Preparatory Studies for Eco-design Requirements of Energy-using Products

Lot 24: Professional Washing Machines, Dryers and Dishwashers

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Final Report, Part: Dishwashers

Task 4: Technical Analysis Existing Products

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For reasons of better readability, two Task 4 reports were prepared.

The report at hand covers ***professional dishwashers***.

The Task 4 report on *professional washing machines and dryers* is published separately.

Part: Professional Dishwashers

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1 Introduction

1.1 Objective

Task 4 entails a general technical analysis of current dishwasher products on the EU-market. It comprises the whole life cycle (production, distribution, use phase (product and system), and end-of-life phase) of the six product categories identified in Task 1. Thus, Task 4 provides general input for the definition of the base cases (Task 5) as well as the identification of part of the improvement potential (Task 7), i.e. the part that relates to the best existing products on the market.

1.2 Methodology and assessment of data quality

All information has been collected through a self-administrated survey amongst the stakeholders. For this purpose, a draft version has been prepared including preliminary assumptions on the basis of discussions with stakeholders and available literature (cf. section 8.1). The working paper was mainly developed to inquire the use phase (Task 3), but also covered certain aspects of Task 4. It has been circulated to stakeholders (manufacturers, industry associations, user associations, see section 8.1.1) for both Task 3 and Task 4. The feedback was used to adjust the preliminary assumptions. Additionally, for Task 4 an Excel file and further questions with respect to the manufacturing, distribution and end-of-life phase (see section 8.1.2 and 8.1.3) have been distributed amongst manufacturers and their industry associations (see section 8.1.4).

Four German manufacturers and CECED Italia answered on the first working document on the use phase. As outlined in Task 3 their answers can be judged as quite viable with regard to information on user behaviour. The same argumentation is true for the appliance specific information asked for in the working document: the manufacturers answering to the working document represent a substantial share of the European manufacturer market (60 to 75%) which also includes the Eastern European market as the responding manufacturers also sell and represent the major market share in these countries. Further, expert-knowledge regarding dishwashers of both main operating principles (program automats and conveyor-type dishwashers) can be expected from the responding manufacturers. The lack of responding users / user associations is not of relevance for Task 4, as it can be expected that they cannot contribute on the technical analysis of products in such detail.

With regard to the excel file and the additional questions with respect to the manufacturing, distribution and end-of-life phase, feedback of three German manufacturers has been received. Thus, information of Italian (and Spanish) manufacturers that also represent a substantial share of the European market, are unfortunately not included in the data compiled in this report.

2 Technical analysis production phase

The technical analysis of the production phase provides product weight and Bill-of-Materials (BOM), distinguishing the weight of different materials fractions and electronics modules at the level of the EuP EcoReport Unit Indicators as proposed in the MEEUP report. This includes packaging materials and an assessment of the primary scrap production during sheet metal manufacturing.

2.1 Main operating principles of dishwashers

The following table gives an overview of the six categories identified in Task 1 and their main properties. For a more detailed description see Task 1.

Table 1 Categorisation of professional dishwashers

<table>
<tr><th>Category-Number</th><th>Water supply</th><th>Number of tanks</th><th>Operating principle</th><th>Type of loading</th><th>Type of washware</th><th>Application</th></tr>
<tr><td>No. 1
Undercounter water-change</td><td>Water-change operation</td><td>0</td><td rowspan="4">Program automats</td><td rowspan="2">Front loaders</td><td rowspan="3">Mainly dishes, glasses, cups, cutlery.</td><td>Semi-professional</td></tr>
<tr><td>No. 2
Undercounter one-tank</td><td rowspan="5">Tank operation</td><td rowspan="4">1</td><td rowspan="5">Professional</td></tr>
<tr><td>No. 3
Hood-type</td><td>Pass-through</td></tr>
<tr><td>No. 4
Utensil/pot</td><td>Front loaders and pass-through</td><td>Black cookware and large utensils.</td></tr>
<tr><td>No. 5
Conveyor-type one-tank</td><td rowspan="2">Conveyor-type</td><td>n.a.</td><td rowspan="2">Mainly dishes, glasses, cutlery, also tablets, black cookware.</td></tr>
<tr><td>No. 6
Conveyor-type multi-tank</td><td>2 and more</td><td>n.a.</td></tr>
</table>

n.a. = not applicable

There are differences between each of the six categories; however some of the categories can be grouped together: e.g. all dishwashers of categories 2 to 6 work with a tank system, where the detergent solution is circulated within the machine and not fully changed between the dishwashing cycles. On the contrary, dishwashers of category 1 use fresh water for each cycle. Similar groups of certain properties apply for other aspects, like operating principle, type of loading, etc.

With regard to the technology there is no essential difference between the dishwasher categories under consideration. Therefore, most important components of all categories are:

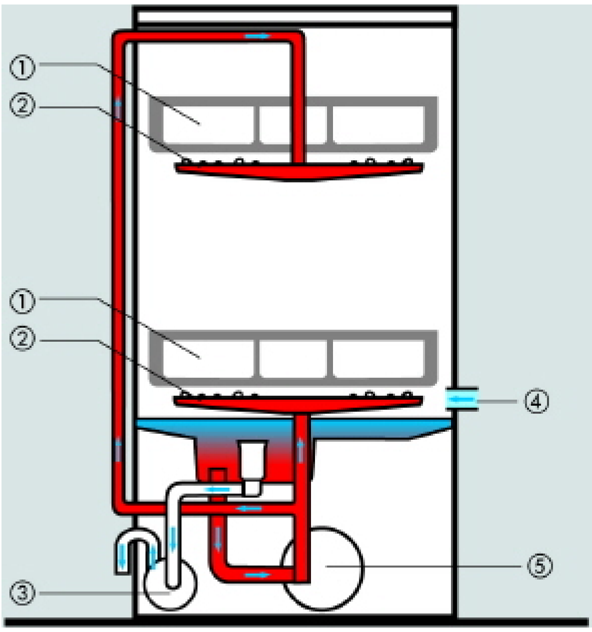
- containment and support structure;
- tanks and / or boilers;
- heating elements;
- motor and pumps;
- spray arms;
- filter system;
- control and display, electronics and sensors, electrics, and,
- where applicable, heat exchangers or heat pumps.

Many parts of a dishwasher, such as the external panelling, the tank, the washing and rinsing water circuits, the piping, the jets, the filters and the support structure are made of stainless steel. Because these parts have to withstand harsh environments and constant use, all manufacturers use this material for their machines. As shown in section 2.2, the stainless steel share of all dishwasher categories is therefore higher than 50% for category 1 and even higher than 70% for categories 2 to 6 (measured as weight percent of net weight, without packaging materials).

In the following sections, the principal function of dishwashers with water-change operation (section 2.1.1) and tank operation (section 2.1.2) is described. Dishwashers with tank operation can further be subdivided into program automats and conveyor-type dishwashers. Section 2.1.3 summarises the differences between water-change and tank operated dishwashers.

2.1.1 Water-change operation

The following illustration provides an overview of the construction and principal function of dishwashers with water-change operation.



Legend

1 Basket / rack
2 Spray arm cleaning and rinsing
3 Drain pump
4 Fresh water inlet
5 Circulating pump

(Source: Miele)

Figure 1 Construction of an undercounter water-change dishwasher (category 1)

The following steps can be distinguished in the dishwashing cycle:

- Pre-wash period: rinsing with cold water (optional);
- Wash period: spraying with warm/hot leach;
- Final rinse period: rinsing with hot water and rinse aid;
- Drying period: drying by use of fresh air or by the residual heat of the final rinse period.

In general dishwashers work with the mechanical force of water jets. The water jets spray against every spot on the dish surface, separate the food-soil from the dish and wash it away. The water is circulated and again sprayed onto the dishes.

Dishwashers of this category work with one set of rotating spray arms for both cleaning and rinsing (2). Sideward-pointing nozzles are placed on the spray arms to create an inclined plane of water jets to clean the dishes and rotate the spray arms through the backlash of the water.

The water is drawn from the fresh water inlet (4) and heated in the wash chamber by means of heating coils. It is then pumped into the spray arms by a circulating pump (5). The drained detergent solution is collected and large dirt and food particles are removed through a filter to avoid damage or blockage of the narrow jet nozzles. The filtered detergent solution is then pumped into the spray arms (2) again. After the wash period the detergent solution is drained by a drain pump (3). For the final rinse, fresh water is used that has to be heated using heating coils.

2.1.2 Tank operation

Professional dishwashers with tank operation can be subdivided into program automats with one-tank (categories 2-4) and conveyor-type dishwashers (categories 5 and 6), either one- or multi-tank. Program automats need much less space than the spacious conveyor-type dishwashers. However, the latter allow continuous dishwashing of large amounts of dishes in a short time.

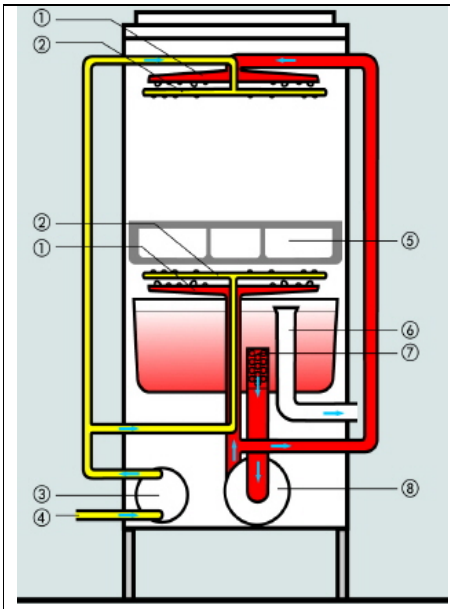
2.1.2.1 Program automats (one-tank)

The following steps can be distinguished in a dishwashing process of one-tank program automats:

- Wash period: spraying with warm/hot leach (usually between 55°C and 65°C);
- Final rinse period: rinsing with hot water and rinse aid (usually between 80 and 85°C; in case of special glasswashers also lower temperatures between 60 and 65°C possible);
- Drying period: drying by use of fresh air or by the residual heat of the final rinse period; this period often takes place outside the machine.

The pre-cleaning is usually performed manually before the items are put into the dishwasher.

The following illustration provides an overview of the construction and principal function of tank operated dishwashers.



Legend

1 Spray arm cleaning
2 Spray arm rinsing
3 Boiler for rinsing solution
4 Fresh water inlet
5 Basket / rack
6 Overflow pipe
7 Intake filter
8 Circulating pump

(Source: Miele)

Figure 2 Construction of a one-tank program automat (categories 2 to 4)

Tank operated program automats work with the mechanical force of water jets. However, they use two separate water cycles and therefore usually work with two sets[1] of rotating spray arms (principle: see Figure 3 below) that are each placed on the top and the bottom of the tub (see Figure 2 above): one set for cleaning (1, red), and one set for rinsing (2, yellow).

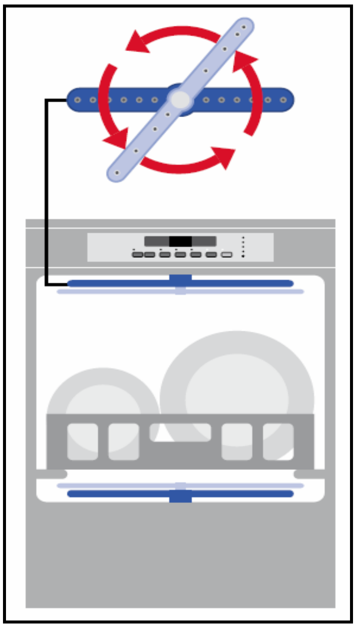


Figure 3 Circular movement of the spray arms in tank operated program automats (categories 2 to 4)

At the beginning of the day the wash tanks of tank operated dishwashers have to be filled with detergent solution and heated to operating temperature (usually between 55 and 65°C). During the day, standby energy consumption occurs because the tank temperature has to be kept on the defined temperature level by the tank heating system (ready-to-use-mode).

During the dishwashing process, the stored detergent solution is continuously pumped into the spray arms for cleaning (1) by the circulating pump (8). The drained detergent solution is collected and large dirt and food particles are removed through a filter (7) (usually a set of different filters) to avoid damage or blockage of the narrow jet nozzles (see also Figure 4). The filtered detergent solution is then pumped into the spray arms for cleaning (1) again. The detergent solution is not changed between two program cycles, but only partly replaced by hot fresh water from the final rinse process (so-called regeneration of detergent solution).

For the rinse process, hot fresh water heated in a separate boiler (3) is sprayed onto the dishes through a different set of spray arms (2). The excess detergent solution (through additional water from final rinse process) is drained through the overflow pipe (6). Once a day or after each working shift the detergent solution in the wash tank is fully changed.

[1] There are also tank dishwashers using only one set of spray arms with 2 tubes for the different water circles.

The following figure shows the filter and heating system of a one-tank program automat.


