni eq.)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Particulate Matter (PM, dust) (kt)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Water emissions																															
Heavy Metals (ton Hg/20)	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.09	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06
Eutrophication (kt PO4)	5.46	5.45	5.43	5.41	5.40	5.28	5.16	5.05	4.91	4.77	4.64	4.51	4.38	4.26	4.15	4.08	4.03	4.02	4.02	4.04	4.06	4.09	4.11	4.13	4.15	4.17	4.18	4.19	4.20	4.20	4.21

Table A2.3 Labelling scenario annual emissions (Use + EoL phases)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Air emissions																															
Greenhouse Gases in GWP100 (Mt CO2e)	1.22	1.20	1.18	1.17	1.15	1.13	1.12	1.10	1.07	1.05	1.03	1.01	0.99	0.97	0.95	0.93	0.91	0.89	0.88	0.86	0.84	0.82	0.80	0.79	0.77	0.75	0.73	0.71	0.70	0.68	0.66
Acidification, emissions (kt SO2 eq.)	5.43	5.41	5.40	5.38	5.37	5.35	5.31	5.28	5.24	5.20	5.16	5.12	5.08	5.03	4.98	4.94	4.90	4.85	4.82	4.78	4.74	4.70	4.67	4.62	4.58	4.54	4.49	4.45	4.40	4.35	4.29
Volatile Organic Compounds (VOC) (kt)	0.65	0.64	0.64	0.64	0.64	0.64	0.63	0.63	0.62	0.62	0.61	0.61	0.60	0.60	0.59	0.59	0.58	0.58	0.57	0.57	0.57	0.56	0.56	0.55	0.55	0.54	0.54	0.53	0.53	0.52	0.51
Persistent Organic Pollutants (POP) (g i-Teq)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Heavy Metals (ton Ni eq.)	0.27	0.27	0.27	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.25	0.25	0.25	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.22	0.22	0.22	0.22	0.21	0.21	0.21	0.21	0.20	0.20	0.20
PAHs (ton Ni eq.)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04
Particulate Matter (PM, dust) (kt)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Water emissions																															
Heavy Metals (ton Hg/20)	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07
Eutrophication (kt PO4)	5.46	5.45	5.43	5.41	5.40	5.38	5.35	5.31	5.27	5.24	5.20	5.16	5.12	5.07	5.03	4.98	4.94	4.90	4.86	4.82	4.79	4.75	4.71	4.67	4.63	4.59	4.54	4.49	4.45	4.40	4.34

Table A2.4 MEPS + Labelling scenario annual emissions (Use + EoL phases)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Air emissions																															
Greenhouse Gases in GWP100 (Mt CO2e)	1.22	1.20	1.18	1.17	1.15	1.11	1.07	1.03	0.99	0.94	0.90	0.86	0.82	0.78	0.74	0.71	0.69	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.60	0.59	0.58	0.57	0.56	0.55
Acidification, emissions (kt SO2 eq.)	5.43	5.41	5.40	5.38	5.37	5.24	5.10	4.96	4.80	4.64	4.48	4.33	4.17	4.02	3.88	3.77	3.69	3.65	3.62	3.61	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60
Volatile Organic Compounds (VOC) (kt)	0.65	0.64	0.64	0.64	0.64	0.62	0.61	0.59	0.57	0.55	0.54	0.52	0.50	0.48	0.46	0.45	0.44	0.44	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
Persistent Organic Pollutants (POP) (g i-Teq)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Heavy Metals (ton Ni eq.)	0.27	0.27	0.27	0.26	0.26	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.20	0.19	0.18	0.17	0.17	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
PAHs (ton Ni eq.)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Particulate Matter (PM, dust) (kt)	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.09	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Water emissions																															
Heavy Metals (ton Hg/20)	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05
Eutrophication (kt PO4)	5.46	5.45	5.43	5.41	5.40	5.28	5.14	5.00	4.84	4.68	4.53	4.37	4.22	4.06	3.93	3.82	3.74	3.69	3.67	3.66	3.65	3.65	3.65	3.65	3.65	3.65	3.65	3.65	3.65	3.65	3.65

