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

Lot 24: Professional Washing Machines, Dryers and Dishwashers

Tender No. TREN/D3/91-2007

May 2011

Final Report,
Part: Washing Machines and Dryers

Task 3: Consumer Behaviour and Local Infrastructure

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For reasons of better readability, two Task 3 reports were prepared.

The report at hand covers ***professional washing machines and dryers***.

The Task 3 report on *professional dishwashers*
is published separately.

Part: Professional Washing Machines and Dryers

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1 Introduction

1.1 Objective

Consumer behaviour can – in part – be influenced by product-design but overall it is a very relevant input for the assessment of the environmental impact and the Life Cycle Costs of a product. One aim of this task is to quantify relevant user-parameters that influence the environmental impact of products during product-life. A second aim is to identify barriers and restrictions to possible eco-design measures, due to e.g. infra-structural factors. As currently no applicable performance measurement standard for professional washing machines and dryers exists (cf. Task 1),[1] the data might be the basis for the development of new standard test conditions. These data serve for calculations of life cycle environmental impacts and costs in later tasks.

The choice of the appropriate washing machine or dryer type depends, amongst other criteria, on the amount of laundry to be cleaned or dried in the establishment. Thus, Section 2 provides a first overview of the main application areas and capacity ranges of the different product categories. Combined with the typical use intensity for each washing machine and dryer category, the total amount of cleaned and dried laundry per year for each product category is calculated.

In Section 3, ideal user behaviour is described in general, which is intended to correlate to the specific consumptions values (i.e. per kilogram laundry) given by manufacturers. By multiplying the typical weight of laundry cleaned or dried per year with the specific consumption values, the energy, water and detergent consumption per year under ideal conditions are calculated for each product category.

In Section 4 aspects of real life operating conditions are described and their influence on the consumption of the appliances is quantified (if possible). Section 5 identifies and describes barriers and opportunities relating to the local infrastructure. Finally, Section 6 gives information about the end-of-life behaviour, i.e. repair-, maintenance and disposal practice.

1 The ISO 9398 standards for industrial laundry machines define the measurement method for the energy and water consumption but do not include the performance. Furthermore, the standard does not describe the common used process in the different laundry market areas. For this reason, most manufacturers (according to Electrolux professional, Kannegiesser, and Miele professional) do not use these standards. Instead, they use internal test procedures under “ideal” use conditions which allow direct comparison between models of similar performance characteristics.

1.2 Methodology and assessment of data quality

In order to derive information on user behaviour and its influence on resource consumption a stepwise approach was taken. All information provided in Task 3 has been collected through a self-administrated survey amongst the stakeholders (see Annex, Sections 7.1 and 7.2). For this purpose, a draft version including preliminary assumptions was prepared on the basis of discussions with stakeholders and literature. The working paper was then circulated to stakeholders (manufacturers, industry associations, user associations). The feedback was used to adjust the preliminary assumptions.

In order to identify the knowledge of manufacturers about their consumers' behaviour and their strategy in terms of eco-design and environmental communication, several manufacturers representing a large share of the European Market[2] were asked for input in the working paper. Five stakeholders replied to the self-administrated working paper by December 2010. Following the discussions at the final stakeholder meeting in Brussels, 12 January 2011, an additional questionnaire regarding the most relevant parameters (e.g. consumption values and local infrastructure) has been sent out. The objective of this questionnaire was to complement/confirm/consolidate the preliminary assumptions. Feedback from four manufacturers (Miele (D), Girbau (ES), Electrolux (SE), and Primus (CZ)) and from the German Engineering Federation VDMA has been received with regard to the additional questionnaire.

The answering manufacturers represent a major market share: According to PRODCOM data in Task 2, Germany and Spain together represent 29% in terms of units produced and 50% (washing machines) to 85% (dryers) in terms of the sales value. Further, analysis in Task 2 shows that also Sweden, Belgium and Czech Republic are major manufacturing countries in the EU; however, their production and sales data are not published in PRODCOM. According to manufacturers' feedback in Task 2, the manufacturers including VMDA members responding to our survey cover approximately 70% to 80% of the market (see Task 2, Table 14). This also includes the Eastern European market as the responding manufacturers also sell and represent the major market share in these countries.

Further, VDMA manufacturers and Miele, Electrolux and Primus principally focus on different washing machine and dryers categories (however, with some machines sizes overlapping): VDMA members tend to produce rather large appliances, whereas the other manufacturers tend to produce smaller applianes. Girbau even offers the whole range of product categories. Thus, the respondents to our questionnaire also represent the laundry market with regard to the machine categories being in the scope of Lot 24.

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2 Many of the professional laundry manufactures are not organised in associations. Moreover, there is no European association for professional manufacturing, except for some manufactures of industrial machines (for the plant engineering and construction) being members of VDMA (German Engineering Federation) – working group "Garment and Leather Technology".

Unfortunately, the user side of professional washing machines (WM) and dryers (D) or their associations have not participated in the survey. However, as around 20 percent of professional washing machines and dryers are usually sold directly from manufacturers to users and tuned to customer specific requirements upon purchase (cf. Task 2) manufacturers have at least in this market segment quite good knowledge on the user behaviour. This is especially true for the larger washing machines and dryers, but also partly for the other professional and semi-professional washing machines and dryers. For the semi-professional and smaller machines the information by manufacturers were additionally counterchecked with previous preparatory studies on household appliances (Lot 14 and Lot 16).Thus, manufacturers' estimations on the typical user behaviour can be judged as viable.

Due to the lack of an applied European measurement standard it is difficult to assess and compare the compiled consumption data for the energy, water, detergent of professional washing machines and dryers. In addition, the information coming from the manufacturers on consumption values is usually given under "ideal" use conditions, i.e. for example, standby times or partial loading of washing machines or dryers are neglected. Additionally, as the exact measuring conditions may vary between different manufacturers, the information on specific consumption values (e.g. kWh per kg) has to be handled with care. This applies particularly because the information is often used for promotional purposes and tends to understate the consumption.

1.3 Sinner's Circle principle ("Sinner'scher Kreis")

To achieve a certain degree of washing performance with professional washing machines, four interdependent factors[3] interact and have to be optimally adjusted (so called "Sinner's Circle", see also Figure 1).[4]

- Temperature (thermal energy consumption);
- Mechanics (mechanical energy consumption);
- Chemistry (type and concentration of detergent and laundry aid);
- Time.

3 These factors are similar in each washing or cleaning process, i.e. also for household dishwashing or in case of laundry treatment.

4 See e.g. aid Infodienst (2005) and DIN 10510.

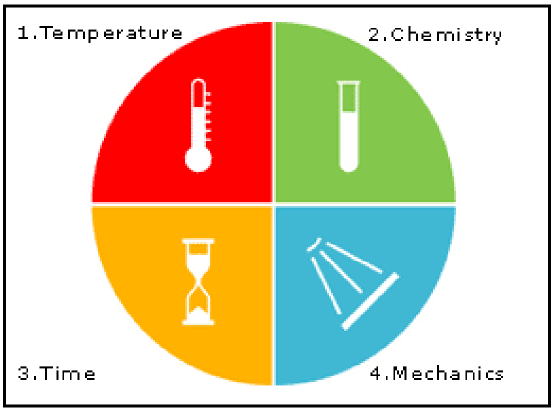

Figure 1 Factors influencing the washing process: Sinner's Circle ("Sinner'scher Kreis")[5]

As most of these factors might also be influenced by consumer behaviour, the Sinner's Circle principle should be taken as theoretical background for Task 3.

If a certain degree of cleaning performance shall be achieved, one factor can only be reduced (e.g. temperature, resulting in lower energy demand), if another factor is accordingly increased (e.g. time). This effect can be observed in case of household washing machines: The programme duration of "coloured 60°C" in household washing machines, for example, is 86 minutes, whereas only 56 minutes in professional washing machines. Thus, if for professional washing machines the detergents would be used in the same concentration as for household machines, the cleaning result, of course, would be less satisfactory. In order to achieve a reasonable compensation, a special detergent or more detergent compared to the amount used in household would be necessary.[6]

This fact also becomes visible when comparing manual washing and machine washing: In the case of manual washing, mechanical action is much more important than in the case of machine washing, where higher temperatures are used and the chemicals are more aggressive. However, both processes (should) lead to the same result.

Without increasing another factor, the contribution of one factor can only be reduced, if the washing performance can be decreased (e.g. when the textiles are less soiled).

In addition to the four cleaning factors, water also plays an important role since it serves as solvent for soluble substances and as carrier for washing chemicals and thermal energy. The amount of water influences the energy consumption. In addition, the water quality influences the washing process.

5 http://www.winterhalter.biz/winterhalter/information/dishwashing-hygiene/index.html

6 http://www.miele-professional.ch/ch/professional/produkt/141_796.htm

In short, the Sinner's Circle explains two facts:

a) Only the interaction of all factors leads to the required cleaning performance.

b) The reduction of one factor necessitates additional use of other factors if the washing performance shall be held constant. Of course, this is only possible within certain limits.

In the following sections, the user parameters and the influence of different user behaviour on these factors is described in detail.