(Source: Hobart)

Figure 4 Filter and heating system of an undercounter one-tank dishwasher (category 2)

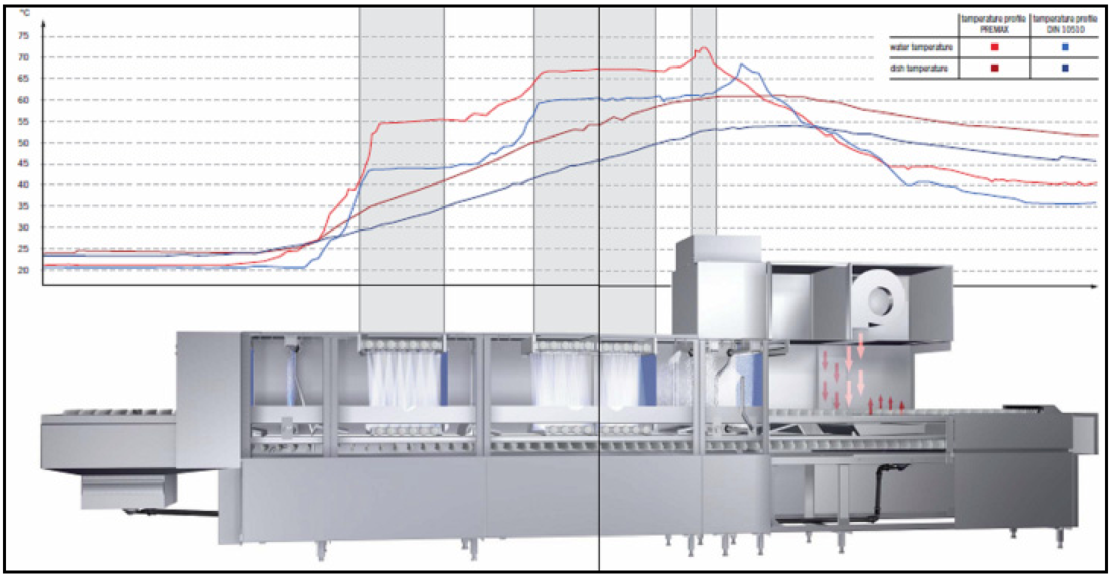
2.1.2.2 Conveyor-type (one-tank / multi-tank)

In principle, the dishwashing process of a conveyor-type dishwasher is the same compared to tank operated program automats. The following steps can be distinguished in a dish-washing process.

- Pre-wash period: rinsing with cold water;
- Wash period: spraying with warm/hot leach (usually between 55 and 65°C);
- Intermediate-rinse period: removal of leach with warm water;
- Final rinse period: rinsing with hot water and rinse aid (usually between 80 and 85°C);
- Drying period: drying by use of fresh air or by the residual heat of the final rinse period, might take place outside the machine.

The main difference to program automats is that with conveyor-type dishwashers the different steps of the dishwashing process are allocated to several individual treatment zones, i.e. the wash ware is transported through these zones. Depending on the type of dishes, the degree of soiling and the available space, conveyor-type dishwashers are provided with one or several wash tanks.

In Figure 5, a multi-tank belt conveyor with one pre-wash zone and one cleaning zone is shown. The red lines in the graph show the temperature of the water (light red) and the dishes (dark red) in the different zones.



(Source: Hobart)

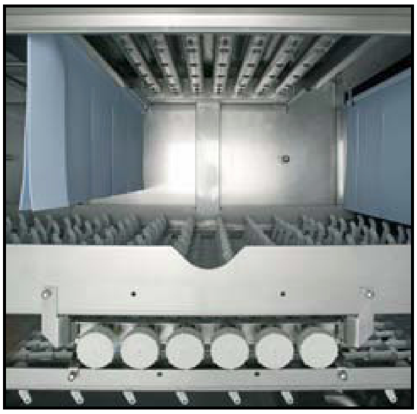
Figure 5 Example of a multi-tank conveyer-type dishwasher (category 6)

As with one-tank program automats the wash tank(s) of conveyor-type dishwashers have to be filled with detergent solution and heated to operating temperature (around 40°C for the pre-wash period and between 55 and 65°C for the wash period) at the beginning of the day/shift. During the day, standby energy consumption occurs because the tank temperature has to be kept on the defined temperature level (ready-to-use-mode).

The different steps of the dishwashing program work in principle as in program automats:

For the pre-washing and for the cleaning process, detergent solution is stored in the wash tanks from where it is continuously pumped into the spray arms by a circulating pump. The drained detergent solution is collected and large dirt and food particles are removed through filters to avoid damage or blockage of the jet nozzles. The filtered detergent solution is then pumped into the spray arms again. The detergent solution is not changed between two program cycles, but only partly regenerated. For the rinse process, hot fresh water heated in a separate boiler is sprayed onto the dishes through another set of spray arms. The excess detergent solution (through additional water from final rinse process) is drained through an overflow pipe at the first of the wash tanks (counter flow principle: the fresh water is used for rinsing, replacing water in the last wash tank. Excess water from this tank flows into the previous wash tank and so on). At the end of the dishwasher there might also be a drying zone, where the dishes are dried by hot air (see red arrows in Figure 5 above). Once a day or after each working shift the detergent solution in the wash tank is fully changed.

In contrast to program automats, the spray arms in conveyor-type dishwashers do not rotate but usually are fixed tubes on top and bottom of the dishwashing channel. In some machines, the spray arms are also installed at the sides in order to achieve uniform wetting.



(Source: Hobart)

Figure 6 Arrangement of wash arms and nozzles

Two different conveyor systems are available (see also Task 1):

- *Basket conveyor dishwashers* (Figure 7, left): the wash ware is put into baskets which are manually put into the machine and then automatically transported through the dishwasher.
- *Belt conveyor dishwashers* (Figure 7, right): the wash ware is put directly on a conveyor belt which continuously moves through the dishwasher.

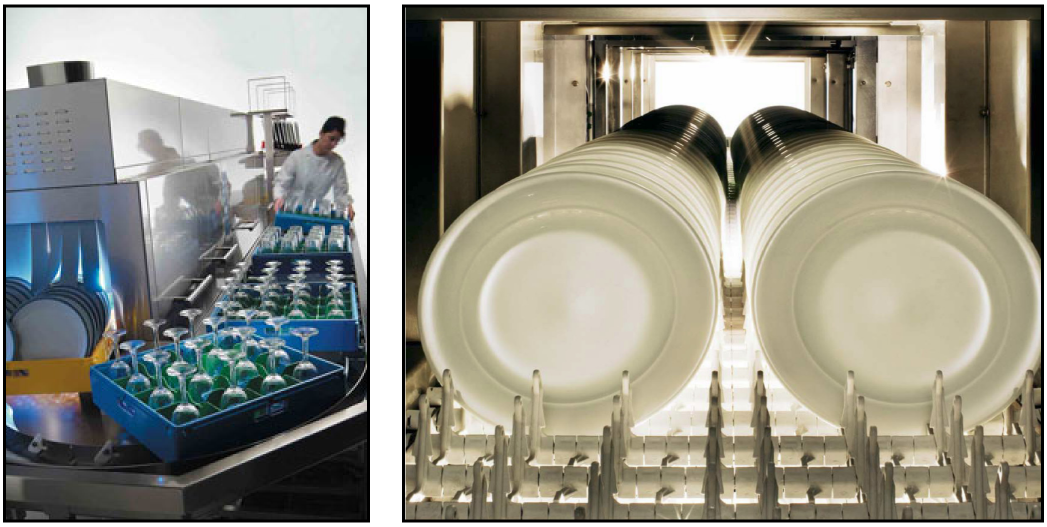


Figure 7 Principle of a basket conveyor dishwasher (left) and a belt conveyor dishwasher (right)

Based on rather different capacity requirements and the economic consequences, conveyor-type dishwashing machines are equipped with quite different technological features. In Task 6 (Best available technologies) the differences and their impact on energy and water consumption are described in detail, while the following table only provides a short overview.[2]

Table 2 Different configuration of a multi-tank conveyor-type dishwasher (category 6)

	Model A Series	**Model B Series**
Energy Management	n. a.	x
Heat recovery exhaust air	optional	x
Insulation	optional	x
Heat pump	n. a.	optional
Optimised final rinse	n. a.	x
Water consumption management	n. a.	x
Data documentation	optional	x

n. a. = not available for the model; x = technology is part of the series or option

2.1.3 Differences between water-change and tank operated dishwashers

A fundamental difference exists between water-change (category 1) and tank operated dishwashers (categories 2–6): While dishwashers in category 1 use fresh water for each step of the program, all other machines work with a tank system of one (categories 2–5) or more tanks (category 6).

The advantage of tank operation compared to water-change dishwashers is that the detergent solution in the wash tank is kept at a constant temperature thus enabling much shorter cleaning cycles and a high throughput per hour as the detergent solution does not have to be heated each time before a dishwashing cycle. Higher water temperatures and higher pressure additionally shorten the cleaning process itself. Depending on the connected load (230 or 400 Volt), cycle times and thus the capacity of the same dishwasher vary to a certain extent. Because the detergent solution is only regenerated and not fully replaced they also use less water per dishwashing cycle, resulting in lower energy and detergent consumption.

The following table gives a summary of the differences between water-change and tank operated dishwashers.

2 Note: Example by one manufacturer; other manufacturers might have different sets of optional configurations.

Table 3 Comparison of freshwater and tank system

Aspect	Water-change (freshwater) system	Tank system
Principal function	Fresh water for every washing and rinsing step	Only fresh water for rinsing
Filtration	Water filtration necessary	Intensive water filtration necessary
Program duration	Medium to long, as the heating of water needs some time.	Very short duration possible, as hot water is stored in wash tanks.
Output per hour	Medium to low	High
Capacity	Two racks possible	Usually only one rack / conveyor belt
Water and energy consumption	Higher, as fresh water is used for each cycle which has to be heated.	Lower, as water is recycled and used for several cycles / racks.
Standby losses	0.01 kW	0.25 kW – 2 kW

2.2 Main characteristics and material composition of dishwashers

In the following sections the main characteristics of the different dishwasher categories are described providing also basic data on the weight of different materials fractions. For details with regard to the data on energy and water consumption, see also Task 3.[3]

2.2.1 Category 1: Undercounter water-change dishwashers

The following illustration shows a typical undercounter water-change dishwasher.

(Source: Miele)

Figure 8 Undercounter front loader with water-change operation (category 1)

Table 4 gives an overview of the characteristics of a typical appliance of this category.

Table 4 Main characteristics of a typical undercounter water-change dishwasher (category 1)

Main characteristics	**Data**
Program	
Number of dishwashing programs	10 (dishwashing process can be adjusted to task)
Washing capacity, ideal	2–20 racks/h (depending on program)
Cycle time	6–27 minutes (depending on program)
Program temperature	Depending on program (between 20–60°C, rinsing temperature up to 93°C)
Construction details	
Height/width/depth	820/600/600 mm
Weight (without packaging)	ca. 50 kg
Tank volume	not applicable

[3] Main characteristics in this section are based on the analysis of technical product information sheets and shall reflect a typical model within the respective categories. On the contrary, usage data compiled in Task 3 are based on direct stakeholder input and provide average values of the categories. Hence, values in Task 4, e.g. on the ideal washing capacity, might differ slightly to information given on the typical use intensity in Task 3.

Main characteristics	Data
Electricity and water connection	
Voltage	Normal (230 V) or high-load connection (400 Volt) possible
Total load	9 kW
Power of pump	0.4 kW

(Source: Miele)

According to stakeholders the material composition is equivalent to that of a household dishwasher as described in the preparatory study on washing machines and dishwashers (Lot 14). Therefore, the following Bill of Materials (BOM) is taken from Lot 14 Task 4 report.[4]

Table 5 Material composition of an undercounter water-change dishwasher (category 1)

Material / component	weight in g	weight in ratio %	Material category
Stainless Steel	24 560	51.0	3-Ferro
Steel Sheet galvanized	403	0.8	3-Ferro
Cast Iron	2 303	4.8	3-Ferro
Polypropylen (PP)	4 980	10.3	1-BlkPlastics
Polyamid (PA)	399	0.8	2-TecPlastics
Polymethylmetacrylate (PMMA)	6	0.0	2-TecPlastics
Acrylonitrile Butadiene Styrene (ABS)	751	1.6	1-BlkPlastics
Plystyrene (PS)	512	1.1	1-BlkPlastics
Styropor expandable polystyrene (EPS)	40	0.1	1-BlkPlastics
Polybutylene Terephthalate (PBT)	35	0.1	1-BlkPlastics
Polyvinylchlorid (PVC)	403	0.8	1-BlkPlastics
EPDM-rubber	524	1.1	1-BlkPlastics
POM	230	0.5	1-BlkPlastics
PE	187	0.4	1-BlkPlastics
Plastics others	268	0.6	1-BlkPlastics
Aluminium	273	0.6	4-Non-ferro
Cu wire	1 006	2.1	4-Non-ferro
CuZn38 cast	23	0.0	4-Non-ferro
Chrom	71	0.1	4-Non-ferro
Bitumen	6 089	12.6	7-Misc.
Concrete	1 263	2.6	7-Misc.
Cotton	452	0.9	7-Misc.
Epoxy	609	1.3	2-TecPlastics
Wood	2 034	4.2	7-Misc.
others (Paper)	285	0.6	7-Misc.
Electronics (control)	448	0.9	6-Electronics
Total net	**48 154**	**100.0**	

4 See http://www.ecowet-domestic.org/

Material / component	weight in g	weight in ratio %	Material category
Packaging	**2 542**		
EPS	724		1-BlkPlastics
PE-Foil	172		1-BlkPlastics
wood	1 011		7-Misc.
cardboard	635		7-Misc.
Total weight	**50 696**		

2.2.2 Category 2: Undercounter one-tank dishwashers

The following figure shows a typical undercounter one-tank dishwasher.