Table A2.5 GHG emission savings (Use + EoL phases)

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Annual GHG emission savings (MtCO2e)																										
MEPS	0.03	0.05	0.07	0.11	0.14	0.17	0.19	0.22	0.24	0.26	0.27	0.28	0.27	0.27	0.26	0.25	0.24	0.22	0.21	0.20	0.19	0.17	0.16	0.15	0.14	0.13
Labelling	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.08	0.08	0.09	0.10	0.11	0.11	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.10
MEPS + Labelling	0.03	0.05	0.09	0.12	0.16	0.19	0.22	0.25	0.28	0.30	0.32	0.33	0.33	0.33	0.33	0.32	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.24	0.22	0.21
Cumulative GHG emission savings (MtCO2e)																										
MEPS	0.03	0.08	0.15	0.26	0.39	0.56	0.75	0.97	1.22	1.48	1.75	2.02	2.29	2.56	2.82	3.07	3.30	3.53	3.74	3.94	4.12	4.30	4.46	4.61	4.75	4.87
Labelling	0.03	0.09	0.18	0.32	0.50	0.72	0.98	1.28	1.60	1.96	2.33	2.71	3.09	3.48	3.85	4.22	4.57	4.92	5.25	5.57	5.87	6.16	6.44	6.70	6.94	7.18
MEPS + Labelling	0.05	0.17	0.35	0.61	0.94	1.35	1.83	2.38	2.98	3.64	4.33	5.04	5.76	6.47	7.18	7.86	8.53	9.17	9.80	10.40	10.97	11.52	12.05	12.55	13.02	13.46

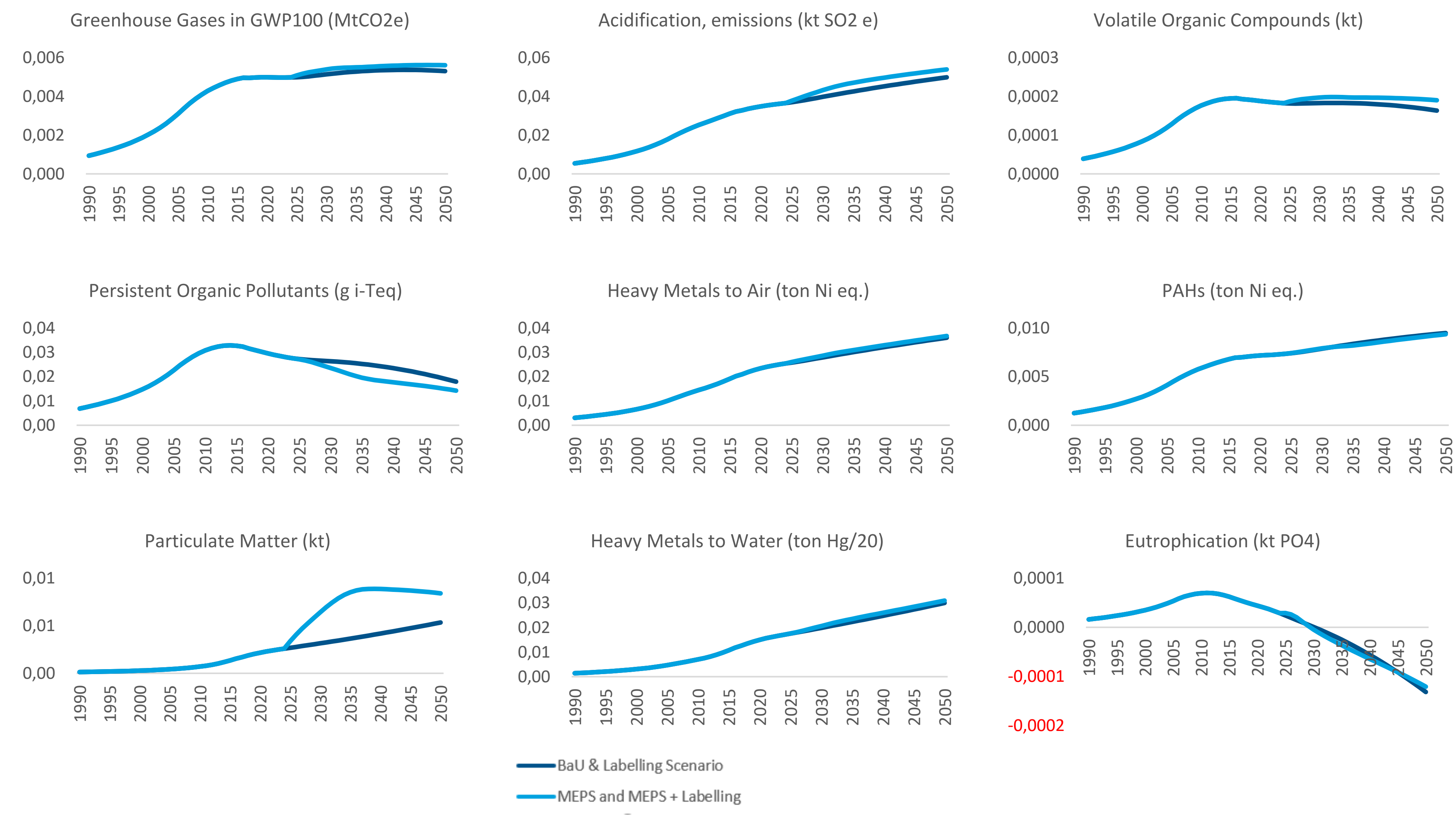
Table A2.6 BaU & Labelling scenarios End of life net emission savings