2 Typical capacity and use intensity of professional washing machines and dryers

The "one and only" professional washing machine or dryer does not exist. Different customer requirements for professional washing machines and dryers result in a range of different product categories available on the market (see Task 1). The user behaviour also depends on the main application. Thus, the different categories of washing machines and dryers identified in Task 1 were assigned to key market / customer areas (see Task 2).

Table 1 and Table 2 give an overview of the main applications of these product categories thus providing a first indication of a possible use intensity of professional washing machines and dryers.[7]

Table 1 Key market segments of professional washing machines according to spatial requirements

Product category	Key market segment	Spatial requirements	Filling ratio[8]	Main operator / user type	Life time (cycles)
WM1: Semi-professional washer extractor	Coin & Card laundry (CCL) and Apartment Household Laundry (AHL)	Rather small amount of space available / necessary	1:8–1:10	Mainly private customers and non trained personnel (with few exemptions)	10 000–15 000
WM2: Professional washer extractor, <15 kg					
WM3: Professional washer extractor, 15-40 kg	Hospitality Laundry (HPL)	Medium amount of space necessary. Used in different market segments.	1:9–1:12	Non and trained personnel	30 000
WM5: Professional washer dryer					
WM6: Professional barrier washer	Healthcare Laundry (HCL)				
WM4: Professional washer extractor, >40 kg	Commercial Industrial Laundry (CIL)	Large amount of space required. Used in large laundries	1:10–1:12	Trained personnel	40 000 resp. 40 000 h
WM7: Washing tunnel machine					

7 Source: own compilation based on stakeholder feedback from working paper and comments on draft report.

8 The applicable filling ratio depends on the density of the laundry to be washed/dried

Table 2 Key market segments of professional dryers according to spatial requirements

Product category	Key market segment	Spatial requirements	Filling ratio[8]	Main operator / user type	Life time (cycles)
D1: Semi-professional dryer, condenser	Coin & Card laundry (CCL) and Apartment Household Laundry (AHL)	Rather small amount of space available / necessary	1:18–1:25	Mainly private customers and non trained personnel (with few exemptions)	10 000–15 000 (D3: 20 000)
D2: Semi-professional dryer, air vented					
D3: Professional cabinet dryer					
D4: Professional tumble dryer, <15 kg					
D5: Professional tumble dryer, 15-40 kg	Hospitality Laundry (HPL)	Medium amount of space necessary. Used in different market segments.	1:18–1:25	Non and trained personnel	30 000
D6: Professional tumble dryer, > 40 kg	Commercial Industrial Laundry (CIL)	Large amount of space required. Used in large laundries	1:20–1:25	Trained personnel	40 000 resp. 40 000 h
D7: Pass-through (transfer) dryer					

Semi-professional and small size professional washing machines and dryers are used mainly in the coin & card operated laundry as well in the apartment house laundries (WM1-2 and D1-4); only a rather small amount of laundry ware is to be cleaned per day. The end-users (mostly private consumers) have no special training. Only in some cases also semi-professional machines could be operated by trained people e.g. when setting up a machine in a commercial laundry.

Categories WM3, WM5-6 and D5 are often used both by non trained persons or trained employees – it depends on the different customer segments; whereas the industrial or heavy duty appliances WM4, WM7 and D6-7 are generally operated by well trained persons.The customers within the market segments and the respective countries obtain their equipment e.g. by purchasing, leasing or renting contracts (cf. Task 2). The heavy duty categories (e.g. tunnelwashers or pass-through dryers) require a quite high amount of laundry to be cleaned per day and also a large amount of space. They are therefore mainly used in commercial or industrial laundries, for example in large hospitals. The categories WM3 and D5 are used in the hospitality sector (hotels, restaurants etc.). The barrier washer (WM5) is installed in spaces with very high hygiene demands.

Annual weight of cleaned and dried laundry

The use intensity mainly depends on the main customer segment for each category, as it defines the number of cycles per day, the working days per year and the amount of load to be treated per cycle. In the following, for each appliance type typical operating conditions in the different customer segments are described to calculate the amount of laundry that is typically cleaned per year. Table 3 and Table 4 show the assumptions regarding the following parameters:

- Typical nominal capacity for each product category
  - in kg per cycle (WM1-6 and D1-6);
  - in kg per hour (WM7 and D7);
- Average load workload (%) in different customer segments;
- Number of average washing and drying cycles per day (categories WM1-6 and D1-6); typical time span (hours) of operation mode per day (categories WM7 and D7)
- Number of working days per year[9] (all categories).

With these input data, for each product category the annual amount (tons) of cleaned or dried laundry is calculated. Especially those data from the most relevant customer segment (marked bold in the following tables) serve as input for the calculations of the annual energy, water and detergent consumption under ideal and real conditions.

9 Assumptions due to stakeholder feedback from the survey

Washing machines

Table 3 Typical intensity of use of the regarded washing machine categories (main customer segments for each category marked bold)

Washing machine category	Customer segment	Typical nominal capacity in kg/cycle[10]	Average workload in %	Washing cycles per day	Cleaned laundry per day in kg/day	Number of working days per year	Cleaned laundry per year in tons/year[11]
WM1 Semi-professional washer extractor	**Coin & Card / AHL**	**6**	**65%**[12]	**6**	**23**	**300**	**7.0**
	Hospitality	6	70%	8	34	220	7.4
	Health care Hospital	6	70%	8	34	220	7.4
	Health care Nursing home	6	70%	6	25	220	5.5
	Commercial Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
WM2 Professional washer extractor, <15 kg	**Coin & Card / AHL**	**10**	**60%**	**8**	**48**	**300**	**14.4**
	Hospitality	10	80%	10	80	220	17.6
	Health care Hospital	10	80%	10	80	220	17.6
	Health care Nursing home	10	80%	10	80	220	17.6
	Commercial Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
WM3 Professional washer extractor, 15-40 kg	Coin & Card / AHL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Hospitality	**24**	**80%**	**10**	**192**	**220**	**42.2**
	Health care Hospital	24	80%	10	192	220	42.2
	Health care Nursing home	24	80%	10	192	220	42.2
	Commercial Laundry	24	80%	12	230	300	69.1
	Speciality Laundry	24	80%	10	192	300	57.6

10 Identified in Task 2

11 Calculated value

12 Applied mainly in Apartment-house-laundry (AHL)

Washing machine category	Customer segment	Typical nominal capacity in kg/cycle[10]	Average workload in %	Washing cycles per day	Cleaned laundry per day in kg/day	Number of working days per year	Cleaned laundry per year in tons/year[11]
WM4 Professional washer extractor, >40 kg	Coin & Card / AHL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Hospitality	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Hospital	90	80%	5	360	220	79.2
	Health care Nursing home	90	80%	5	360	220	79.2
	Commercial Laundry	**90**	**80%**	**9**	**648**	**300**	**194.4**
	Speciality Laundry	90	80%	8	576	300	172.8
WM5 Professional washer dryer	Coin & Card / AHL	6	60%	10	36	300	10.8
	Hospitality	**6**	**70%**	**8**	**34**	**220**	**7.4**
	Health care Hospital	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Nursing home	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Commercial Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
WM6 Professional barrier washer	Coin & Card / AHL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Hospitality	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Hospital	**32**	**80%**	**10**	**256**	**220**	**56.3**
	Health care Nursing home	**32**	**80%**	**10**	**256**	**220**	**56.3**
	Commercial Laundry	32	80%	5	128	300	38.4
	Speciality Laundry	32	80%	8	205	300	61.4
WM7 Washing tunnel machine	Coin & Card / AHL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Hospitality	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Hospital	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Nursing home	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Commercial Laundry	**1 500 kg/h (1 000–2 000)**	**85%**	**10h[13]**	**12 750**	**300**	**3 825**
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

n.a. = not applicable or no information available *(Source: own calculations based on stakeholder feedback from survey and literature)*

[13] Typical operating time span per day in hours

Dryers

Table 4 Typical intensity of use of the regarded dryer categories (main customer segments for each category marked bold)

Dryer category	Customer segment	Typical nominal capacity in kg/cycle[14]	Average workload in %	Drying cycles per day	Dried laundry per day in kg/day	Number of working days per year	Dried laundry per year in tons/year[15]
D1 Semi-professional dryer, condenser	**Coin & Card / AHL**	**6**	**60%**	**6**[16]	**22**	**300**	**6.5**
	Hospitality	6	70%	8	34	220	7.4
	Health care Hospital	6	70%	6	25	220	5.5
	Health care Nursing home	6	70%	6	25	220	5.5
	Commercial Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
D2 Semi-professional dryer, air vented	**Coin & Card / AHL**	**6**	**60%**	**6**	**22**	**300**	**6.5**
	Hospitality	6	70%	8	34	220	7.4
	Health care Hospital	6	70%	6	25	220	5.5
	Health care Nursing home	6	70%	6	25	220	5.5
	Commercial Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
D3 Professional Cabinet dryer	**Coin & Card / AHL**	**8**	**60%**	**6**	**29**	**220**[16]	**6.3**
	Hospitality	8	70%	6	34	220	7.4
	Health care Hospital	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Nursing home	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Commercial Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