(Source: Zanussi 2009)

Figure 9 Manually loaded undercounter front loader with one-tank (category 2)

In case of undercounter one-tank dishwashers, usually only one basket can be placed into the dishwasher (loading and unloading from the front side), as the tank needs space as well.

Undercounter dishwashers can be constructed as “generalists” for different items (dishes, glasses, and cutlery) or as specialised versions, i.e. only for dishes, for glasses or for cutlery respectively. As the temperature and mechanical action vary for different adjustments, the related energy and water consumption varies to a certain extent.

For example, glasswashers are also available in smaller dimensions (undercounter models that are only 415 to 475 mm wide). These models are often used in bar areas. The basic mode of operation is the same as in the 600 mm wide models; however, they usually work with lower temperatures to avoid damage of the sensitive washware.

Table 6 gives an overview of the characteristics of a typical undercounter one-tank dishwasher (category 2).

Table 6 Main characteristics of a typical undercounter one-tank dishwasher (category 2)

Main characteristics	Data
Program	
Number of dishwashing programs	3
Washing capacity, ideal	40 racks/h (with 400 Voltage) 25 racks/h (with 230 Voltage)
Cycle time	60-360 sec (with 400 Voltage) 140 / 180 / 360 sec (with 230 Voltage)
Tank temperature	usually between 55°C and 65°C
Boiler temperature	usually between 80°C and 85°C (glasswashers: also 60-65°C possible)
Construction details	
Height/width/depth	820/600/650 mm (glasswashers: 415-475 mm width)
Weight (without packaging)	ca. 70 kg (glasswashers: ~ 50 kg)
Tank volume	7-20 litres, average 15 litres
Electricity and water connection	
Voltage	230 Volt or 400 Volt
Total load	With 400 Voltage: 7.7 kW With 230 Voltage: 3.6 kW
Power of pump	0.2-0.8 kW, typical 0.6 kW

The following table shows the BOM of a typical dishwasher of category 2, the shares of the different materials and the category to which the materials are assigned. The packaging material is listed separately.

Table 7 Material composition of an undercounter one-tank dishwasher (category 2)

Material / component	Weight in g	Fraction in %	Material category according to MEEuP
Stainless steel	49 760	71.2	3-Ferrous
Polypropylene (PP)	4 565	6.5	1-BlkPlastics
Polyamide (PA)	500	0.7	2-TecPlastics
Epoxy	1 000	1.4	2-TecPlastics
Acrylonitrile Butadiene Styrene (ABS)	70	0.1	1-BlkPlastics
Pumps (copper)	2 500	3.6	4-Non-ferrous
Pumps (stack of sheets)	2 500	3.6	3-Ferrous
Pumps (stainless steel wave)	2 250	3.2	3-Ferrous
Pumps (Al)	2 250	3.2	4-Non-ferrous
Cable (copper)	1 100	1.6	4-Non-ferrous
Cable sheath (PVC)	600	0.9	1-BlkPlastics
Cable sheath (silicone, EDPM)	300	0.4	1-BlkPlastics
Electronics (control)	500	0.7	6-Electronics
Gaskets (EDPM)	2 040	2.9	1-BlkPlastics

Material / component	Weight in g	Fraction in %	Material category according to MEEuP
Total net	**69 935**	**100.0**	
Packaging	**9 250**		
polystyrene	500		1-BlkPlastics
wood	6 000		7-Misc.
cardboard	2 750		7-Misc.
Total weight	**79 185**		

2.2.3 Category 3: Hood-type dishwashers

The following figure shows a typical hood-type (pass-through) dishwasher.

(Source: Hobart)

Figure 10 One-tank pass-through (hood-type) dishwasher (category 3)

In case of hood-type dishwashers the baskets are put into the dishwasher from one side and are taken out of the dishwasher from the other side. As in case of other tank dishwashers, only one basket can be cleaned at one level, as the tank also needs space. There are appliances, however, where two baskets can be cleaned next to each other, integrated in one housing at the same time. Such appliances are like a double or twin appliance.

Hood-type dishwashers are ergonomically easier to operate than undercounter dishwashers, because the filled baskets stay at working level and can easily be moved into and out of the dishwasher. Additionally, the separation of a dirty and a clean area is possible when using the pass-through type. They are usually constructed as “generalists” for different items, such as dishes, glasses, cutlery, etc.

Table 8 gives an overview of the main characteristics of a hood-type dishwasher (category 3).

Table 8 Main characteristics of a typical hood-type dishwasher (category 3)

Main characteristics	Data
Program	
Number of dishwashing programs	3
Washing capacity, ideal	60 racks/h
Cycle time	60-180 sec
Tank temperature	usually between 55°C and 65°C
Boiler temperature	usually between 80°C and 85°C
Construction details	
Height/width/depth (with open door)	2 000/760/820 mm
Weight (without packaging)	ca. 120 kg
Tank volume	16-60 litres, average 40 litres
Electricity and water connection	
Voltage	400 Volt
Total load	7 kW
Power of pump	0.75-1.5 kW, typical 0.9 kW

The following table shows the BOM of a typical dishwasher of category 3, the shares of the different materials and the category to which the materials are assigned. The packaging material is listed separately.

Table 9 Material composition of a hood-type dishwasher (category 3)

Material / component	Weight in g	Weight in ratio %	Material category
Stainless steel	93 090	79.1	3-Ferrous
Polypropylene (PP)	4 310	3.7	1-BlkPlastics
Polyamide (PA)	1 000	0.8	2-TecPlastics
Epoxy	800	0.7	2-TecPlastics
Acrylonitrile Butadiene Styrene (ABS)	70	0.1	1-BlkPlastics
Pumps (copper)	3 000	2.5	4-Non-ferrous
Pumps (stack of sheets)	3 000	2.5	3-Ferrous
Pumps (stainless steel wave)	2 500	2.1	3-Ferrous
Pumps (Al)	3 000	2.5	4-Non-ferrous
Cable (copper)	1 700	1.4	4-Non-ferrous

Material / component	Weight in g	Weight in ratio %	Material category
Cable sheath (PVC)	1 000	0.8	1-BlkPlastics
Cable sheath (silicone, EDPM)	500	0.4	1-BlkPlastics
Electronics (control)	600	0.5	6-Electronics
Gaskets (EDPM)	3 085	2.6	1-BlkPlastics
Total net	**117 655**	**100.0**	
Packaging	**17 500**		
polystyrene	500		1-BlkPlastics
wood	12 250		7-Misc.
cardboard	4 750		7-Misc.
Total weight	**135 155**		

2.2.4 Category 4: Utensil / pot dishwashers

The following illustration shows a typical utensil / pot dishwasher.

(Source: Winterhalter)

Figure 11 Example of an utensil / pot dishwasher (category 4)

The main difference to one-tank undercounter and pass-through dishwashers is that utensil / pot dishwashers are especially constructed for the cleaning of items other than dishes, glasses and cutlery, i.e. black cookware, pots, pans, containers, trays or other mostly large utensils. Therefore, the dimensions are often larger than those of undercounter front loaders or pass-through dishwashers for dishes, glasses and cutlery as the items to be cleaned are also bulkier. Further, the cleaning performance is usually higher, e.g. by means of higher scavenging pressure or other stronger mechanical and chemical treatment in order to dissolve incrustations. Due to their high scavenging pressure, they cannot be loaded with glass or ordinary crockery.

Two construction types can be distinguished:

- Front loading dishwashers;
- Pass-through dishwashers.

The pass-through dishwashers are usually loaded manually, however, some manufacturers offer special roller containers that can be filled outside the machine and then pushed into the dishwasher. Table 10 gives an overview of the characteristics of a typical utensil / pot dishwasher (category 4).

Table 10 Main characteristics of a typical utensil / pot dishwasher (category 4)

Main characteristics	**Data**
Program	
Number of dishwashing programs	3
Washing capacity, ideal	20 racks/h
Cycle time	90–540 sec
Tank temperature	usually between 55°C and 65°C
Boiler temperature	usually between 80°C and 85°C
Construction details	
Height/width/depth (with open door)	2 000/876/900 mm
Weight (without packaging)	ca. 200 kg
Tank volume	60-130 litres, average 100 litres
Electricity and water connection	
Voltage	400 Volt
Total load	13.0 kW
Power of pump	typical 1.6 kW

A special type of pot dishwasher is the so called granulate dishwasher. With these dishwashers (both front loaders and pass-through) the mechanical cleaning is intensified through scouring of the wash ware (mainly black cookware) with plastic granules of different size. A granule collector catches the plastic pellets during the granule washing program.

The following illustration shows the working principle of granulates.

(Source: Granuldisk)

Figure 12 Granulates to foster the cleaning process

The granules can subsequently be cleaned out in a sink with a pipe-mounted sprayer. The special advantage of this process is that less water and energy is needed to clean the pots and other black cookware. Pre-rinsing is not necessary. Granulates are reused in the machine. After about 2 500 cycles they are worn out and have to be replaced.

The following table shows the main characteristics of an exemplary granulate dishwasher.

Table 11 Main characteristics of an exemplary pot dishwasher with granulate

Main characteristics	**Data**
Program	
Number of dishwashing programs	3
Cycle time	120–310 sec
Tank temperature	usually between 55°C and 65°C
Boiler temperature	usually between 80°C and 85°C
Construction details	
Loading volume	190 litres
Height/width/depth (with open door)	2 400/850/900 mm
Weight (without packaging)	413 kg
Tank volume	83 litres
Electricity and water connection	
Voltage	400 Volt
Total load	15 kW
Power of pump	2.6 kW

(Source: Granuldisk)

The following table shows the BOM of a typical dishwasher of category 4 (without granulates[5]), the shares of the different materials and the category to which the materials are assigned. The packaging material is listed separately.

Table 12 Material composition of a utensil / pot dishwasher (category 4)

Material / component	**Weight in g**	**Weight in ratio %**	**Material category**
Stainless steel	165 000	80.1	3-Ferrous
Polypropylene (PP)	3 000	1.5	1-BlkPlastics
Polyamide (PA)	4 000	1.9	2-TecPlastics
Epoxy	0	0.0	2-TecPlastics
Ethylene Propylene Dien M-class rubber (EPDM)	4 000	1.9	1-BlkPlastics
Acrylonitrile Butadiene Styrene (ABS)	0	0.0	1-BlkPlastics

5 Granulate dishwashers are not seen as typical for category 4 but rather as special case. The material composition is thus based on a pot dishwasher without granulates. Granulate dishwashers will be further analysed in Task 6.

Material / component	Weight in g	Weight in ratio %	Material category
Pumps (copper)	5 000	2.4	4-Non-ferrous
Pumps (stack of sheets)	4 000	1.9	3-Ferrous
Pumps (stainless steel wave)	3 000	1.5	3-Ferrous
Pumps (Al)	5 000	2.4	4-Non-ferrous
Cable (copper)	2 400	1.2	4-Non-ferrous
Cable sheath (PVC)	1 400	0.7	1-BlkPlastics
Cable sheath (silicone, EDPM)	1 100	0.5	1-BlkPlastics
Electronics (control)	2 100	1.0	6-Electronics
Gaskets, etc. (EDPM)	6 000	2.9	1-BlkPlastics
Total net	**206 000**	**100.0**	
Packaging	**20 000**		
polystyrene	500		1-BlkPlastics
wood	16 000		7-Misc.
cardboard	3 500		7-Misc.
Total weight	**226 000**		

2.2.5 Category 5: One-tank conveyor-type dishwashers

The following illustration shows a typical one-tank conveyor-type dishwasher.

(Source: Winterhalter)

Figure 13 One-tank basket conveyer dishwasher (category 5)

One-tank conveyor-type dishwashers use one wash tank for cleaning and fresh water for the final rinsing. Pre-cleaning is normally performed manually (i.e. outside the dishwasher). The detergent and rinse aid are automatically dosed from a reservoir. The dishwashers can be used for different wash ware: dishes, glasses, cutlery, more seldom also for black cookware (pots and pans) and utensils. The following table gives an overview of the characteristics of a typical one-tank conveyor-type dishwasher (category 5).

Table 13 Main characteristics of a typical one-tank conveyor-type dishwasher (category 5)

Main criteria	**Data**
Program	
Number of dishwashing programs	2–3
Washing capacity, ideal	70–110 racks/h
Cycle time	90–180 sec
Tank temperature	usually between 55°C and 65°C
Boiler temperature	usually between 80°C and 85°C
Construction details	
Width/depth/height	1 300/800/1 420 mm (without preparing zone)
Depth/height of passage height	500/460 mm
Weight (without packaging)	ca. 900 kg
Tank volume	110-130 litres, average (120 litres)
Electricity and water connection	
Voltage	400 V
Power of pump	typical 1.5 kW

The following table shows the BOM of a typical dishwasher of category 5, the shares of the different materials and the category to which the materials are assigned. The packaging material is listed separately.