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Air emissions																															
Greenhouse Gases in GWP100 (Mt CO2e)	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Acidification, emissions (kt SO2 eq.)	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Volatile Organic Compounds (VOC) (kt)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Persistent Organic Pollutants (POP) (g i-Teq)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Heavy Metals (ton Ni eq.)	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
PAHs (ton Ni eq.)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Particulate Matter (PM, dust) (kt)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Water emissions																															
Heavy Metals (ton Hg/20)	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Eutrophication (kt PO4)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00

Table A2.7 MEPS & MEPS + Labelling scenarios End of life net emission savings

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Air emissions																															
Greenhouse Gases in GWP100 (Mt CO2e)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Acidification, emissions (kt SO2 eq.)	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Volatile Organic Compounds (VOC) (kt)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Persistent Organic Pollutants (POP) (g i-Teq)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
Heavy Metals (ton Ni eq.)	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
PAHs (ton Ni eq.)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Particulate Matter (PM, dust) (kt)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Water emissions																															
Heavy Metals (ton Hg/20)	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Eutrophication (kt PO4)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00

Table A2.8 EoL emission savings



Annex 3 Task 7 Costs

Table A3.1 BaU scenario costs (M€, net of inflation)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Purchase price of all sales (M €)	34	37	40	43	46	49	54	59	64	70	75	84	93	102	111	122	129	136	144	151	159	191	223	256	288	321	298	339	345	350	355
Installation cost for all units sold (M €)	18	20	21	23	24	26	29	32	34	37	40	45	49	54	59	64	64	65	66	66	67	72	78	84	89	95	87	98	99	101	102
Cost with repair & maintenance of units in stock (M €)	4	5	5	5	6	6	7	7	8	9	9	10	11	12	13	14	16	17	19	21	23	25	28	32	36	41	47	51	57	61	65
Cost with filter of units in stock (M €)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	1	2	3	4	6	8	11	15	19	23	27	31	34
Cost with electricity of units in stock (M €)	97	104	113	121	131	140	151	162	175	189	204	220	238	259	282	265	296	326	356	385	412	430	448	464	480	494	510	519	531	541	549
Total cost of externalities (M €)	16	17	19	20	21	22	24	25	27	29	31	33	35	38	41	44	48	51	54	56	58	60	61	63	64	65	66	66	66	66	66
Total sales & installation costs (M €)	52	57	61	66	70	75	83	91	99	107	115	128	142	156	169	186	194	201	209	217	225	263	301	339	378	416	384	437	444	451	457
Total running costs (M €)	101	109	118	127	136	147	158	170	183	198	213	230	249	271	295	279	311	344	376	408	438	459	481	504	527	550	576	593	614	633	649
Total with externalities (M €)	170	183	197	212	228	244	264	286	309	333	359	392	427	465	505	509	553	596	639	681	721	782	844	906	969	1,031	1,027	1,096	1,124	1,149	1,172
Total without externalities (M €)	154	166	179	193	207	222	240	261	282	304	328	359	391	427	464	464	505	545	586	625	663	722	783	844	905	965	961	1,031	1,058	1,083	1,106