[14] Load capacity depends on typical dryer per each category (see Task 2)

[15] Calculated value

[16] Applied mainly in Apartment-house-laundry (AHL)

Dryer category	Customer segment	Typical nominal capacity in kg/cycle[14]	Average workload in %	Drying cycles per day	Dried laundry per day in kg/day	Number of working days per year	Dried laundry per year in tons/year[15]
D4 Professional tumble dryer, <15 kg	**Coin & Card / AHL**	**10**	**60%**	**8**	**48**	**300**	**14.4**
	Hospitality	10	80%	10	80	220	17.6
	Health care Hospital	10	80%	10	80	220	17.6
	Health care Nursing home	10	80%	10	80	220	17.6
	Commercial Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
D5 Professional tumble dryer, 15-40 kg	Coin & Card / AHL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Hospitality	**23**	**80%**	**10**	**184**	**220**	**40.5**
	Health care Hospital	23	80%	10	184	220	40.5
	Health care Nursing home	23	80%	10	184	220	40.5
	Commercial Laundry	23	80%	12	221	300	66.2
	Speciality Laundry	23	80%	10	184	300	55.2
D6 Professional tumble dryer, > 40 kg	Coin & Card / AHL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Hospitality	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Hospital	70	80%	5	280	220	61.6
	Health care Nursing home	70	80%	5	280	220	61.6
	Commercial Laundry	**70**	**80%**	**10**	**560**	**300**	**168.0**
	Speciality Laundry	70	80%	8	448	300	134.4
D7 Pass-trough (transfer) tumble dryer	Coin & Card / AHL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Hospitality	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Hospital	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Health care Nursing home	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Commercial Laundry	**400 kg/h (300–500)**	**85%**	**10h[17]**	**3 400**	**300**	**1 020**
	Speciality Laundry	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

n.a. = not applicable or no information available so far *(Source: own calculations based on stakeholder feedback from survey and literature)*

[17] Typical operating time span per day in hours

Dosage and consumption of detergent

According to A.I.S.E.[18] customers generally ask for good wash performance (i.e. fewer cases of rewash) with the lowest cost per wash (i.e. with the possible lowest detergent concentration). Safety and simplicity combined with a good service level are further requests of customers. Further, according to A.I.S.E, customers tend to look for more automatic and controlled dosing systems, easy and simple systems to use, convenience and ergonomics, multi component systems, hygiene claims, powders and liquids, lower temperatures (40-60°C), sustainable solutions – i.e. energy, water, but also cost savings.

Professional laundries do not simply buy a product or range of products from their suppliers. They buy a full service – the solution to their specific laundry problems – in order to make their operation satisfactory. Suppliers to professional laundries must therefore offer complete systems including installations, control systems and dosing equipment or other hardware. The laundries also demand other services such as training of personnel, advice on effluent control measures and monitoring of wash performance and hygiene.

Modern detergent systems, powder, liquid, paste and combination systems can be automatically or manually dosed into the washing machine. Automatic dosing equipment can provide the benefits of reduced work, reduced manual handling, minimized chemical exposure, accurate repeated dosing and process validation.[19]

The various use patterns and framework conditions with regard to professional laundry washing result in a rather complex product category, with broad variety of needs, conditions and applications across Europe.[20]

- Regional variance of water quality is huge – from Norway with low water hardness to Spain and Turkey / Switzerland with water hardnesses over 30°DH. This results in the need for different detergent products or different dosing levels to achieve the best wash result within different hardness of the water (soft, medium or hard water)
- Many machines have fixed temperatures and programs.
- Besides the overall EU Detergent Regulation, different legislations also exist across countries, leading for example to the possible limitation of some raw materials (e.g. phosphate, EDTA) in professional laundry products.
- Customer perception of product effectiveness can also vary and may depend on whether the product can clean market segment specific soils (e.g. blood in laundry from medical applications, oil in industrial applications). Together with different cost

[18] International Association for Soaps, Detergents and Maintenance Products

[19] http://www.laundry-sustainability.eu/en/html/module_4_detergents.html, sighted on 23 Juli 2010

[20] A.I.S.E professional EU ecolabel criteria for laundry/autodish detergents, Ecolabelling Denmark

acceptance by customers, this leads to significant variations in product dosage over various European countries.

The dosage of detergent and laundry aid can be provided upon by

- special service providers,
- the manufacturers of the washing machines or
- the operators of the washing machines.

In case of industrial equipment, manufacturers rather only deliver the appliances or systems. The specifications of the washing process (i.e. the "recipe" of the process, including programme time, temperature, dosage of chemicals, water/laundry ratio, etc.) can be defined individually. This definition of the recipe is mostly done by the customer himself or the detergent provider. The energy, water and detergent consumption depends on this definition of the recipe. Further, the differences in detergent consumption of the product categories also arise from the different load ratio, types of dosing system and water consumption per functional unit.

During the course of our study, we could not get reliable information about differences in the composition and the use of detergent and laundry aid in different EU countries. Also A.I.S.E. could not provide data with such level of detail.[21] For the purposes of the study and the further calculations, the following **concentration values for detergents including laundry aid** have been assumed (in brackets: range of data).[22]

- WM 1+2: 17 g/kg[23]
- WM 3+5: 14 g/kg (8-20 g/kg)[24,25]
- WM 4+6: 18 g/kg (15-20 g/kg)[25]
- WM 7 = 9 g/kg[25]

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21 According feedback from A.I.S.E

22 Feedback on consumption data with regard only to specific wash ware (24 g/kg for blue work wear) could not be taken into account as it could not be allocated to the different machine categories. Another feedback provided extremely high consumption of up to 36 g/kg compared to the other input values; thus, this value was not taken into account as it was not considered to be typical detergent consumption.

23 Source: Öko-Institut e.V., Orientative life-cycle assessment (LCA) of fabric softeners. Substudy 2 within the UFO-Plan project 296 64 145 „LCA of laundry detergent and cleaning agent raw materials and their use in commercial washing", Freiburg 2000

24 Source: ISO 9398-4:2003(E): Table 2 – Test cycle B for industrial washer extractors

25 Source: According to feedback from manufacturers

3 Ideal user behaviour

3.1 Ideal operating conditions and user behaviour

Information by manufacturers about the energy, water and detergent consumption of professional washing machines and dryers is usually given under “ideal” use conditions. This means that

- “Standard” laundry type is used (e.g. cotton with standard soiling);
- The capacity in kg (or drum volume in l) of the washing machine / dryer is fully used;
- The most frequently used washing or drying programme (duration and temperature) is used (cf. Table 18 and Table 19);
- Detergents and laundry aids are used in the required form and concentration;
- External influences independent from the machine are not considered;
- Energy consumption in low-power modes (e.g. end-of-programme) is not included;
- Washing tunnels: average “standard” model with a “standard” configuration chosen (pre-wash, main wash, rinse, neutralisation, extraction);
- Dryers: systemic influences (interaction of washing and drying appliances) are taken into account in that respect that the residual moisture of the laundry coming out of the washing process is “ideal” with respect to each laundry type and market segment for the following drying process.

3.2 Energy, water and detergent consumption under ideal conditions

Table 5 and Table 6 provide an overview of the specific average energy, water and detergent (incl. laundry aid) consumption of the different washing machine and dryer categories. The given data is based on the main customer segment (see Task 2), on cold water connection (water temperature 15°C) and on the main energy source (cf. Section 5.2), the consumption range given in brackets reflects the different ranges of capacity sizes and heating options within each machine category. The tables show the consumption values of washing machines and dryers with an average technology (not including special BAT) being offered currently on the market. They are used for preliminary calculation of energy, water and detergent consumption during the use phase under ideal conditions in order to give an overview on the environmental relevance of the different washing machine and dryer categories and to subsequently determine the influence of specific aspects of of user behaviour which are not included under ideal conditions.

Note: The following data corresponds to 1 kg laundry as specified by manufactures data. As there is no applied European measurement standard the exact measuring conditions may vary between different manufacturers. The values are therefore presented with a certain degree of uncertainty. Further, the values were provided under ideal conditions as described above.