Table 14 Material composition of a one-tank conveyor-type dishwasher (category 5)

Material / component	**Weight in g**	**Weight in ratio %**	**Material category**
Stainless steel	642 250	72.06	3-Ferrous
Polypropylene (PP)	55 500	6.23	1-BlkPlastics
Polyamide (PA)	6 140	0.69	2-TecPlastics
Polyvinyl chloride (PVC)	4 600	0.52	1-BlkPlastics
Polystyrene (PS)	4 430	0.50	1-BlkPlastics
Acrylonitrile Butadiene Styrene (ABS)	5 000	0.56	1-BlkPlastics
Pumps (copper)	16 825	1.89	4-Non-ferrous
Pumps (stack of sheets)	15 625	1.75	3-Ferrous
Pumps (stainless steel wave)	12 335	1.38	3-Ferrous
Pumps (Al)	17 470	1.96	4-Non-ferrous
Condenser (AL)	4 720	0.53	4-Non-ferrous
Condenser (Cu)	7 080	0.79	4-Non-ferrous
Ventilator, fan (AL)	17 440	1.96	4-Non-ferrous
Ventilator, fan (Cu)	10 160	1.14	4-Non-ferrous
Drive motor (AL)	4 000	0.45	4-Non-ferrous
Drive motor (Cu)	5 000	0.56	4-Non-ferrous

Material / component	Weight in g	Weight in ratio %	Material category
Cable (copper)	16 300	1.83	4-Non-ferrous
Cable sheath (PVC)	8 640	0.97	1-BlkPlastics
Cable sheath (silicone, EDPM)	5 170	0.58	1-BlkPlastics
Electric contactor (copper)	10 000	1.12	4-Non-ferrous
Electronics (control)	9 800	1.10	6-Electronics
Gaskets (EDPM)	12 800	1.44	1-BlkPlastics
Total net	**891 285**	**100.00**	
Packaging	**81 940**		
polystyrene	2 940		1-BlkPlastics
wood	63 500		7-Misc.
cardboard	15 500		7-Misc.
Total weight	**973 225**		

Category 5 (one-tank) conveyor-type dishwashers are also available with a steam heating system. In this case the additional material input for the heating system is estimated to be 150 kg (mainly stainless steel).

2.2.6 Category 6: Multi-tank conveyor-type dishwashers

The following illustration shows a typical multi-tank conveyor-type dishwasher.

(Source: Winterhalter)

Figure 14 Multi-tank basket conveyer dishwasher (category 6)

These dishwashers comprise at least one pre-wash zone using a wash tank, one cleaning zone using a wash tank and a final rinse zone using fresh water. The dishwashers can be used for different wash ware: dishes, glasses, cutlery, and more seldom black cookware (pots and pans) and utensils.

Multi-tank dishwashers are usually a combination of different modules for pre-washing and cleaning. These modules can be quite different in size and determine the washing capacity of the machine (plates/hour). Also the passage width and height can be different.

Table 15 gives an overview of the characteristics of a typical multi-tank conveyor-type dishwasher (category 6).

Table 15 Main characteristics of a typical multi-tank conveyor-type dishwasher (category 6)

Main criteria	Data
Program	
Number of dishwashing programs	3
Washing capacity	1 700–6 000 dishes/h
Cycle time	90–180 sec
Tank temperature	usually between 55°C and 65°C
Boiler temperature	usually between 80°C and 85°C
Construction details	
Width (without packaging)	4 700–7 400 mm (without preparing zone)
Depth/height of passage height	Different modules available
Weight	ca. 1 300 kg
Tank volume	130-750 litres, average 230 litres
Electricity and water connection	
Voltage	400 Volt
Total load	39–51 kW
Power of pump	no data available

The following table shows the BOM of a typical dishwasher of category 6, the shares of the different materials and the category to which the materials are assigned. The packaging material is listed separately.

Table 16 Material composition of a multi-tank conveyor-type dishwasher (category 6)

Material / component	Weight in g	Weight in ratio %	Material category
Stainless steel	980 000	76.3	3-Ferrous
Polypropylene (PP)	58 000	4.5	1-BlkPlastics
Polyamide (PA)	18 660	1.5	2-TecPlastics
Epoxy	0	0.0	2-TecPlastics
Ethylene Propylene Dien M-class rubber (EPDM)	12 000	0.9	1-BlkPlastics
Acrylonitrile Butadiene Styrene (ABS)	0	0.0	1-BlkPlastics
Pumps (copper)	39 020	3.0	4-Non-ferrous
Pumps (stack of sheets)	37 070	2.9	3-Ferrous
Pumps (stainless steel wave)	25 370	2.0	3-Ferrous

Material / component	Weight in g	Weight in ratio %	Material category
Pumps (Al)	44 880	3.5	4-Non-ferrous
Cable (copper)	19 800	1.5	4-Non-ferrous
Cable sheath (PVC)	11 440	0.9	1-BlkPlastics
Cable sheath (silicone, EDPM)	8 360	0.7	1-BlkPlastics
Electronics (control)	15 400	1.2	6-Electronics
Gaskets, etc. (EDPM)	15 000	1.2	1-BlkPlastics
Total net	**1 285 000**	**100.0**	
Packaging	**180 000**		
polystyrene	5 290		1-BlkPlastics
wood	141 180		7-Misc.
cardboard	33 530		7-Misc.
Total weight	**1 465 000**		

Category 6 (multi-tank) conveyor-type dishwashers are also available with a steam heating system. In this case the additional material input for the heating system is estimated to be 200 kg (mainly stainless steel).

2.2.7 Overview of all dishwasher categories

An overview of the material input in the different categories of professional dishwashers is shown in the following tables (both absolute values and shares of material categories according to MEEuP, including packaging material).

Table 17 Material input for the different categories of professional dishwashers (material categories according to MEEuP, including packaging)

Materials-category	Unit	No.1	No. 2	No. 3	No. 4	No. 5	No. 6
Bulk Plastics	g	8 826	8 075	9 465	16 000	99 080	110 090
TecPlastics	g	1 014	1 500	1 800	4 000	6 140	18 660
Ferrous	g	27 266	54 510	98 590	172 000	670 210	1 042 440
Non-ferrous	g	1 373	5 850	7 700	12 400	108 995	103 700
Coating	g	0	0	0	0	0	0
Electronics	g	448	500	600	2 100	9 800	15 400
Misc.	g	11 769	8 750	17 000	19 500	79 000	174 710
Total weight	g	50 696	79 185	135 155	226 000	973 225	1 465 000

For classification details see the legend to the following Table 18.

Table 18 Share of material categories (according to MEEuP) for the different categories of professional dishwashers (including packaging)

Materials-category	Unit	No.1	No. 2	No. 3	No. 4	No. 5	No. 6
Bulk Plastics	g	17.4%	10.2%	7.0%	7.1%	10.2%	7.5%
Tec Plastics	g	2.0%	1.9%	1.3%	1.8%	0.6%	1.3%
Ferrous	g	53.8%	68.8%	72.9%	76.1%	68.9%	71.2%
Non-ferrous	g	2.7%	7.4%	5.7%	5.5%	11.2%	7.1%
Coating	g	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Electronics	g	0.9%	0.6%	0.4%	0.9%	1.0%	1.1%
Misc.	g	23.2%	11.1%	12.6%	8.6%	8.1%	11.9%
Total weight	**g**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

No. 1 Undercounter front loaders with water-change operation
No. 2 Undercounter front loaders with one-tank
No. 3 Hood-type dishwashers
No. 4 Utensil / pot dishwashers
No. 5 One-tank conveyor-type dishwashers
No. 6 Multi-tank conveyor-type dishwashers

In all categories, the share of ferrous metal (mainly stainless steel) is with approximately 55% to 75% (including packaging) predominant.

International standards like ASTM or NSF/ANSI as well as standards in Europe (for example DIN 10510) require the use of corrosion resistant material for surfaces exposed to wash and rinse water according to the intended use environment (cf. Task 1).

2.3 Other materials

According to MEEuP, certain material categories are assessed. In professional dishwashers, there are some further materials not covered by MEEuP which are described below.

- **Mercury**: According to stakeholders the dishwashers of all six categories do not contain mercury. All materials used within the products comply with the restrictions set out in the RoHS Directive.[6]
- **Refrigerants**: Dishwashers of categories 5 and 6 might be equipped with a heat pump containing refrigerant. The refrigerant used is R-134a (tetrafluorodichlorethene), R-407C (a hydrofluorocarbon blend of R-32, R-125, and R-134a) and others with an average filling of 3 to 4.5 kg. As the use of heat pumps is considered as BAT (Best Available Technology) this aspect is further elaborated in Task 6.
- **Silver ions**:

[6] Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2002/95/EC (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:037:0019:0023:EN:PDF) (see Task 1).

- Application: Nowadays there is a wide range of products containing silver because of its antibacterial activity. Individually silver applies as a solution, as a suspension and in nanoparticular form. Whenever silver contacts wetness, silver ions are emitting. Their antibacterial characteristic is used in following scopes and products: Water treatment, washing, medical applications, impregnation of fibres etc[7].
- Advantages: Silver ions provide advantages e.g. when they are added to wall paints which are used in surgeries to improve the hygienic conditions. Used in dishwashers, silver ions are supposed to prevent retention of bacteria on dishes after the cleaning process.
- Disadvantages: There are also negative aspects which have to be mentioned. For example, due to the increasing use of silver as a bactericide, environmental impacts could be bacterial resistance of silver ions because of a pollution of sludge in sewage plants. Further, there are knowledge gaps and uncertainties concerning possible impacts of silver ions, e.g. toxicity for terrestrial and sediment organisms, material flows in municipal wastewater, characteristic and quantity of emissions from products containing silver, toxicity of silver nanoparticles in comparison to silver compounds, occurring of different reactions in the environment, etc.
- Use of silver ions in dishwashers: According to stakeholders' feedback, the use of silver ions due to their antimicrobial properties is not applied anymore. In Germany, warnings from the German Federal Institute for Risk Assessment[8] with regard to possible harmful aspects and missing comprehensive data to allow conclusive risk assessments, especially for nano silver, caused the market to rethink. Moreover, according to stakeholders there is no need of silver ions in dishwashers, because there are other possibilities (temperature, chemistry, steam) to guarantee the same hygienic standard. Therefore, use of silver is no alternative anymore, as negative aspects increase.

3 Technical analysis distribution phase

The following table shows an overview of the average volume and weight of the final packaged product. These values are used to calculate the environmental impacts resulting from distribution.

[7] http://www.umweltdaten.de/publikationen/fpdf-l/3673.pdf

[8] Bundesinstitut für Risikobewertung (BfR) www.bfr.bund.de

Table 19 Average volume and weight of the final packaged product in the different categories of professional dishwashers

Dishwasher category	Average volume of the final packaged product	Average weight of the final packaged product	Source of information
Undercounter water-change	0.40 m^3	ca. 50 kg	According to Lot 14
Undercounter one-tank	0.48 m^3	ca. 80 kg	Information provided by stakeholders
Hood-type	1.03 m^3	ca. 135 kg	Information provided by stakeholders
Utensil/pot	4.95 m^3	ca. 225 kg	Based on dimensions given in Table 10
Conveyor-type one-tank	12.25 m^3	ca. 975 kg	Information provided by stakeholders
Conveyor-type multi-tank	16.58 m^3	ca. 1 465 kg	Assumed dimensions Length/depth/height (in mm) 6 700/1 100/2 250

4 Technical analysis use phase (product)

This section provides an assessment of the annual resources consumption (energy, water, detergent) and direct emissions during product life. Usually, the consumption values should be measured according to existing test standards. However, currently no European applicable measurement standard for quantifying the energy and water consumption of professional dishwashers exists (see Task 1). Therefore, the assessment of data quality and comparability in the following sections should be seen with regard to this context.