Table A3.2 MEPS scenario costs (M€, net of inflation)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Purchase price of all sales (M €)	34	37	40	43	46	49	54	59	64	70	75	84	93	102	111	122	129	136	144	151	159	191	223	256	288	321	298	339	345	350	355
Installation cost for all units sold (M €)	18	20	21	23	24	26	29	32	34	37	40	45	49	54	59	64	64	65	66	66	67	72	78	84	89	95	87	98	99	101	102
Cost with repair & maintenance of units in stock (M €)	4	5	5	5	6	6	7	7	8	9	9	10	11	12	13	14	16	17	19	21	23	25	28	32	36	41	47	51	57	61	65
Cost with filter of units in stock (M €)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	1	2	3	4	6	8	11	15	19	23	27	31	34
Cost with electricity of units in stock (M €)	97	104	113	121	131	140	151	162	175	189	204	220	238	259	282	265	296	326	356	385	412	430	448	464	480	494	510	519	531	541	549
Total cost of externalities (M €)	16	17	19	20	21	22	24	25	27	29	31	33	35	38	41	44	48	51	54	56	58	60	61	63	64	65	66	66	66	66	66
Total sales & installation costs (M €)	52	57	61	66	70	75	83	91	99	107	115	128	142	156	169	186	194	201	209	217	225	263	301	339	378	416	384	437	444	451	457
Total running costs (M €)	101	109	118	127	136	147	158	170	183	198	213	230	249	271	295	279	311	344	376	408	438	459	481	504	527	550	576	593	614	633	649
Total with externalities (M €)	170	183	197	212	228	244	264	286	309	333	359	392	427	465	505	509	553	596	639	681	721	782	844	906	969	1,031	1,027	1,096	1,124	1,149	1,172
Total without externalities (M €)	154	166	179	193	207	222	240	261	282	304	328	359	391	427	464	464	505	545	586	625	663	722	783	844	905	965	961	1,031	1,058	1,083	1,106

Table A3.3 Labelling scenario costs (M€, net of inflation)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Purchase price of all sales (M €)	34	37	40	43	46	49	54	59	64	70	75	84	93	102	111	122	129	136	144	151	159	191	223	256	288	321	298	339	345	350	355
Installation cost for all units sold (M €)	18	20	21	23	24	26	29	32	34	37	40	45	49	54	59	64	64	65	66	66	67	72	78	84	89	95	87	98	99	101	102
Cost with repair & maintenance of units in stock (M €)	4	5	5	5	6	6	7	7	8	9	9	10	11	12	13	14	16	17	19	21	23	25	28	32	36	41	47	51	57	61	65
Cost with filter of units in stock (M €)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	1	2	3	4	6	8	11	15	19	23	27	31	34
Cost with electricity of units in stock (M €)	97	104	113	121	131	140	151	162	175	189	204	220	238	259	282	265	296	326	356	385	412	430	448	464	480	494	510	519	531	541	549
Total cost of externalities (M €)	16	17	19	20	21	22	24	25	27	29	31	33	35	38	41	44	48	51	54	56	58	60	61	63	64	65	66	66	66	66	66
Total sales & installation costs (M €)	52	57	61	66	70	75	83	91	99	107	115	128	142	156	169	186	194	201	209	217	225	263	301	339	378	416	384	437	444	451	457
Total running costs (M €)	101	109	118	127	136	147	158	170	183	198	213	230	249	271	295	279	311	344	376	408	438	459	481	504	527	550	576	593	614	633	649
Total with externalities (M €)	170	183	197	212	228	244	264	286	309	333	359	392	427	465	505	509	553	596	639	681	721	782	844	906	969	1,031	1,027	1,096	1,124	1,149	1,172
Total without externalities (M €)	154	166	179	193	207	222	240	261	282	304	328	359	391	427	464	464	505	545	586	625	663	722	783	844	905	965	961	1,031	1,058	1,083	1,106