Table 5 Specific energy, water and detergent consumption of an average current device of different washing machines categories under ideal conditions

Washing machine category	Energy consumption (range)	Water consumption (range)	Detergent / laundry aid consumption (range)
	kWh/kg laundry	*l/kg laundry*	*g/kg laundry*
WM1: Semi-professional washer extractor	0.15 (0.12–0.18)	9 (8–10)	17
WM2: Professional washer extractor, <15 kg	0.17 (0.14–0.20)	12 (10–14)	17
WM3: Professional washer extractor, 15-40 kg	0.21 (0.17–0.25)	13 (10–16)	14 (8–20)
WM4: Professional washer extractor, >40 kg	0.35 (0.20–0.50)	14 (10–18)	18 (15–20)
WM5: Professional washer dryer	0.80 (Wash and Dry)	10 (8–12)	14 (8–20)
WM6: Professional barrier washer	0.39 (0.28–0.50)	16 (14–18)	18 (15–20)
WM7: Washing tunnel machine	0.35 (0.30–0.40)	6 (4–8)	9

(Source: specified manufactures data and feedback from survey)

Table 6 Specific energy consumption of an average current device of different dryer categories under ideal conditions

Dryer category	Energy consumption (range) kWh/kg laundry
D1: Semi-professional dryer, condenser[26]	0.60
D2: Semi-professional dryer, air vented[26]	0.56
D3: Professional Cabinet dryer	0.75 (0.60–0.90)
D4: Professional tumble dryer, <15 kg	0.55 (0.40–0.70)
D5: Professional tumble dryer, 15-40 kg	0.65 (0.55–0.75)
D6: Professional tumble dryer, > 40 kg	0.85 (0.75–0.95)
D7: Pass-trough (transfer) tumble dryer	0.80 (0.70–0.90)

(Source: specified manufactures data and feedback from working paper and draft report)

[26] Data for categories D1 and D2 taken over from Lot 16

Based on the annual weight of cleaned and dried laundry given in Table 3 and Table 4, the following Table 7 and Table 8 show the annual consumption of energy, water and detergent (incl. laundry aid) for each of the washing machine and dryer categories **under ideal conditions.**

Table 7 Annual energy, water and detergent consumption of different professional washing machine categories under ideal conditions

Category	Cleaned laundry	Energy consumption	Water consumption	Detergent / laundry aid consumption
	tons/year	*kWh/year*	*litres/year*	*kg/year*
WM1: Semi-professional washer extractor	7.0	1 050	63 000	119
WM2: Professional washer extractor, <15 kg	14.4	2 448	172 800	245
WM3: Professional washer extractor, 15-40 kg	42.2	8 862	548 600	591
WM4: Professional washer extractor, >40 kg	194.4	68 040	2 721 600	3 499
WM5: Professional washer dryer	7.4	5 920	74 000	104
WM6: Professional barrier washer	56.3	21 957	900 800	1 013
WM7: Washing tunnel machine	3 825	1 338 750	22 950 000	34 425

(Source: calculated data based on the stakeholder feedback)

Table 8 Annual energy consumption of different professional dryer categories under ideal conditions

Category	Dried laundry	Energy consumption
	tons/year	*kWh/year*
D1: Semi-professional dryer, condenser	6.5	3 900
D2: Semi-professional dryer, air vented	6.5	3 640
D3: Professional cabinet dryer	6.3	4 725
D4: Professional tumble dryer, <15 kg	14.4	7 920
D5: Professional tumble dryer, 15-40 kg	40.5	26 325
D6: Professional tumble dryer, > 40 kg	168	142 800
D7: Pass-trough (transfer) tumble dryer	1 020	816 000

(Source: calculated data based on the stakeholder feedback)

4 Real-life user behaviour

In technical information sheets of professional washing machines and dryers, the energy, water and detergent / laundry aid consumption is usually specified under ideal conditions as described in Section 3.1. However, there are several reasons why there are considerably differences between ideal and real-life consumption:

- The **user behaviour** during continuous operation is not “ideal”:
  - Customer segments: depending on the specific customer segment the machines might be used differently (cf. Table 3 and Table 4);
  - Workload: compared to the rated capacity the machines might not be fully loaded, leading to a higher consumption per kg laundry;
  - Other programs: the consumption data usually represent the consumption of the most used program. However, the machines are also used in other programmes;
  - Maloperation: Mistakes in user behaviour (e.g. incorrect dosage of the detergent and laundry aid) lead to increased consumption. Or: systemic influences (interaction of washing and drying appliances) are not taken into account so that the residual moisture of the laundry coming out of the washing process is not ideal with respect to each laundry type and market segment for the following drying process, leading to increased energy consumption.
- Washing machines or dryers can also be in low-power modes; the duration e.g. in left-on mode[27] might represent a quite long period of time causing additional **standby consumption**.

In the following sections, we will describe these parameters in more detail and show their influence compared to the consumption under ideal conditions. However, some of the parameters queried in the working paper are difficult to specify by stakeholders. Hence, the “average” values are best-possible estimates by either stakeholders or authors of this study.

4.1 Influence of user behaviour

4.1.1 Customer Segments

As outlined in Task 1, six customer segments were defined in which each of the seven washing machine and dryer categories are used to a different degree.

Within the customer segments also the typical user behaviour might be diverse. For example, the use of a semi-professional washer extractor (category WM1) in the customer

[27] Status of appliances at the end of a programme, while waiting for user attention

segment Hospitality laundry (HPL) might result in another energy and water consumption compared to the use of the same machine type in the customer segment Coin & Card Laundry (CCL), as the types or soiling of the laundry and the average user behaviour (private customers vs. trained personnel) might be different.

At the beginning of the stakeholder process within EuP Lot 24, we were asked for specifying the different consumption values with regard to all relevant customer segments. However, no quantification of the consumption data at this detailed level was provided by stakeholders; as the study is addressing the average energy and other resources consumption, in the further tasks we will only focus on the typical machines and applications in the key customer segment for each washing machine and dryer category.

4.1.2 Partial workload

In the technical information sheets of professional washing machines and dryers, the energy, water and detergent consumption is usually specified under optimal conditions and full load. In real life, however, the workload (kg of laundry in the drum) of washing machines and dryers might be considerably lower. This results from the fact that despite of the professional, thus profit-oriented operation of the machines the processes are customer and laundry type specific; i.e. no mix of laundry from different customers or different laundry types is applied reducing the possibilities to always use full load capacities. Further, in customer segments with mainly non-professional users like in Coin & Card Laundry or Apartment House Laundry, the partial workload can be assumed to be similar to that in household applications. The impact of lower workload in general is difficult to quantify and can be very different depending on the customer segments. Moreover, it depends on the organisation of the laundry process in total.

For the purposes of the study and further calculations we assume that in the respective main customer segment the influence of real workload on the consumption of energy, water and detergent is in the range of[28]

- Washing machines:
  - Categories WM1-7: **+10%** compared to the ideal **energy** consumption
  - Categories WM1-3, WM5: **+20%** compared to the ideal **water and detergent** consumption and
  - Categories WM4, WM6-7: **+10%** compared to the ideal **water and detergent** consumption.

Note: The concentration of the detergent solution has always to be kept at a constant level (less concentration would lead to insufficient cleaning results; overdosage on the other hand

[28] According to feedback from manufacturers at the final Lot 24 stakeholder meeting and at the International Detergency Conference (IDC) in Düsseldorf, Germany, 3 to 5 May 2011

should be avoided as it might result in undesirable detergent remains on the laundry and also is a cost factor). The concentration of the detergent depends on the amount of water used for cleaning the laundry. Thus, the proportionally increased water consumption due to partial load leads to an equivalent increase of the detergent consumption.

- Dryers:
  - +10% compared to the ideal **energy** consumption.

4.1.3 Use of other programmes

The performance of the washing process depends on the following factors (cf. Section 1.3):

- Thermal action (i.e. water temperature),
- Mechanical action,
- Chemical action (i.e. detergent concentration), and
- Time.

Thus, choosing another temperature or programme duration by the selection of different washing or drying programmes in the use phase would also influence the overall energy, water and detergent consumption.

The following Tables 9 and 10 provide an overview of the typically used programmes (temperature, programme duration) for each product category in the respective main customer segment (for typically used programmes in other customer segments, see Annex section 7.4).

Besides the most used programme, other common programmes are selectable which mainly differ by their duration, temperature and the respective cleaning performance, thus also resulting in different consumption values. However, as many of the professional washing machine and dryer categories are operated by trained personnel (cf. Table 1) the influence of the use of other – less effective – programmes would be relevant most likely for the appliances used by non trained personnel in CCL and AHL market segments.

A quantified influence of the use of other programmes will be presented within the next section (influence of maloperation on energy, water and detergent consumption).