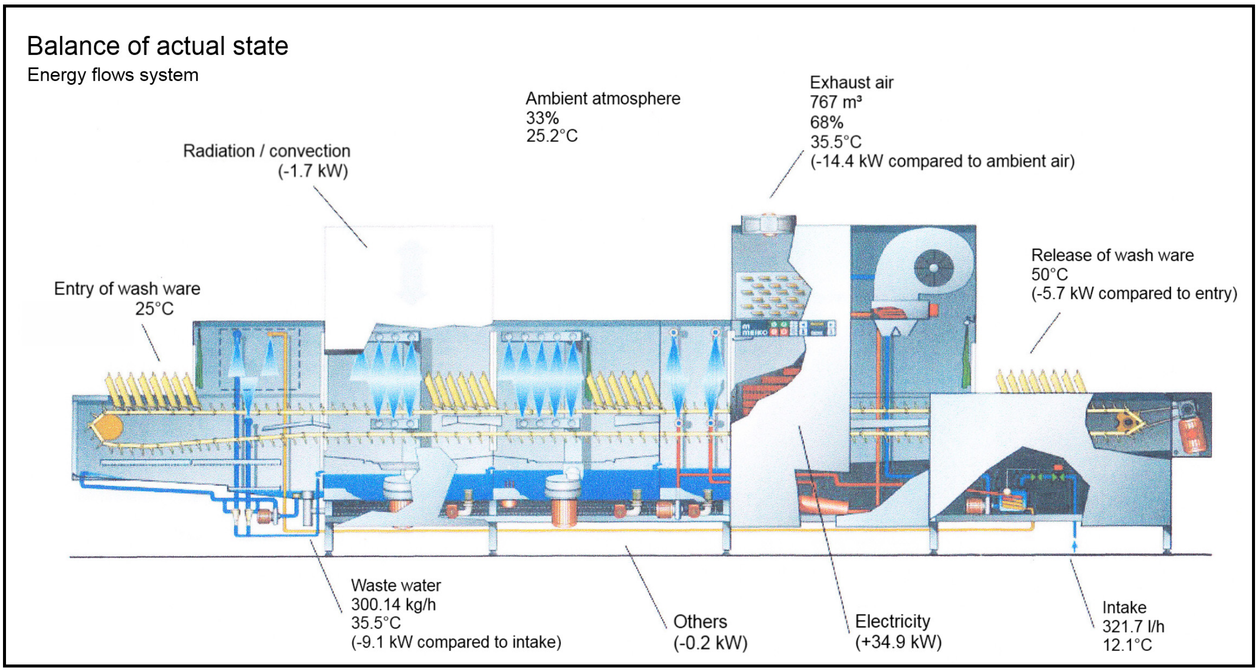
As introduction, in section 4.1 we first provide an overview of energy flows and energy losses in professional dishwashers. In section 4.2, the energy, water and rinse aid consumption of different dishwasher categories under ideal and real-life conditions are shown.

4.1 Energy flow in professional dishwashers

This section exemplifies how much energy is used for the different process steps in a typical dishwashing process. As outlined in Task 3, electric energy is the usual energy form used for heating in the dishwasher examples below (other heating options could be steam/hot water or direct gas heating). Figure 15 to Figure 17 show the respective energy flows of a conveyor-type dishwasher as exemplary illustration,[9] in absolute numbers and as percentage.

[9] Note: The energy flow of conveyor-type dishwashers is very specific for different machine configurations. There is wide range of energy input and output which depends mainly on the machine capacity (dishes per hour) and its configuration (type and number of sections, heat recovery system). Thus, the heat losses of the

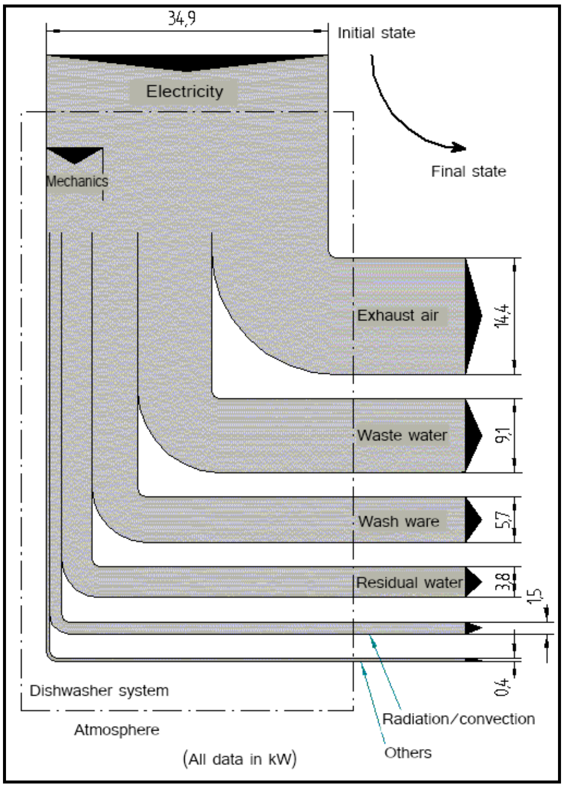
Figure 15 shows the temperature levels of the ambient air and of the specific dishwasher components (including water and dishes) in the different sections, together with the related energy flows. Figure 16 summarises the resulting energy input and output flows, Figure 17 shows the respective share of the different forms of energy output.



(Source: Meiko)

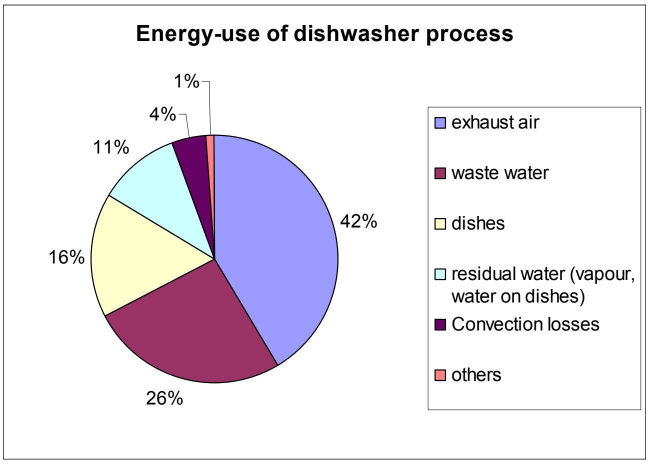
Figure 15 Energy flow in a conveyor-type dishwasher (category 6)

sample conveyor-type dishwasher described in this section can differ from other models and shall only show possible ranges.



(Source: Meiko)

Figure 16 Energy in- and output of an exemplary conveyor-type-dishwasher



(Source: own calculation based on data from Meiko)

Figure 17 Share of energy output in a conveyor-belt dishwasher

About 22% of the incoming energy is used to drive motors, pumps, ventilation, and the conveyor belt as well as to control the whole system. Most of the energy input, however, is used to heat up the water, the dishes and the air.

On the other hand, most of the energy is lost through exhaust air (42%), even though the dishwasher in the example above is equipped with a heat recovery system using the heat from the exhaust air to preheat the fresh water. Through this device, the air is expelled with a temperature of 35.5°C. Without heat exchanger, the exhaust air temperature would be around 60°C[10] and the heat loss correspondingly higher.

The second largest energy loss comes from the waste water. According to Figure 15, every hour 300 litres of warm water (temperature 35.5°C) leave the wash-cycle process and take 9.1 kWh/h of heat out of the system. This equates to 26% of the total energy consumption of the dishwashing process.

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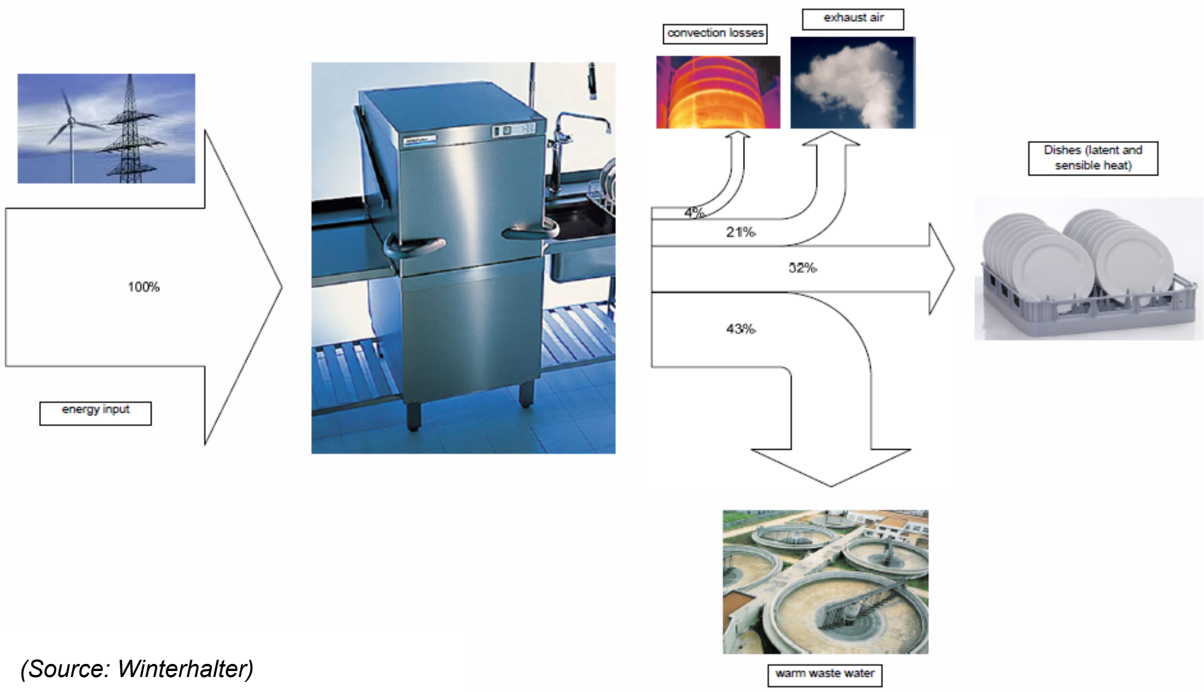
[10] However, according to stakeholder feedback, not all existing technologies work with exhaust temperatures around 60°C. There are also long practised existing technologies with exhaust temperatures below 40°C even without heat recovery unit.

Another relevant energy loss occurs to the heat which is transported out of the system through hot dishes. Usually, the dishes leave the dishwasher with a temperature of about 50°C. In the example described, the losses amount to 5.7 kWh/h which is equal to 16% of the total energy consumption. This share depends on the type and material of wash ware as the heat contained depends on the weight and the heat capacity of the material.

Further, 3.8 kWh/h or around 11% of the total energy consumption is lost through water vapour. As can be seen in Figure 15, about 322 litres of water enter the machine and only about 300 litres leave the dishwasher as waste water. That means that 22 litres of water leave the system in the form of vapour or adherent to the dishes. The losses through heat convection are relatively small: Only 1.5 kWh/h or 4% of the total energy consumption of the dishwashing process is related to heat convection.

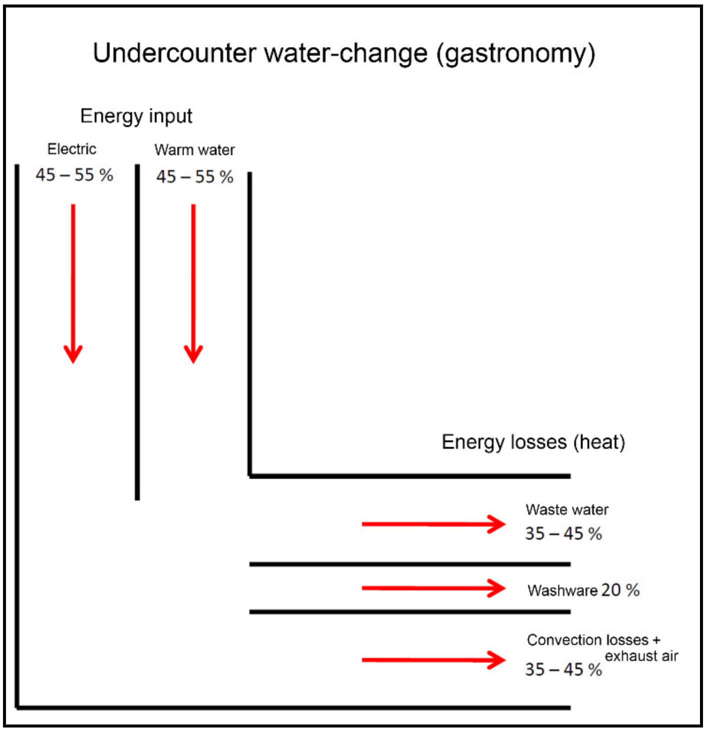
As another example, Figure 18 below shows the energy flow of a hood-type dishwasher (category 3). Compared to the energy output in a conveyor-type dishwasher (see Figure 17 above), the differences in the fragmentation of the energy losses occur due to the different construction and working principle as well as due to the different water consumption of both machine types.



(Source: Winterhalter)

Figure 18 Energy flow in a hood-type dishwasher (category 3)

Finally, Figure 19 shows a rough estimation of energy flows and losses in a water-change program automat (category 1). The values of the different categories may vary depending on the used dishwasher program.



(Source: Miele)

Figure 19 Energy flow in a water-change dishwasher (category 1)

In summary, the examples of the three different dishwasher categories show that the most important losses occur in the following areas:

- exhaust air,
- waste water, and
- hot, clean dishes.

They sum up to approximately 90% of the total energy losses.

In Task 6, we will further use these results to derive potential improvement options and to describe best available technologies (BAT) to overcome the specific losses.

4.2 Typical composition of detergents and rinse aids for professional dishwashers

DIN 10512 defines standard compositions of detergents and rinse agents for testing one-tank dishwashers. The tests with the standard treatment agents shall provide evidence that the dishwashing machine fulfils the hygiene requirements (see Task 1).