Table A3.4 MEPS + Labelling scenario costs (M€, net of inflation)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Purchase price of all sales (M €)	34	37	40	43	46	49	54	59	64	70	75	84	93	102	111	122	129	136	144	151	159	191	223	256	288	321	298	339	345	350	355
Installation cost for all units sold (M €)	18	20	21	23	24	26	29	32	34	37	40	45	49	54	59	64	64	65	66	66	67	72	78	84	89	95	87	98	99	101	102
Cost with repair & maintenance of units in stock (M €)	4	5	5	5	6	6	7	7	8	9	9	10	11	12	13	14	16	17	19	21	23	25	28	32	36	41	47	51	57	61	65
Cost with filter of units in stock (M €)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	1	2	3	4	6	8	11	15	19	23	27	31	34
Cost with electricity of units in stock (M €)	97	104	113	121	131	140	151	162	175	189	204	220	238	259	282	265	296	326	356	385	412	430	448	464	480	494	510	519	531	541	549
Total cost of externalities (M €)	16	17	19	20	21	22	24	25	27	29	31	33	35	38	41	44	48	51	54	56	58	60	61	63	64	65	66	66	66	66	66
Total sales & installation costs (M €)	52	57	61	66	70	75	83	91	99	107	115	128	142	156	169	186	194	201	209	217	225	263	301	339	378	416	384	437	444	451	457
Total running costs (M €)	101	109	118	127	136	147	158	170	183	198	213	230	249	271	295	279	311	344	376	408	438	459	481	504	527	550	576	593	614	633	649
Total with externalities (M €)	170	183	197	212	228	244	264	286	309	333	359	392	427	465	505	509	553	596	639	681	721	782	844	906	969	1,031	1,027	1,096	1,124	1,149	1,172
Total without externalities (M €)	154	166	179	193	207	222	240	261	282	304	328	359	391	427	464	464	505	545	586	625	663	722	783	844	905	965	961	1,031	1,058	1,083	1,106

Table A3.5 Savings (M€, net of inflation)

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Total annual cost savings (M €)																										
MEPS	-23	-14	-4	16	37	57	77	97	116	133	146	153	156	155	152	148	143	138	132	126	120	114	108	101	95	88
Labelling	2	6	11	18	25	32	39	45	52	58	64	69	73	76	78	80	81	82	83	83	84	83	83	82	81	79
MEPS + Labelling	-23	-12	1	24	47	70	93	117	139	160	177	188	194	198	198	197	195	192	188	184	180	175	170	165	159	152
Cumulative cost savings (M €)																										
MEPS	-53	-67	-71	-55	-18	39	116	214	330	463	609	762	918	1,073	1,225	1,373	1,516	1,654	1,786	1,912	2,031	2,145	2,253	2,354	2,448	2,536
Labelling	2	7	19	37	62	93	132	177	229	287	351	420	493	569	647	727	808	891	974	1,057	1,141	1,224	1,307	1,389	1,470	1,549
MEPS + Labelling	-53	-65	-63	-39	8	78	172	288	428	587	765	953	1,147	1,345	1,542	1,739	1,934	2,126	2,314	2,499	2,679	2,854	3,024	3,188	3,347	3,500