Table 9 Programme selection of professional washing machine categories

Type of appliance	Main customer segment	Duration of the typically used washing programme	Share of the typically used washing programme	Temperature of the typically used washing programme
WM1: Semi-professional washer extractor	Coin & Card Laundry + Apartment Household Laundry	35–55 min	60%	40°C
WM2: Professional washer extractor, <15 kg	Coin & Card Laundry + Apartment Household Laundry	35–55 min	60%	40°C
WM3: Professional washer extractor, 15–40 kg	Hospitality Laundry	50 min	60%	60°C
WM4: Professional washer extractor, >40 kg	Commercial Industrial Laundry	30 min (programmable)	60%	60°C
WM5: Professional washer dryer	Hospitality Laundry	75 min (wash+dry) 50 min (wash)	60%	60°C
WM6: Professional barrier washer	Healthcare Hospital Laundry	45 min (programmable)	60%	>60°C
WM7: Washing tunnel machine	Commercial Industrial Laundry	30 min	>90%	Pre-rinse / main wash / rinse zone 40°C / 70-80°C / 40°C

Table 10 Programme selection of professional dryer categories

Type of appliance	Main customer segment	Duration of the typically used washing programme	Share of the typically used washing programme	Temperature of the typically used washing programme
D1: Semi-professional dryer, condenser	Coin & Card Laundry + Apartment Household Laundry	30–45 min	100%	70°C
D2: Semi-professional dryer, air vented	Coin & Card Laundry + Apartment Household Laundry	30–45 min	100%	70°C
D3: Professional cabinet dryer	Coin & Card Laundry + Apartment Household Laundry	130 min	60%	90°C
D4: Professional tumble dryer, <15 kg	Coin & Card Laundry + Apartment Household Laundry	30 min	>95%	70°C
D5: Professional tumble dryer, 15-40 kg	Hospitality Laundry	20–30 min	>95%	70°C
D6: Professional tumble dryer, >40 kg	Commercial Industrial Laundry	15–20 min	80%	60°C
D7: Pass-through (transfer) tumble dryer	Commercial Industrial Laundry	15–25 min	> 90 min	Fresh air ~200°C Exhaust air ~100°C

4.1.4 Maloperation

Maloperation of professional washing machines and dryers can influence the energy, water and detergent and laundry aid consumption. There are following main reasons for the maloperation of professional washing machines and dryers:

- The “wrong” program, e.g. with regard to temperature and time is chosen (see also Section 4.1.3 above) and the laundry process has to be repeated because the result of the washing or drying process is not satisfactory. This effect arises e.g. in case of mixed laundry, as temperature is usually oriented to the most delicate laundry item.
- The concentration of detergent and laundry aid is not sufficient and the result of the washing process therefore not acceptable. The washing process has to be repeated. This occurs when the container for the detergent or laundry aid is empty and the user does not pay attention to the corresponding signal.
- The concentration of detergent is too high resulting of a high waste water amount and possibly residues on the textiles. This effect arises e.g. in case of mixed heavily and light soiled laundry, as the detergent concentration is usually oriented to the most soiled laundry item.

The dosage of the detergent and laundry aid can be decided upon by

- Special service providers,
- The manufacturers of the washing machines or
- The operators of the washing machines.

In the first two cases, incorrect dosage of the detergent rarely occurs because service providers and manufacturers have a strong interest to deliver good washing results with least possible detergent input and will therefore pay high attention to ensure that the right concentration of detergent and laundry aid will be available. In the third case, incorrect dosage might occur from time to time, e.g. in the case of non-trained personnel.

The impact of maloperation is difficult to quantify as it can vary significantly from user to user and also depends on the overall organisation of the laundry process. For example, in market segments with professional washing machines and dryers used by manual programme settings, manual dosage and rather untrained personnel, the error rate might be higher than in market segments with highly trained personnel and machines with higher automatisation rate. Thus, due to lack of differentiated feedback from customers, for the purposes of the study and further calculations we assume that the influence on the consumption of energy, water and detergent is on average

- **Washing machines:**
  - Categories WM1-3, WM5: **+15%** and
  - Categories WM4, WM6-7: **+10%** compared to ideal energy, water and detergent consumption.

- **Dryers:**[29]
  - Categories D1-5: **+15%** and
  - Categories D6-7: **+10%** compared to ideal energy consumption.

4.2 Influence of low-power modes consumption

Washing machines and dryers might not be switched off directly after the end of the programme and therefore remain a certain time in "left-on mode". In this low-power mode[30], the equipment may persist for an indefinite time after completion of the programme without any further intervention by the end-user besides unloading of the appliances.

The following Tables 11 and 12 show the typical time and power consumption of professional washing machines and dryers in low-power mode.

For household appliances, the aim is to reduce the low power modes consumption (in case the user does not switch off the appliance after operation). For especially the larger professional machines and dryers the consumption of the low-power mode is negligible due to optimized machine performance. Only for washing machine and dryer categories WM1–3 and D1–3 standby data could be quantified and thus will be outlined in the further chapters of this study. The power consumption in off-mode has not been considered as it is negligible compared to the overall energy consumption of the machines.

Table 11 Typical time in low-power mode(s) consumption of professional washing machines

Washing machine category	Time in low-power modes per day	low power modes consumption (in kWh/h)
WM1: Semi-professional washer extractor	120 min	~0.003
WM2: Professional washer extractor, <15 kg	120 min	~0.003
WM3: Professional washer extractor, 15-40 kg	120 min	~0.003
WM4: Professional washer extractor, >40 kg	negligible	negligible
WM5: Professional washer dryer	n.a.	n.a.
WM6: Professional barrier washer	n.a.	n.a.
WM7: Washing tunnel machine	negligible	negligible[31]

n.a. = no information available *(Source: manufacturers' data)*

[29] According to feedback from manufacturers at the final Lot 24 stakeholder meeting.

[30] According the Directive 2009/125/EC with regard to ecodesign requirements for household washing machines.

[31] Washing tunnel machines and transfer dryers are usually heated by steam or gas (sometimes hot water or thermo oil). Only 5% (washing tunnels) resp. 10% (transfer dryers) of the total energy consumption is by electricity (e.g. motor) (see Task 4). The time in low-power mode is negligible due to the optimized machine performance, resulting in standby consumption in a per mille area.

Table 12 Typical time in low-power mode(s) consumption of professional dryers

Dryer category	Time in low-power mode per day	Low-power mode consumption (in kWh/h)
D1: Semi-professional dryer, condenser	180 min	~0.0025
D2: Semi-professional dryer, air vented	180 min	~0.0025
D3: Professional cabinet dryer	180 min	~0.003
D4: Professional tumble dryer, <15 kg	n.a.	n.a.
D5: Professional tumble dryer, 15-40 kg	n.a.	n.a
D6: Professional tumble dryer, > 40 kg	negligible	negligible
D7: Pass-trough (transfer) tumble dryer	negligible	negligible[31]

n.a. = no information available *(Source: manufacturers' data)*

4.3 Energy, water and detergent consumption under real-life usage conditions

The following tables summarise the different influence parameters of the sections above and show the annual consumption of energy, water and detergent (incl. laundry aid) for each of the seven washing machine and dryer categories under real-life conditions in the main customer segment. The results show that under real-life conditions the additional consumption of energy, water, detergent and laundry aid might be 20 to 35% higher compared to ideal conditions.

Table 13 Annual energy, water and detergent consumption (real life conditions) of all washing machine categories

Category	Energy consumption	Water consumption	Detergent / laundry aid consumption
	kWh/year	litres/year	kg/year
WM1: Semi-professional washer extractor	1 332	85 050	161
WM2: Professional washer extractor, <15 kg	3 026	233 280	330
WM3: Professional washer extractor, 15-40 kg	10 973	740 610	798
WM4: Professional washer extractor, >40 kg	81 648	3 265 920	4 199
WM5: Professional washer dryer	7 400	99 900	140
WM6: Professional barrier washer	26 461	1 080 960	1 216
WM7: Washing tunnel machine	1 606 500	27 540 000	41 310

Table 14 Annual energy consumption (real life conditions) of all dryer categories

Category	Energy consumption
	kWh/year
D1: Semi-professional dryer, condenser	4 877
D2: Semi-professional dryer, air vented	4 552
D3: Professional cabinet dryer	5 924
D4: Professional tumble dryer, <15 kg	9 936
D5: Professional tumble dryer, 15-40 kg	32 805
D6: Professional tumble dryer, > 40 kg	171 360
D7: Pass-through (transfer) tumble dryer	979 200

4.4 Measures to optimise user behaviour and consumption parameters

According the analysis of Task 3 and Task 4 it is evident that a better use of laundry appliances can save a substantial amount of resources and costs. On the other hand, the additional consumption which is due to real-life conditions and behaviour will be reduced with the development and use of more efficient washing machines and dryers.

The additional consumption through real-life use results from five major reasons which could be improved by education, incentives and responsibilities. For example, it is important to explain the consequences of partial loading the machine to users as this aspect leads to increased energy, water and detergent/rinse aid consumption. To avoid maloperation during the dishwashing process, responsibilities clearly assigned to users might be helpful, e.g. concerning the dosage of the detergent and laundry aid.

In case of washing machine and dryer operators not being well informed about low power modes consumption, a first step could be to educate them about such consumption in order to facilitate reduced times in low power modes of the machines (e.g. not switching on machines until needed, switching off if not needed any more).

A more detailed discussion of technical improvement options (BAT) compensation real life user behaviour, like for example automatic information and control systems, sensor systems regulating the water consumption of washing machines or the residual moisture control of dryers, will be accomplished in Task 6.

5 Local Infrastructure

This section aims at identifying opportunities and obstacles linked to the local infrastructure which can influence the choice of professional washing machines and dryers.

5.1 Water supply

The water for the laundry process can be received by municipal supply or by usage of self supply (e.g. fresh water taken from wells, springs, rivers and – theoretically - rain water that mainly has to be pre-treated before application in laundry). Water acts as heating medium, transport medium and solvent for detergents and soil, and additionally it transfers the mechanical action of the washing machine to the laundry.

Professional washing machines can either be connected to cold and/or warm water supply. The machines also occupy a drain valve for the waste water. According to stakeholders' feedback connection only to warm water does not make sense; also low temperatures are needed as using only hot water could fix stains like blood or other proteins on the textiles.