Although these standard treatment agents are not commercially available, their compositions comply with commercially available detergents and rinse aids. The standard detergent consists of potassium hydroxide, sodium silicate (water glass) and potassium tripoly-phosphate whereas the standard rinse agent consists of non-ionic surfactants, citric acid and hydrotropes as sodium cumolsulfonate to increase the solubility of the detergent in the product (Table 20 and Table 21).

Table 20 Standard composition of detergents for one-tank dishwashing machines

Component	Range (%)
Potassium tripolyphospate solution, 50 % (mass fraction)	20
Potassium hydroxide, 50 % (mass fraction)	36
Sodium silicate (water glass)	23
Oxidising agent[a)]	0–4
De-ionised water	ad 100

a) Oxidising agents are not part of the standard test detergent defined in DIN 10512. However, one manufacturer of dishwashing machines named oxidising agents as typical component in dishwashing detergents.

Table 21 Standard composition of rinse agents for one-tank dishwashing machines

Component	Range (%)
Citric acid-monohydrate, crystalline	5
Non-ionic surfactants, fatty alcohol$_{C12/C14}$ + 5 EO + 4 PO	20
Sodium cumolsulfonate	5
De-ionised water	ad 100

Bleaching or oxidizing agents typically used in detergents are mainly based on either oxygen (hydrogen peroxide/sodium percarbonate, sodium perborate[11]) or chlorine (hypochlorite). The advantage of chlorine bleaches like hypochlorite is that they provide effective bleaching and disinfection (hygiene) even at low (ambient) temperatures whereas sodium percarbonate and sodium perborate exhibit less bleaching efficiency at temperatures below 60°C. Furthermore, compared with chlorine and other disinfectants, hydrogen peroxide is not a very powerful disinfectant.

4.3 Energy, water and detergent consumption

The following input parameters were specified to define the respective energy, water, and detergent consumption of professional dishwashers during the use phase (see also Task 3):

- Initial filling (only relevant for tank operated dishwashers);
- Operation consumption;
  - Ideal conditions;
  - Real life conditions:

11 The use of sodium percarbonate has gained importance in those countries in which boron is either banned or restricted for environmental and regulatory reasons, or is negatively discussed.

  - Influence of real life workload on consumption;
  - Influence of use of other programmes on consumption;
  - Influence of maloperation;
- Standby consumption (ready-to-use mode or left-on mode).[12]

In case of water-change dishwashers (category 1), energy, water and detergent consumption only occurs during the dishwashing cycle and energy consumption during the left-on-mode.

In case of tank operated dishwashers (categories 2–6), first the wash tanks are filled with (water and) detergent solution, which has to be heated up to the operating temperature[13]. As the detergent solution has to be maintained at the set temperature (i.e. ready-to-use mode), standby energy is consumed as long as the dishwasher is in this stage. Finally, energy, water and detergent consumption occurs during a certain time of the day when the dishwasher is operating in its main function, i.e. cleaning dishes.

The use phase parameters have already been compiled and discussed in Task 3. Therefore, the following sections only summarise the annual consumption assumptions of the different dishwasher categories, differentiated according to the processes.

4.3.1 Category 1: Undercounter water-change dishwashers

Table 22 Energy, water and detergent consumption of a professional undercounter water-change dishwasher (cold water connection)

	Energy	Water	Detergent
Typical use intensity: Number of dishes p.a.	24 000		
Specific consumption	4.3 kWh/100 dishes	80 litres/100 dishes	268 g/100 dishes
Operation mode (annual consumption, ideal conditions)	*1 032 kWh*	*19 200 litres*	*64 kg*
Real-life user behaviour			
Additional consumption through partial workload	+15%	+25%	+25%
Consumption through use of other programmes in comparison to standard programme	96%	100%	100%
Additional consumption through maloperation	+10%		
Operation mode (annual consumption, real life user behaviour)	*1 249 kWh*	*25 920 litres*	*87 kg*
Initial filling (annual consumption)	not applicable	not applicable	not applicable
Standby (annual consumption, left-on-mode)	5 kWh	-	-
Total annual consumption (real life)	***1 254 kWh***	*25 920* ***litres***	***87 kg***

[12] Ready-to-use mode: reactivations function; left-on mode: information status.

[13] In the following sections, the energy consumption for the initial filling of the tank is based on cold water filling.

4.3.2 Category 2: Undercounter one-tank dishwashers

Table 23 Energy, water and detergent consumption of a professional undercounter one-tank dishwasher (cold water connection, electric heating)

	Energy	Water	Detergent
Typical use intensity: Number of dishes p.a.	237 600		
Specific consumption	1.6 kWh/100 dishes	16 litres/100 dishes	54 g/100 dishes
Operation mode (annual consumption, ideal conditions)	*3 802 kWh*	*38 016 litres*	*128 kg*
Real-life user behaviour			
Additional consumption through partial workload	+7.5%	+25%	+25%
Consumption through use of other programmes in comparison to standard programme	98%	100%	100%
Additional consumption through maloperation	+10%		
Operation mode (annual consumption, real life user behaviour)	*4 391 kWh*	*51 322 litres*	*173 kg*
Initial filling (annual consumption)	236 kWh	4 500 litres	15 kg
Standby (annual consumption, ready-to-use mode)	626 kWh	-	-
Total annual consumption (real life)	***5 253 kWh***	***55 822 litres***	***188 kg***

4.3.3 Category 3: Hood-type dishwashers

Table 24 Energy, water and detergent consumption of a professional hood-type dishwasher (cold water connection, electric heating)

	Energy	Water	Detergent
Typical use intensity: Number of dishes p.a.	345 600		
Specific consumption	1.7 kWh/100 dishes	16 litres/100 dishes	54 g/100 dishes
Operation mode (annual consumption, ideal conditions)	*5 875 kWh*	*55 296 litres*	*187 kg*
Real-life user behaviour			
Additional consumption through real-life workload	+ 7.5%	+25%	+25%
Consumption through use of other programmes in comparison to standard programme	99%	100%	100%
Additional consumption through maloperation	+10%		
Operation mode (annual consumption, real life user behaviour)	*6 845 kWh*	*74 650 litres*	*252 kg*
Initial filling (annual consumption)	629 kWh	12 000 litres	40 kg
Standby (annual consumption, ready-to-use mode)	784 kWh	-	-
Total annual consumption (real life)	***8 258 kWh***	***86 650 litres***	***292 kg***

<u>For comparison:</u>

The Danish Technological Institute (DTI)[14] has measured data on energy and water consumption for a total of ten hood-type dishwashers. The data have been determined according to „VGG Prüfverfahren zur Reinigungs-Index-Bestimmung von gewerblichen Geschirrspülmaschinen, Blatt 1 Kleinmaschinen; Entwurf 1970, ergänzt 1973“, with some modifications. The modifications follow as far as possible the European standard EN 50242 for household dishwashers (for details, cf. Task 1).

The following table gives an overview of the DTI results compared to the data provided from manufacturers for EuP Lot 24.

Table 25 Comparison of performance data for hood-type dishwashers

	Energy consumption use phase per 100 dishes (kWh)		Water consumption use phase per 100 dishes (litres)		Energy consumption ready-mode per hour (kWh/h)	
Source[15]	**DTI**	**EuP Lot 24**	**DTI**	**EuP Lot 24**	**DTI**	**EuP Lot 24**
Lowest value	1.4	1.5	12.0	-	0.19	-
Highest value	4.9	2.0	32.1	-	0.54	-
Average value	**2.9**	**1.7**	**20.7**	**16**	**0.34**	**0.35**

The DTI results show a high spread: the dishwasher with the highest energy consumption needs 3.5 times more energy compared to the most efficient one. Looking at the water consumption there is a factor 2.7, and for standby consumption a factor 2.8 between the best and the most consuming machine. Compared to the data provided by manufacturers in the context of EuP Lot 24, the standby consumption is in the same dimension; the water consumption used in EuP Lot 24 is about 23% lower than the average value of DTI; the EuP values for the energy consumption in on-mode are about 41% lower than the values resulting from DTI measurements.

However, according to information from DTI at the final stakeholder meeting[16] and via feedback form (cf. Annex section 8.2), the information provided by the DTI test results is not necessarily comparable as not all of the dishwashers and programmes tested are designed to only clean dishes with the “VGG type” of soiling[17], although they have been evaluated

14 www.dti.dk

15 Source DTI: mean value out of 10 dishwashers measured by Danish Technological Institute. Source EuP Lot 24: mean value according to manufacturers’ feedback; for water and standby consumption, only average values available.

16 www.ecowet-commercial.org/open_docs/Minutes_Final%20SH%20meeting%20dishwashers_09.12.2010.pdf

17 Also it should be noted that the measurement results for water, energy and time as well as the measured temperatures are determined on the test conditions provided Task 1, Annex 7.3 and will be independent of the soiling and the soiling method as long as the dishwasher is not equipped with sensors that can make the dishwasher react on the soiling in the wash water or the soiling on the dishes. The soiling is used to see

under the same conditions. Some of the machines tested by DTI are indeed made for tougher jobs and soiling (machines using a higher rinsing temperature also have higher energy consumption). This might be a reason for the differences between the DTI test results and the values of EuP Lot 24. Further, according to DTI it is not for sure that the ten tested machines are representative of the market in terms of performance level in Europe, as the machines were submitted by manufacturers for testing on a voluntary basis.

Therefore, the results back the urgency for a standardised methodology for performance measurements (for details, see also section 7).

For further calculations in the following tasks, we will take the data provided directly by manufacturers in the context of EuP Lot 24. They have been confirmed at the interim stakeholder meeting and the approach is consistent to the other dishwasher categories.

4.3.4 Category 4: Utensil / pot dishwashers

Table 26 Energy, water and detergent consumption of a professional utensil/pot dishwasher (cold water connection, electric heating)

	Energy	Water	Detergent
Typical use intensity: Number of dishes p.a.	9 000 cycles		
Specific consumption	0.5 kWh/cycle	5.2 litres/cycle	17 g/cycle
Operation mode (annual consumption, ideal conditions)	*4 500 kWh*	*46 800 litres*	*153 kg*
Real-life user behaviour			
Additional consumption through real-life workload	+7.5%	+30%	+30%
Consumption through use of other programmes in comparison to standard programme	103%	100%	100%
Additional consumption through maloperation	+10%		
Operation mode (annual consumption, real life user behaviour)	*5 423 kWh*	*65 520 litres*	*214 kg*
Initial filling (annual consumption)	1 257 kWh	24 000 litres	80 kg
Standby (annual consumption, ready-to-use mode)	2 233 kWh	-	-
Total annual consumption (real life)	***8 913 kWh***	***89 520 litres***	***294 kg***

possible effects of change in temperatures, water pressure, water distribution, and amount as well as washing time etc. The “VGG type” soiling may be exchanged with other types of soiling.

4.3.5 Category 5: One-tank conveyor-type dishwasher

Table 27 Energy, water and detergent consumption of a professional one-tank conveyor-type dishwasher (cold water connection, electric heating)

	Energy	Water	Detergent
Typical use intensity: Number of dishes p.a.	1 515 900		
Specific consumption	2.0 kWh/100 dishes	13 litres/100 dishes	44 g/100 dishes
Operation mode *(annual consumption, ideal conditions)*	*30 318 kWh*	*197 067 litres*	*667 kg*
Real-life user behaviour			
Additional consumption through real-life workload	+10%	+10%	+10%
Consumption through use of other programmes in comparison to standard programme	98%	98%	98%
Additional consumption through maloperation	+5%		
Operation mode *(annual consumption, real life user behaviour)*	*34 259 kWh*	*222 686 litres*	*754 kg*
Initial filling (annual consumption)	1 728 kWh	33 000 litres	111 kg
Standby (annual consumption, ready-to-use mode)	1 716 kWh	-	-
Total annual consumption (real life)	***37 703kWh***	***255 686 litres***	***865kg***

4.3.6 Category 6: Multi-tank conveyor-type dishwasher

Table 28 Energy, water and detergent consumption of a professional multi-tank conveyor-type dishwasher (cold water connection, electric heating)

	Energy	Water	Detergent
Typical use intensity: Number of dishes p.a.	4 009 500		
Specific consumption	2.0 kWh/100 dishes	12 litres/100 dishes	40 g/100 dishes
Operation mode *(annual consumption, ideal conditions)*	*80 190 kWh*	*481 140 litres*	*1 604 kg*
Real-life user behaviour			
Additional consumption through real-life workload	+ 10%	+10%	+10%
Consumption through use of other programmes in comparison to standard programme	103%	103%	103%
Additional consumption through maloperation	+5%		
Operation mode *(annual consumption, real life user behaviour)*	*94 624 kWh*	*567 745 litres*	*1 892 kg*
Initial filling (annual consumption)	3 975 kWh	75 900 litres	254 kg
Standby (annual consumption, ready-to-use mode)	3 630 kWh	-	-
Total annual consumption (real life)	***102 229 kWh***	***643 645 litres***	***2 146 kg***

4.3.7 Overview of all dishwasher categories

The following Table 29 summarises the annual energy, water, and detergent consumption to be used as input data for Task 5 (environmental impact assessments of base cases).