5.2 Energy infrastructure of different heating options

This section aims at identifying the different ways to heat the water of washing machines and the air of dryers depending on the infrastructure available on site, which might influence the overall choice for a specific type of washing machine or dryer. On the other side, the different heating systems result in different environmental impacts and different operating costs accordingly.

For heating processes in laundries, different energy sources can be used[32]: electricity, steam, hot water, natural gas, and thermo oil[33] (extra light or heavy). Hot water or steam is generally used to generate process heat; electricity and gas are used for direct machine heating as well as for indirect application to heat transfer media. Thermo oil is normally applied in industrial plants (see following figure).

The specific advantages or disadvantages of the different heating mediums will be described in Task 6.

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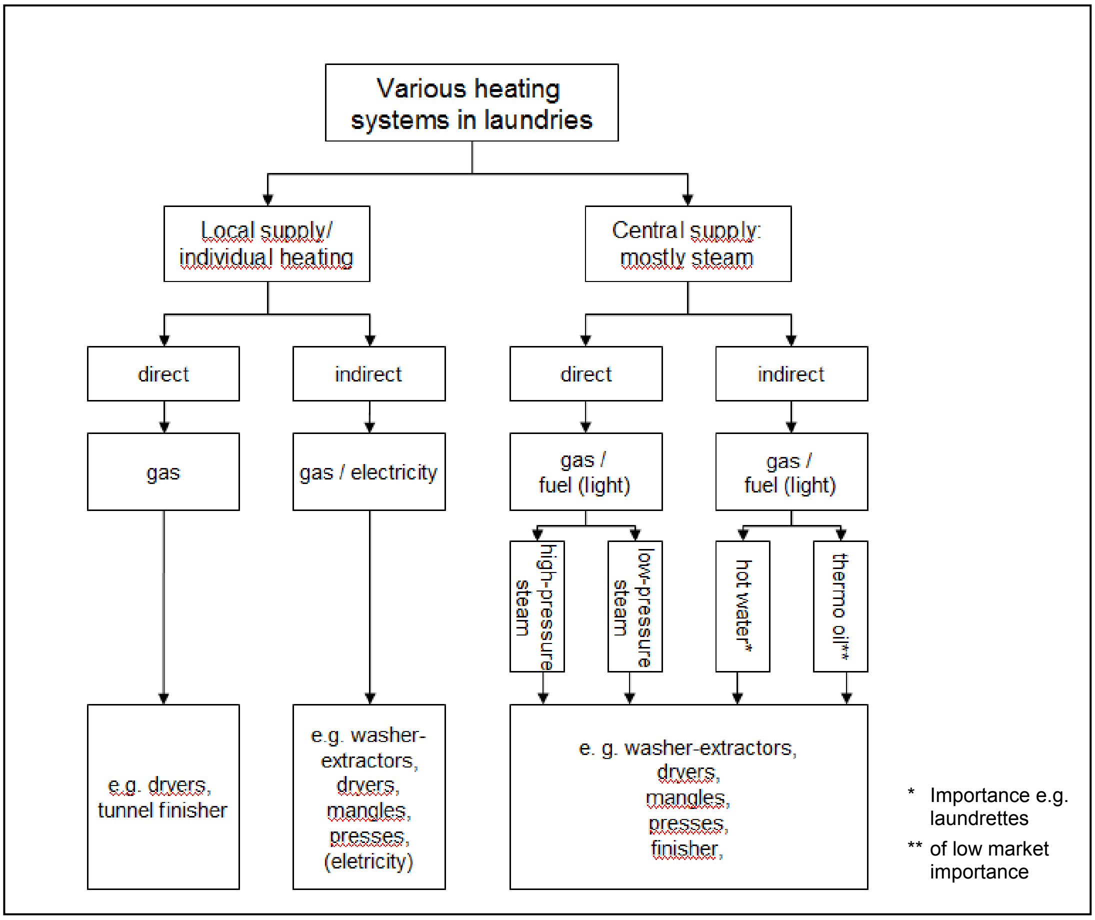
[32] The energy consumption of a washing machine or a dryer is defined as the number of kilowatts hours of steam, gas, electricity or heat-transport fluid required for washing, extraction as well for drying of the load.

[33] Thermo or thermal oil in heat transfer systems is used to transmit thermal energy. It is heated in a heater and transported by pipeline to the places where a machines needs to be heated. An advantage of thermal oil compared to conventional heat sources such as hot water is the much higher boiling point. For example, the temperature reaches above 300°C. Thermal oil can be produced from both synthetic and organic oils.



(Source: BDEW, http://www.gewerbegas-online.de/index.php?id=262)

Figure 2 Various heating systems in laundries

Regarding the internal or external heating[34] for washing machines and dryers, the different water or air heating options can be structured as follows:

- internal
  - electric heating,
  - natural gas heating,
  - steam heating,
- external heating (washing machines: the supplied water is already warm; dryers: hot air input from external source) by any sources like e.g. gas or fuel, and
- others.

[34] **Internal heating** refers to a heating process that takes place within the machine (direct heating); whereas **external heating** refers to a process that takes place outside the machine (i.e. the air or water already arriving at the machine is already heated up so that the machine itself does not need any more energy for heating).

The following tables show the share of different energy sources to heat up the water for washing machines and the air for dryers in the main customer segments.

Table 15 Energy Sources for water heating in professional washing machines

Washing machine category	Internal heating, Electricity in %	Internal heating, Natural gas in %	Internal heating, Steam in %	External heating (warm water in-put), any source (gas, fuel, …)	Others (please specify): … in %
WM1: Semi-professional washer extractor	60	0	<5	35	0
WM2: Professional washer extractor, <15 kg	55	<2	8	35	0
WM3: Professional washer extractor, 15-40 kg	40	15	25	20	0
WM4: Professional washer extractor, >40 kg	15	18	60	7	0
WM5: Professional washer dryer	100	0	0	0	0
WM6: Professional barrier washer	25	10	45	20	0
WM7: Washing tunnel machine	0	5	95	0	0

(Source: own assumptions based on http://www.gewerbegas-online.de and stakeholder feedback)

Table 16 Energy Sources for heating in new professional dryers

Dryer category	Internal heating, Electricity in %	Internal heating, Natural gas in %	Internal heating, Steam in %	External heating (hot air input), any source (gas, fuel, …)	Others (please specify): … in %
D1: Semi-professional dryer, condenser	100	0	0	0	0
D2: Semi-professional dryer, air vented	65	35	0	0	0
D3: Professional cabinet dryer	100	0	0	0	0
D4: Professional tumble dryer, <15 kg	45	50	5	0	0
D5: Professional tumble dryer, 15-40 kg	30	45	25	0	0
D6: Professional tumble dryer, > 40 kg	10	50	40	0	0
D7: Pass-trough (transfer) tumble dryer	0	65	35	0	0

(Source: own assumptions based on http://www.gewerbegas-online.de and stakeholder feedback)

Washer-dryers, semi-professional condenser dryers and cabinet dryers are only available with electric heating. According to stakeholders, other heating sources do not make sense as throughputs are lower and the necessary infrastructure is often not available for these categories.

Only a small share of washing maschines (5 to 18%) uses internal heating with natural gas. For dryers, gas heating is significantly more common (35 to 60%). The use of gas as energy source for heating is economically[35] and ecologically more efficient compared to the average European electricity generation mix[36], however it requires special connections and a special tube for exhausting the air[37].

In most washing machines categories, except for washer dryers, large washer extractors and tunnel washing machines, a certain share of appliances is heated by externally heated hot water. Washing tunnel machines (WM7) and heavy duty dryers (D7) are either heated by steam or by gas.

Further findings can be drawn:

- Other heating options, e.g. solar energy, are not yet adopted in practice. The producers of laundry equipiment do not have any experience in this field.
- No significant variations of the existing infrastructure between the different EU Member States have been reported by stakeholders.

In large professional laundries usually a wide range of machinery and options are used to process the different types of laundry. To optimize the laundry operation both under economical and environmental aspects, the machines used for washing, extraction, drying and finishing are often integrated into a comprehensive energy and water management system. Thus, in such laundries the water and energy consumption per kg laundry is often lower compared to the operation of single machines. Such an infrastructural optimisation however cannot be conducted on a single-product basis but only on basis of the whole laundry process system, considering key factors like available energy and water sources, amount of laundry and existing floor space. It therefore goes beyond the scope of the preparatory Lot 24 study at hand.

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[35] See gas and electricity prices in Task 2.

[36] The share of the electricity from renewable sources in EU27 is 15.6%. However, for instance in Norway the share of the hdryo power generation is 105.1% and therefore more ecologically efficient than the use of gas. (Source: Eurostat, May 2009 and Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market.

[37] A more detailed discussion of the different heating options will be accomplished in Task 6.

6 Maintenance and repairs, end-of-life behaviour

Regular maintenance of the machines has a preventive function, thus ensuring that signs of wear at the machinery can be detected and replaced betimes. Furthermore, it can be assumed that damaged professional devices are rather repaired than replaced due to the relatively high purchase costs of professional washing machines and dryers. At a certain point, however, the user will replace the machine with a new one.

Professional washing machines and dryers with high capacities usually are regularly maintained, at least once a year. Thus, laundries with a high demand of washware (and therefore a high risk in case of failure) usually have a service and inspection contract with the manufacturer or a special service provider. For smaller devices (semi-professional), this is not usual. The repairs are almost exclusively done at the customers' premises. No additional transport of the devices is necessary. In this context, fast availability of a qualified technician by customer service is important.

If the washing and drying demand of a customer changes over time, he can sell the washing machine or dryer on the second-hand market where devices offered in most cases have lower performance and higher consumption data than models manufactured/sold new on the market. However, there is only a relative small market for used washing machines and dryers (UK,[38] Germany[39] and in Eastern Europe). Disadvantage for purchasera might be that they usually get no warranty for the product. In some cases, manufacturers or their sellers can act as brokers, if one of their customers wants to exchange a still operating appliance, and another customer is looking for a used device.

Almost no professional washing machines and dryers will end at a landfill, as the materials (mostly stainless steel) are too valuable. For this reasons, the products would always either be refurbished or recycled for scrap parts or materials. However, it could not be excluded that difficult recyclable residues such us printed circuit boards (PCB) are disposed of.

At the end of their life, professional washing machines and dryers are usually received in payment by the manufacturer of the new machine as the largest proportion of the machine is of valuable stainless steel. They are sold by the user to be scraped or to second hand dealers. Some parts of the machine can directly be reused; the rest of the machine will be sold to recycling companies.

The smaller semi-professional machines are collected by certified scrap dealers. According to stakeholder feedback, the owner of an old washing machine or dryer will usually get small revenue of about 50 to 100 Euros from the scrap dealer, depending on the prices of commodities.

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[38] Mainly in UK, http://www.clmlaundry.co.uk/used_machines.php, sighted on 10 August 2010

[39] http://waeschereitechnik.com/shop_produkt.php?c=164,168&pid=624

7 Annex

7.1 Stakeholder involvement

The working paper containing preliminary assumptions on aspects regarding main applications of professional washing machines and dryers, the typical user behaviour, the influence of real-life conditions on ideal consumption and specific consumption values was circulated to the following stakeholders. The table also indicates from whom responses have been received.

Table 17 Documentation of institutions to which the working document on use phase has been sent out and their responses

	Working paper use phase (covering Task 3 and some aspects of Task 4)	
	Sent out	Feedback
Manufacturers and Industry Associations		
CENELEC (TC59X/SWG 1.12)	Yes	Yes
Electrolux Professional (currently not member of an industry association)	Yes	Yes
Fagor Industrial	Yes	No
GIRBAU	Yes	Yes
IMESA	Yes	No
IPSO		
Miele Professional (sub divison laundry equipment currently not member of an industry association)	Yes	Yes
PRIMUS	Yes	Yes
Schulthess	Yes	No
VDMA, German Engineering Federation – “Garment and Leather Technology”, representing ▪ Kannegiesser ▪ Jensen Group ▪ Eazy Clean (manufacturer dry-cleaning) ▪ Veith ▪ Seibt Kapp	Yes Yes Yes Yes Yes Yes	Yes Yes Yes No No No
Xeros ltd.	Yes	Yes
A.I.S.E. International Association for Soaps, Detergents and Maintenance Products	Yes	Yes
Henkel AG & Co. KGaA (Detergents)	Yes	Yes
User associations		
ETSA (European Textile Services Association)	Yes	No
DTV-Bonn (Germany, Deutscher Textilreinigungsverband e.V.)	Yes	No

	Working paper use phase (covering Task 3 and some aspects of Task 4)	
	Sent out	Feedback
INTEX (Germany, Industrieverband Textil Service)	Yes	No
AFEHC (Spanish exporting manufacturers association for the hospitality industry)	Yes	No
Others		
Danish Technological Institute	Yes	Yes

7.2 Working Paper "Task 3" and additional questions for stakeholders

The general working paper and additional questions for the final report concerning heating options are provided separately in the following documents:

- EuP_Lot24_Wash_T3_T4_Annex_Workingpaper.pdf
- EuP_Lot24_Wash_T2-T7_Questionnaire_for_Final_Report.xls

7.3 Stakeholder feedback to draft versions of Task 3

Please note that the feedback refers to prior versions of draft Task 3 report; thus the indicated numerations of chapters, tables, figures or pages might have changed.

Stakeholder	Clause	Comment	Response
Electrolux Laundry Systems	1.2-1	Standards IEC/EN 60456 and IEC/EN 61121 must be mentioned. In the scope of these standards the user segments of apartment hoses and launderettes are mentioned and therefore a large part of the semi-professional and professional segments are covered	Considered in revision
	Table 1	We would not recommend that performance standards for professional laundry equipment include sanitation as this will interfere with other standards within the hygienic sector. If wear shall be included this means a test of at least 50 washes (unrealistic)	Considered in revision
	Table 2 and other tables	The abbreviations are not stringent. All market segments shall have abbreviations and they shall be stringent within all tables in the report.	Considered in revision
	2.2	2nd last part. As the standard for tumble dryers is very high.... Unclear Last part: It is not the different types of machine that are operated by different kind of users. Also semi-professional machines can be operated by trained people in industrial market segments. This part must be rewritten saying that private customers use the machines in apartment house and launderette segments and trained and non trained operators may use the equipment in hospitality and healthcare sectors	Considered in revision

Stakeholder	Clause	Comment	Response
	Table 3	The table must be changed according to the comments above. Type of users follows market segments and not the type of machines	Considered in revision
	2.3	1st part. Last sentence is not clear. Rewrite? 2nd part page 13.Text is wrong. Hand washing has not a more important part in mechanical action. For hand washing action is lower, temperature (usually) lower and amount of detergent less compared with normal machine washing. The difference is the performance level of the wash result. 3rd part. Text wrong. Water is not an extra factor. Water is a large (dominating) part within the chemistry sector of the circle. 1st part page 14.Last sentence: Time can reduce energy. Longer programmes do not need the same temperature for equal performance	Considered in revision
	Table 4	WM1. Delete washing machine in text Semi-professional washing machine and washer-extractor. No comments will be given in this table and all other tables regarding detergent consumption.	Considered in revision
	Table 5	A range should be given for the energy consumption as in table 4	Considered in revision
	Table 6	WM5 the 100% shall be in hospitality and not CCL/HAL. See also comment table 2.	Considered in revision
	Table 7	Water consumption shall be 12 litre/kg load	Considered in revision
	4.3.1 Table 10	WM1 Duration of CCL/AHL semi professional machine shall be 35–55 min. Most common temperature is 40°C WM2 Time shall be 35–50 min and most common temp 40°C WM3 CCL/AHL most majority is n/a. Time hospitality 50 min and time health care hospital 50–60 min. Temp health care hospital is 60C+	Considered in revision
	Table 11	D1–D2 Use of std programme shall be 100% on all. Temp shall be 70C on all. D3 Time CCL/AHL and Hospitality shall be 45–60 min. Temperature shall be 60°C. Std programme 100% D4 and D5 Temp shall be 70C. Std programme 100%	Considered in revision
	4.4 Table 14	Time standby for WM2 and WM3 120 min	Considered in revision
	4.5	2nd part page 36. Do not believe that industrial laundries consume only 10–20% detergent /kg compared to domestic. Less but not so little.	Noted
	5.3	3rd part. Few machines are received in payment at replacement. They are sold by the user to be scrapped or to second hand dealers	Considered in revision
	Table 17	No washing machine (or extremely few) is direct heated with gas. The warm water may be heated by gas. Therefore column 3 and 4 should be merged. The values for column 4 may be correct.	Considered in revision
	Table 18	D3: 0% for Electricity & gas. D4 Electricity 60% Elctricity & gas 40% Steam 0%. D5. Electricity30% Elctricity & gas 50% Steam 20%, D6 Electricity20% Elctricity & gas 60% Steam 20%	Considered in revision
	Table 19	Use of warm water WM1 50%, WM2 70% WM3 100% and WM4 (0–20)%	Considered in revision