Table 29 Annual energy, water, and detergent consumption (real life conditions) of all dishwasher categories

Dishwasher categories	Annual energy consumption per appliance (kWh)	Annual water consumption per appliance (litres)	Annual detergent consumption per appliance (kg)
Undercounter water-change	1 254	25 920	87
Undercounter one-tank	5 253	55 822	188
Hood-type	8 258	86 650	292
Utensil/pot	8 913	89 520	294
One-tank conveyor-type	37 703	255 686	865
Multi-tank conveyor-type	102 229	643 645	2 146

5 Technical analysis use phase (system)

Almost every product has a clear interface with the surrounding system. The technical analysis of the systemic use phase describes the functional system to which the product in question belongs and – if possible – quantifies those product features that can reduce the environmental impact not only of the product but of the system as a whole. However, the scope of the system analysis is restricted only to those issues that can be influenced by technical features of the products under investigation. Furthermore, the system analysis serves as an addition to the more traditional product-specific analysis in section 4, i.e. to design product-specific legislation (if any) in such a way that it would not make system-oriented innovations impossible.

Professional dishwashers are used in various applications like restaurants, clinics, and canteens etc. (see Task 3). The corresponding surroundings can be quite different and might influence the energy and water consumption of the dishwashers. This section provides an overview of different determining factors influencing the energy, water and detergent consumption of professional dishwashers.

Type of dishes: As shown in section 4.1 the dishes have to be heated by the dishwasher. A considerable part of the energy contained in the dishes gets lost through hot dishes and other wash ware at the end of the dishwashing process. The amount of energy needed to heat up the dishes and the losses depend on the type of wash ware (i.e. its weight and heat capacity). For example, the material china has a heat capacity of about 1 080 J/kg*K.

Input temperature of dishes: The energy consumption of dishwashers also depends on the input temperature of the wash ware, which depends on the general ambient temperature.

Soiling: The soiling of the wash ware can vary significantly from case to case. Especially in category 3 (utensil / pot dishwasher), heavy soiling of the washware might lead to additional pre-wash prior to the regular dishwashing cycle (outside of the machine). Another consequence of heavy soiling could be that users choose different programs. Longer running cycles, used for more heavily soiled dishes, usually have a better cleaning performance but also a higher energy and water consumption (see Task 3). Heavy soiling finally might lead to additional running cycles, if the result of the dishwashing process is not satisfying.

Quality of water: The information about water, energy and detergent consumption is usually based on ideal conditions. This means for example, that water hardness should be below 6°dH. Higher water hardness results in higher energy, water and/or detergent consumption. Therefore often a special softening plant is installed in order to obtain a good dishwashing performance.

Input water temperature: The water used for the dishwashing process (about 120 to 160 litres of water per 1 000 plates) has to be heated up from the input temperature to the tank or rinsing temperature. Every degree the input water being colder would cause an additional energy input of 0.14 kWh to 0.19 kWh (related to 120 litres and 160 litres per 1 000 dishes respectively).

Ambient temperature: The washing process produces heat and moisture which has to be expelled from the room. The energy consumption of the respectively needed ventilation and/or the air conditioning is related to the dishwashing process and also depends on the technology used. In case of a dishwasher with heat recovery system or heat pump, less energy is needed by a ventilation and/or air conditioning system to keep the ambient temperature and humidity within a comfortable range.

Infrastructure: The existing infrastructure has an influence on the electricity consumption:

- Water supply: The initial filling of the tanks with warm or hot instead of cold water at the beginning of the first dishwashing process might reduce electricity consumption.
- Alternative heating: Heating with natural gas or steam will not lead to a reduced end-energy demand but to a reduction of electricity consumption and in most cases also to a reduction of CO_2 emissions and other air polluting gases such as NO_x and SO_2. The environmental impact is dependent on the technology of the water heating and the steam process on the one hand, and on avoided emissions of the electricity system on the other hand.

6 Technical analysis end-of-life phase

This section shall provide considerations regarding the end-of-life of the professional dishwashers' material flows for handling as pure waste (landfill, pyrolytic incineration), heat recovery (non-hazardous incineration optimised for energy recovery) and/or re-use or closed-loop recycling.

At the end of their life time (for details, cf. Task 3), almost no professional dishwasher will end at a landfill, as materials are too valuable. For this reason, most products will either be refurbished or recycled for scrap parts or materials. We assumed that only 5% by weight of the products are not recovered (i.e. go to landfill) during the end-of-life phase. Indeed, in principle, almost all materials in the dishwashers' composition are recovered (assumption: 95% in post-WEEE conditions according to MEEuP) and follow one of the following options:

- Metals are recycled;
- Paper, cardboard, and plastics are incinerated (thermal recycling with possible benefits of energy recovery) or mechanically recycled. Plastics may also be directly reused;
- Other types of waste (concrete, bitumen) go to landfill. Hazardous waste consists only of electronic components, which are considered easy to disassemble and are in limited quantity (around 1% of the total weight).

The plastic share of professional dishwashers is mostly less than 10% related to its overall weight (see Table 18 in section 2.2.7). Regarding the recovered plastic fraction, the following end-of-life management options were estimated for all BCs, based on stakeholders' feedback:

- Thermal recycling: 70 %.
- Material (or mechanical) recycling: 29 %
- Re-use, closed loop recycling: 1 %

Printed wiring boards (PWB) are used in dishwashing machines of all categories. According to stakeholder information, these parts are easy to dismantle and are completely recycled by certified scrap dealers.

If a dishwasher with an installed heat pump is dismantled, specialized technicians will extract the refrigerant from the heat pump. In this process, only a technically unavoidable, small amount of refrigerant will escape.

7 Recommendation on mandates

On the basis of the analysis carried out in Tasks 1 to 4, this section shall include first recommendations for the content of possible mandates to be issued by the European Commission to the European standardisation organisations on (measurement) standards for professional dishwashers. Overall, as already initiated by CENELEC TC59X (see Task 1), a standardised definition of the terms and respective appliances “professional, commercial, and industrial” will be necessary.

To date, there are no directives or regulations in Europe and not even voluntary agreements between manufacturers concerning a consistent measurement methodology of consumption and performance data for professional dishwashers. This means that data provided by manufacturers is currently neither comparable nor subject to any control. Therefore, consumers who want to buy a professional dishwasher with low environmental impact and least life-cycle costs are confronted with the following challenges:

- In many cases no data on the energy consumption of professional dishwashers are provided at all.
- The information in brochures and catalogues concentrates on the figures for energy reduction (for example 30%) compared to an undefined product of a competing company or of an own product without a certain feature. The worse comparative value is frequently not communicated at all or en detail.
- If the energy consumption is noted, it is not really comparable to information on other appliances of other or maybe even the same manufacturer, because there is no standard method for measuring the consumption parameters of professional dishwashers.

This in turn results in the following:

- Consumers base their purchasing decision on non-comparable information.
- Competition between manufacturers is distorted.
- Manufacturers who provide realistic information on energy and water consumption are disadvantaged compared to those who communicate over-optimistic information.
- The further development of efficient technologies is slowed.
- Additional environmental impacts result from purchasing decisions made on the basis of insufficient information.
- Economic damage might result at EU level as a result of misdirecting the demand and insufficient allocation of resources.

A further consequence of the current situation is that important instruments of an efficiency policy cannot be applied. The application of minimum standards, efficiency labelling of devices, the introduction of binding life-cycle cost accounting, financial incentives for optimum devices as well as other instruments, presuppose a reliable data basis for assessing the consumption of the devices. This makes it advisable to develop and introduce a generally applicable and binding measuring method for determining the consumption of professional dishwashers at European level. Note: The existing approaches and considerations have already been set out in Task 1.

A prerequisite for determining the efficiency of a professional dishwashing process and dishwasher respectively is the implementation of standardised measuring methods. The following aspects would need to be defined for each of the dishwashing categories in order to deliver comparable results of the performance and consumption parameters[18]:

- Ambient temperature and humidity;
- Input water temperature;
- Input temperature for the wash ware;
- Selection of program ('standard' dishwashing program);
- Cleaning capacity (dishes per hour);
- Type (formulation) and dosage of detergent and rinse aid;
- Standard wash ware in terms of size, surface and heat capacity;
- Soiling of the items including dry-on time of the soiling.

The following parameters would need to be evaluated / measured:

- Cleaning results and hygienic performance;
- Energy and water consumption during continuous use (conveyor-type dishwashers) or per cycle (program automats);
- Energy demand in standby modes (ready-to-use, left-on, and if applicable: off mode); if possible, the termination of standby modes should follow the definitions of Commission Regulation (EC) No. 1275/2008 on Standby.
- Real-life use conditions: Energy and water consumption in partial load / discontinuous operation; possibly consumption in other than 'standard' program

Standard conditions should represent real-life conditions as precisely as possible. However, as there is a great variation in the user behaviour of professional dishwashers even within the categories identified, the energy and water consumption in day-to-day operation may still differ from that under standard test conditions.

Regarding the hygienic performance, stakeholders pointed out that they would prefer to define certain hygienic requirements (e.g. germ reduction by five log10 levels) and leave it up to the manufacturers how they solve this issue over certain mandatory minimum temperatures as defined in the current German DIN standards. Also in the revised DIN standards (currently under development) there will be no mandatory minimum temperatures

[18] The draft energy efficiency standard for commercial dishwashers by EFCEM might be an example of such a standard.

defined anymore. Similar arguments apply for the amount and type of detergent: manufacturers are in favour of not defining a standard detergent in the measurement standards. To avoid a possible shift of environmental burdens from those through energy consumption (e.g. Global Warming Potential, GWP) to those through ingredients of detergents (e.g. aqua toxicity, human toxicity) such information would need to be given as well when measuring the consumption parameters according to the standard that has to be developed.

8 Annex

8.1 Stakeholder enquiries

8.1.1 Working paper “Task 4” for stakeholders

Questions with regard to the technical analysis of the use phase have already been included into the working paper for Task 3 (cf. EuP_Lot24_Dish_T3_T4_Annex_Workingpaper.pdf).

8.1.2 Excel enquiry – production, distribution and end-of-life phase

EuP Lot 24: Professional washing machines, dryers and dishwashers

Task 4 - Technical Analysis of Existing Products - Part on Professional Dishwashers

The data is used to determine the environmental profile and impact analysis of the identified product categories with the "EuP-EcoReport" tool for:

1. Production Phase
2. Assembling / Distribution Phase
3. Use Phase*
4. End of Life Phase

* data collection included in seperate working paper on use phase, including user behaviour

PRODUCTION (including packaging material)

Main Materials Category type	Material (EuP EcoReport)	Example Average data Dishwasher 12ps model (data from Lot 14) [g]	Manually loaded program automats, under counter front loaders with water change operation [g]	Manually loaded program automats, under counter front loaders with one tank [g]	One-tank pass through dishwasher ('hood type dishwasher') [g]	Wareashing Utensil / Pot dishwasher [g]	One-Tank transport dishwasher [g]	Multi-Tank transport dishwasher [g]		
								Exclusively electricity	steam and hot water	gas
Bulk Plastics	Low-density polyethylene (LDPE)	695								
	High-density polyethylene (HDPE)	417								
	linear low density polyethylenes (LLDPE)									
	Polypropylene (PP)	4.980								
	Plystyrene (PS)	512								
	Styropor expandable polystyrene (EPS)	764								
	High Impact Polystyrene (HI-PS)									
	Polyvinylchlorid (PVC)	403								
	Styrol-Acrylnitril (SAN)									
	Acrylonitrile Butadiene Styrene (ABS)	751								
Bulk Plastics		***8.522***	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
TecPlastics	Polyamide (PA)	399								
	Plolycarbonate (PC)									
	Polymethylmetacrylate (PMMA)	6								
	Epoxy									
	Rigid-Pur									
	Flex - Pur									
	Talcum filler									
	E-glass fibre									
	Aramid fibre									
TecPlastics		***405***	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Ferrous metals	Steel Sheet galvanized	403								
	Steel tube/profile	15.869								
	Cast Iron	2.303								
	Ferrite									
	Stainless 18/8 coil	8.691								
Ferrous metals		***27.266***	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*

Non ferrous metals	Al sheet/extrusion	269								
	Al diecast									
	Cu winding wire									
	Cu wire	1.006								
	Cu tube/sheet									
	CuZn38 cast	23								
	ZnAl4 cast	4								
	MgZn5 cast									
Non ferrous metals		***1.302***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
Coating	pre-coating coil									
	powder coating									
	Cu/ni/Cr plating									
	Au/Pt/Pd									
Coating		***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
Electronics	LCD per m² scrn									
	CRT per m² scrn									
	big caps & coils									
	slots / ext. Ports									
	IC´s avg., 5% Si, Au									
	IC´s avg., 1% Si									
	SMD/LED´s avg.									
	PWB 1/2 lay 3.75kg/m²									
	PWB 6 lay 4.5kg/m²									
	PWB 6 lay 2kg/m²									
	Solder SnAg4Cu0.5									
	controller board									
Electronics		***448***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
Miscellaneous	Glass for Lamps									
	Bitumen	6.089								
	Cardboard	3.677								
	Office Paper	209								
	Concrete	1.263								
Miscellaneous		***11.238***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***

OUT of Scope EUP **	others	59								
	Resins	120								
	thermostat	10								
	Cotton	452								
	Cotton+Resins noise absorbers	489								
	adhesive	10								
	PBT polybutylene terephthalate	35								
	Plastics, others	268								
	wood	0								
	PU Foam - Insulation	2								
	Cr	71								
OUT of Scope EUP		***1.516***	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
TOTAL		***50.697***								

** For some materials no correspondance with EuP EcoReport is possible, in that case please allocated the materials in the main category "out of scope"

ASSEMBLING / DISTRIBUTION

		Example Average data Dishwasher 12ps model (data from Lot 14)	Manually loaded program automats, under counter front loaders with water change operation	Manually loaded program automats, under counter front loaders with one tank	One-tank pass through dishwasher ('hood type dishwasher')	Wareashing Utensil / Pot dishwasher	One-Tank transport dishwasher	Multi-Tank transport dishwasher		
								Exclusively electricity	steam and hot water	gas
Energy (kWh)										
Electricity		17,31								
Heat		9,2								
Mechanical										
Water (m3)		0,09								
Other materials (g)		315								
Volume of packaged final product (m3)		0,4								
Transport average (km)		652								

END OF LIFE

			Manually loaded program automats, under counter front loaders with water	Manually loaded program automats, under counter front loaders with one	One-tank pass through dishwasher ('hood type dishwasher')	Wareashing Utensil / Pot dishwasher	One-Tank transport dishwasher	Multi-Tank transport dishwasher		
			in %	in %	in %	in %	in %	in %	in %	in %
Landfill (fraction of products not recovered)			5	5	5	1	1	1		
Recycling of plastics										
Re-use, closed loop recycling			0	0	0	0	0	0		
Materials Recycling			80	80	80	80	90	90		
Thermal Recycling (%)			20	20	20	20	10	10		
Total			**100**	**100**	**100**	**100**	**100**	**100**		

8.1.3 Additional questions – production, distribution, end-of-life phase

Together with the excel-file (see section 8.1.2), stakeholders were kindly asked to fill in the following data:

1. Production:

- Material composition of the defined product categories (incl. packaging material)

  The data should be valid for electrically heated dishwashers (as we assume this as standard). If possible, we would like to ask you to specify the additional materials required for other heating possibilities in case of transport dishwashers (steam / hot water and gas heating respectively, therefore 3 columns there), either as percentage or in absolute values possible. The data should be valid for a "typical" dishwasher of each category. We know that especially in case of transport dishwashers there are quite big differences.

2. Assembling, Distribution:

- Energy, water and other material demand for the manufacturing process at the dishwasher manufacturer. It is obvious, that this can be only rough values, perhaps not differentiated per category, as it is difficult to allocate them to specific products.
- Volume of packaged final product
- Transport average (manufacturer – user)

3. End of life

- Fraction of products not recovered ("landfill" in any sense)
- Fraction of plastics that 1) is re-used, 2) goes to material recycling or 3) goes to thermal recycling (you find an assumption in the excel-file already)

Additionally, we would like to ask the following questions:

- Which percentage of the used sheetmetal is made of scrap metal?
- Are the PWB (printed wiring boards) easy to disassemble?
- Do the products contain refrigerants? If yes, which and how much? We assume that this is the case, if the waste steam condensation takes place with a heat pump, which, however we assume not as "standard" but rather as BAT.
- How is the refrigerant of the heat pumps being disposed of in the end-of-life phase? Which fraction of it is retained?
- Do the products contain mercury? If yes, how much and for which purpose? Which fraction is retained in the end-of-life phase?

8.1.4 Documentation of stakeholder response to enquiries

The following table shows to which stakeholders the working paper and an additional Excel file including questions with regard to production, distribution and end-of-life phase were circulated. The table also indicates from whom a response has been received.

Table 30 Documentation of enquiry addressees and their responses

	Working paper use phase (covering Task 3 and use phase aspects of Task 4)		**Excel-File + additional questions on production, distribution and end-of-life-phase**	
	Sent out	**Feedback**	**Sent out**	**Feedback**
Manufacturers and Industry Associations				
Hobart (currently not member of an industry association)	Yes	Yes	Yes	Yes
VGG (Verband der Hersteller von Gewerblichen Geschirr-spülmaschinen (Association of commercial dishwashers), representing the manucturers Winterhalter and Meiko)	Yes	Yes, feedback by both member companies Meiko and Winterhalter	Yes	Yes, feedback by both member companies Meiko and Winterhalter
EFCEM (European Federation of Catering Equipment Manufacturers) European umbrella associations of nine national catering equipment manufacturers' associations:	Yes	Spread working document to member associations	Yes	Spread working document to member associations
SYNEG, France	via EFCEM		via EFCEM	
HKI, Germany, representing ▪ Electrolux professional ▪ Miele professional ▪ Palux ▪ Stierlen	via EFCEM	HKI spread the working document to member companies. Feedback received by Miele.	via EFCEM	HKI spread the file and questions to member companies. No feedback by manufacturers.
CEA, Ireland	via EFCEM		via EFCEM	
CECED Italia, Italy	via EFCEM	Yes, feedback by association.	via EFCEM and was additionally contacted directly.	CECED Italia spread the file and questions to member companies. No feedback by manufacturers.
NVLG, Netherlands	via EFCEM		via EFCEM	
FELAC, Spain	via EFCEM and was additionally contacted directly.		via EFCEM	
BFS, Sweden	via EFCEM		via EFCEM	
TUSID, Turkey	via EFCEM		via EFCEM	

	Working paper use phase (covering Task 3 and use phase aspects of Task 4)		Excel-File + additional questions on production, distribution and end-of-life-phase	
	Sent out	Feedback	Sent out	Feedback
CESA, United Kingdom	via EFCEM		via EFCEM	
User associations				
HOTREC (Trade association of hotels, restaurants and cafes in the European Union)	Yes, twice	Response on e-mail but no comment on working paper.	No	
IHRA (International Hotel and Restaurant Association)	Yes, twice		No	
ACE (Association of Catering Excellence)	Yes, twice		No	
CLITRAVI (Liaison Center for the Meat Processing Industry in the European Union)	Yes, twice	Feedback that they did not feel responsible.	No	
C.E.B.P. (European Confederation of Bakers and Confectionary Organizations)	Yes, twice		No	
HCI (Health Caterers International)	Yes, twice	Response on e-mail but no comment on working paper.	No	
IFSA (International Flight Service Association)	Yes, twice		No	
ITCA (International Travel Catering Association)	Yes, via contact form on the internet		No	
Others				
CSFG (Catering for a Sustainable Future Group)	Yes		No	

8.2 Stakeholder feedback to draft versions of Task 4

Please note that the feedback refers to prior draft versions of Task 4 report; thus the indicated numerations of chapters, tables, figures or pages might have changed.

Feedback		Comment
Hobart		
3.5.1, 3.5.2, 3.5.3, p. 13, 15, 18	**Table 5, Table 7, Table 9** – Tank temperature according to DIN 10512: 55 to 65°C – Boiler temperature according to DIN 10512: 80 to 85°C – The aforementioned temperatures may go above or below these limits as long as the specified hygiene requirements are met. (Some machines are designed to operate at a different temperature profile). – Rinse water consumption should be expressed in litres/cycle not litres/hour (Table 7).	Considered in revision.
3.6, 3.6.1, 3.6.2, p. 20, 24, 26	**Text, Table 12, Table 14** – Tank temperature according to DIN 10510/10512: 55 to 65°C – Boiler temperature according to DIN 10510/10512: 80 to 85°C – The aforementioned temperatures may go above or below these limits as long as the specified hygiene requirements are met. (some machines are designed to operate at a different temperature profile)	Considered in revision.
5.1, p. 30ff.	**Entire section** – Energy flow of conveyor-type dishwashers is very specific for different machine configurations. – There is wide range of energy input and output which depends mainly on the machine capacity (plates per hour) and its configuration (type and number of sections, heat recovery system). – The sample conveyor dishwasher described in this section has a heat loss through dishes of only 5,7 kWh/h. We have major doubts if this is an appropriate value for a machine with a capacity of approx. 2 500 plates per hour.	Considered in revision
5.2.7, p. 36	**Table 23** the content of this table should be consistent with Table 2-12 of the Task 2 report	Section has been deleted in revision as part of task 5 report.
Miele		
3.4, p. 7	**The water is drawn from the fresh water inlet (4) and heated in a boiler. […] For the final rinse fresh water is used that has to be heated by the boiler again.** Water-change models don't have a boiler in its classical meaning (like one-tank program automats). They use heating coils that are located in the inner cabinet (wash chamber). Therefore it should say: "The water is drawn from the fresh water inlet (4) and heated in the wash chamber by the means of heating coils. […] For the final rinse fresh water is used that has to be heated again using the heating coils.	Considered in revision.
3.4, p. 7	**Table 2, 3 to 27 minutes, depending on program** correct is: 6 to 27 minutes	Considered in revision.
3.5.1, p. 13	**Table 5, Height/Width/depth** There are also undercounter models that are only 415–475 mm wide. These models are often used in bar areas and usually used	Included in the text

Feedback		Comment
	as glasswashers. These models are a significant portion of the overall undercounter market. The basic mode of operation is the same as in the 600 mm wide models.	
Winterhalter		
3.5.3, p. 17	**Figure 9** The machine shown is not very typical because it is probably the smallest and only undercounter potwasher on the market. I will provide a picture of a typical machine in about the dimensions mentioned on page 18	Considered in revision.
3.6, p. 20	**Wash temperatures** It is mentioned, that the leach-temperature is usually 65°C. The usual temperature-range – depending on the whole cleaning process – is 55–65°C (mentioned in DIN 10512). There are only some systems on the market that prefer higher temperatures – common temperatures are about 60°C.	Considered in revision.
3.6, p. 22	**Swinging Wash-arms** We do not know conveyor machines on the market, where the spraywash-arms swing. In utensil – washers some do so ….	Considered in revision
3.6.2, p. 26	**Table 14, Tank-temperature** See above mentioned. I only know one process from one manufacturer that works with this tank temperature. So it is not typical as mentioned below table 14.	Considered in revision.
5.1, p. 32	**Exhaust air temperature** Not all existing technologies work with exhaust temperatures around 60°C. There are also long practised existing technologies with exhaust temperatures below 40°C even without heat recovery unit.	Considered in revision.
CECED Italia		
2, p. 3	**Sinner Circle** 55°C is the range required from detergent manufacturer. It should not be a must, because it means to pose a limit to research and energy reduction.	Considered in revision.
2, p. 3	**Sinner Circle (90 seconds)** These values are defined from DIN standards it is possible to have good performance with lower time, it must be an opportunity of manufacturer to choice value for the four factors.	Considered in revision.
3.2, p. 5	**Main components of professional dishwashers** Air ventilation and dryer?	Considered in revision.
3.6.2, p.28	**Table 16, Energy management TOP TEMP** Every manufacturer has different set of optional available.	Considered in revision.
3.6.4, p. 29	**Hazardous materials** The refrigerant used is R134a, R407C and other…	Considered in revision.
5.1, p. 30	**Energy flow** In the text: “As outlined in Task 3, typically only electric energy is used.” => Steam energy too.	Considered in revision.

Feedback		Comment
5.1, p. 33	**Improvement potential** – “The heat losses through china…” It should compromise dryer performance: Cold dishes require more hot air or other solutions. – Sanitizing is not obtained by temperature in dishwasher. Thermal disinfection requires completely different process.	Considered in revision.
5.2.2, p. 34	**Table 2** In the table: “specific consumption detergent 3.35 g/l” => this value depend to detergent specification, we consider typically 2g/litre	The assumption is derived in task 3 and included rinse aid con-sumption. It seems that there is a quite big variation of detergents on the market. We therefore keep 3.35 g/l for the base case calculations.
8, p. 42	**Performance and consumption parameters** Refer to CECED proposal	Considered in revision.
Granuldisk		
p. 19, table 10	We want to complement table 10 on page 19 in Task 4 Report with the following information: – Energy consumption in operation: 0.4–0.7 kWh/cycle (depending on program and/or cold/hot water connection) – Energy consumption in ready-to-use mode: 1 kWh/h	Considered in revision. Thank you for this information.
Hobart		
p. 42	Replace “(e.g. germ reduction by three log10 levels)” by “(e.g. germ reduction by five log10 levels)”	Considered in revision.
Danish Technological Institute (DTI)		
p. 35, table 25 + com-ments	We agree in the figures shown from the DTI measurements It should however be noted that not all dishwashers and programmes tested are made only to clean dishes with the “VGG type” of soiling. Some of them are indeed made for tougher jobs and soiling. Also it should be noted that the measurement results for water, energy and time as well as the measured temperatures are determined on the conditions given in Report for part 1 section 7 Annex 7.3 and will be independent of the soiling and the soiling method as long as the dishwasher is not equipped with sensors that can make the dishwasher react on the soiling in the wash water or the soiling on the dishes. The soiling is used to see possible effects of change in temperatures, water pressure, water distribution, and amount as well as washing time etc. The “VGG type” soiling may be exchanged with other types of soiling.	Considered in revision.