Stakeholder	Clause	Comment	Response
	6.1.3	Second last sentence. Adding only hot water in first wash (main wash) is not a good practice as hot water will fixate stains of blood and other proteins. Therefore the savings should only be calculated on half the amount of water in main wash.	Noted
	Table 21	Column must be added with conditions according to EN/IEC 60456. The accuracy of the specified parameters in ISO 9398-4 are too wide to be useful in a performance standard.	Considered in revision
	Table 22	Column must be added with conditions according to EN/IEC 61121 The accuracy of the specified parameters in ISO 9398-2 is also too wide to be useful in a performance standard.	Noted
Miele Professional	Page 7	It should be noticed, that the described washing process in ISO 9398-4 does not decribe the common used process in the industry. Especially the use of chlorine bleach is most likely not used anymore.	Noted
	Page 8	Data for a possible standard test can't be "partly sanitation". This should be taken out of the spread sheet. Reason: As soon as it comes down to hygienic aspects there are specific requirements in different countries which need to be fullfilled during the wash process. Mostlikely the hygiene process is related to a specific temperature profile or to a specific process which includes also the use of specific soap/disinfectant. Pending in the definition it might be important at what time step during the wash cycle the soap/disinfectant needs to get dispensed.	Noted
		Consumption data: The amount of detergent should be standardized (e.g. ISO 60456). Reason for that is, to get also the performance of the wash included in the possible standard test. If the amount of soap would be not clearly defined, the result will be not comparable. Even the mark indicates the same approche; it should be taken out of the table.	Noted
	Page 10	Similar to WM1 to WM4	
		In general...washing machine is to clean, rinse and extract.	
	2.2 Page 11	Cancle the word "excess"	Considered in revision
		Cancle → (single product solution or comprehensive laundries)	Considered in revision
		The type of soiling instead the type of pollution	Noted
		Instead of sanitary field → health care sector	Noted
		High capacities and short running times → that's what usually accounts	Noted
		Instead of spatial requirements → dimensions of the appliance	Noted
		The fact that somebody is well trained doesn't mean automatically that industrial processes are more economical than professional appliances.	Noted
		Operator: Semi-professional → Trained and non trained personnel should be included Professional → dto. Heavy duty → dto.	Considered in revision
		The customer group definition should be from Task 1 to Task 7 the same	Noted

Stakeholder	Clause	Comment	Response
		Domestic → 1:6, X to 1:9 Semi Professional → 1:8 to 1:10 Professional → 1:9 to 1:12 Heavy duty → 1:10 to 1:12 All those numbers are based on standard cotton load	Considered in revision
		Domestic → 1:16 to 1:18 Semi Professional → 1:18 to 1:25 Professional → 1:18 to 1:25 Heavy duty → 1:20 to 1:25 All those numbers are based on standard cotton load	Considered in revision
		Domestic → 2 500 – 5 000 I doubt that heavy duty is designed for more than 30 000 cycles – from our point of few there is no difference to the Professional equipment.	Considered in revision.
		Typo – cleaning efficiency.	
		Wash time domestic for 60°C from xx to yy – here I would recommend to use some wash times from differen manufacturers	
		Wash time professional washer from xx to yy e.g. 30 min to 60 min.	Considered in revision.
		... . In addition, water quality (water hatdness, heavy metal conc.) will inluenece the washing cycle	Noted
		The capacity ... , with a filling ratio of 1:10, depending on the declaration of the manufacturer	
		The given data is based on cold water connection and some numbers are based on hot water connection (most likely with 60°C)	
		Mostlikely the detergent is not based on ISO 9398-4 – reason is, that the desribed cycles are not really common cycles in the market (still using hypochlorite etc.)	
		I would add: While the extraction process, especially with the development of high speed washers, the following drying process is getting influenced by the washer more and more.	
		As long as there is no specific wash cycle defined the table doesn't make sense. E.g. Are those parameters reflecting the consumption data of a 60°C cycle where the machine will achieve 60°C – or will the machien achieve only 40°C? As long as the parameters of a wash cycles are not defined the range from to has to be enlarged quite a bit. For example WM1 – from 0.1 to 0.24 kWh/kg This has to be discussed in general! The average use of soap should be defined by the detergent manufacturer.	Noted
		Same as comment above re the washing machines. As long as we have no specific drying cycle defines the numbers are not relevant. The range can go from 0.4–0.6 kWh/kg.	Noted
		In technical leaflets is no information re the usage of detergent/laundry aid	

7.4 Use of other programmes in different customer segments

Besides the most used programme, other common programmes are selectable which mainly differ by their duration, temperature and the respective cleaning performance, thus also resulting in different consumption values. Section 4.1.3 provides an overview of the typically used programmes (temperature, programme duration) for each product category in the respective main customer segment. Data for typically used programmes in other customer segments are given in the following Table 18 and Table 19.

Table 18 Programme selection of professional washing machine categories, further customer segments

Customer segment	Duration of the typically used washing programme	Share of the typically used washing programme	Temperature of the typically used washing programme
WM1: Semi-professional washer extractor			
Coin & Card / AHL	**35–55 min**	**60%**	**40°C**
Hospitality	35–55 min	70%	60°C
Health care Hospital	35–55 min	70%	>60°C
Health care Nursing home	35–55 min	80%	60°C
Commercial Laundry	n.a.	n.a.	n.a.
Speciality Laundry	n.a.	n.a.	n.a.
WM2: Professional washer extractor, <15 kg			
Coin & Card / AHL	**35–55 min**	**60%**	**40°C**
Hospitality	30–50 min	60%	40°C
Health care Hospital	30–50 min	80%	>60°C
Health care Nursing home	30–50 min	80%	60°C
Commercial Laundry	25–45 min	80%	60°C
Speciality Laundry	45 min	60%	60°C
WM3: Professional washer extractor, 15-40 kg			
Coin & Card / AHL	30 min	60%	60°C
Hospitality	**50 min**	**60%**	**60°C**
Health care Hospital	50–60 min	80%	>60°C
Health care Nursing home	45 min	80%	60°C
Commercial Laundry	30 min	80%	60°C
Speciality Laundry	30 min	60%	60°C
WM4: Professional washer extractor, >40 kg			
Coin & Card / AHL	n.a.	n.a.	n.a.
Hospitality	50 min	80%	60°C
Health care Hospital	45 min (programmable)	60%	>60°C
Health care Nursing home	45 min (programmable)	60%	60°C
Commercial Laundry	**30 min (programmable)**	**60%**	**60°C**
Speciality Laundry	30 min (programmable)	60%	60°C
WM5: Professional washer dryer			
Coin & Card / AHL	75 min (wash and dry) 50 min washing time	60%	60°C
Hospitality	**75 min (wash and dry) 50 min washing time**	**60%**	**60°C**
Health care Hospital	n.a.	n.a	n.a.

Customer segment	Duration of the typically used washing programme	Share of the typically used washing programme	Temperature of the typically used washing programme
Health care Nursing home	n.a.	n.a	n.a.
Commercial Laundry	n.a.	n.a	n.a.
Speciality Laundry	n.a.	n.a	n.a.
WM6: Professional barrier washer			
Coin & Card / AHL	n.a.	n.a	n.a.
Hospitality	n.a.	n.a	n.a.
Health care Hospital	**45 min (programmable)**	**60%**	**>60°C**
Health care Nursing home	**45 min (programmable)**	**60%**	**>60°C**
Commercial Laundry	45 min (programmable)	60%	n.a.
Speciality Laundry	n.a.	n.a.	n.a.
WM7: Washing tunnel machine[40]			
Coin & Card / AHL	n.a.	n.a	n.a.
Hospitality	n.a.	n.a	n.a.
Health care Hospital	n.a.	n.a	n.a.
Health care Nursing home	n.a.	n.a	n.a.
Commercial Laundry	**30 min**	**>90%**	**Pre-rinse / main wash / rinse zone 40°C / 70–80°C / 40°C**
Speciality Laundry	n.a.	n.a	n.a.

n.a. = not applicable or no information available so far *(Source: specified manufacturers' data)*

Dryers

Table 19 Programme selection of professional dryer categories, further customer segments

Customer segment	Duration of the typically used drying programme	Share of the typically used drying programme	Temperature of the typically used drying programme
D1: Semi-professional dryer, condenser <8kg			
Coin & Card / AHL	**30–45 min**	**100%**	**70°C**
Hospitality	45 min	100%	70°C
Health care Hospital	45 min	100%	70°C
Health care Nursing home	45 min	100%	70°C
Commercial Laundry	n.a.	n.a.	n.a.
Speciality Laundry	n.a.	n.a.	n.a.
D2: Semi-professional dryer, air vented <8kg			
Coin & Card / AHL	**30–45 min**	**100%**	**70°C**
Hospitality	45 min	100%	70°C
Health care Hospital	45 min	100%	70°C
Health care Nursing home	45 min	100%	70°C
Commercial Laundry	n.a.	n.a.	n.a.
Speciality Laundry	n.a.	n.a.	n.a.

[40] Transfer time through all compartments of the washing tunnel machine

Customer segment	Duration of the typically used drying programme	Share of the typically used drying programme	Temperature of the typically used drying programme
D3: Professional cabinet dryer			
Coin & Card / AHL	**130 min**	**60%**	**90°C**
Hospitality	n.a.	n.a	n.a.
Health care Hospital	n.a.	n.a	n.a.
Health care Nursing home	n.a.	n.a	n.a.
Commercial Laundry	n.a.	n.a	n.a.
Speciality Laundry	n.a.	n.a	n.a.
D4: Professional tumble dryer, <15 kg			
Coin & Card / AHL	**30 min**	**>95%**	**70°C**
Hospitality	30 min	>95%	70°C
Health care Hospital	30 min	>95%	70°C
Health care Nursing home	30 min	>95%	70°C
Commercial Laundry	20 min	>95%	70°C
Speciality Laundry	20 min	>95%	70°C
D5: Professional tumble dryer, 15-40 kg			
Coin & Card / AHL	30 min	>95%	70°C
Hospitality	**20–30 min**	**>95%**	**70°C**
Health care Hospital	30 min	>95%	70°C
Health care Nursing home	30 min	>95%	70°C
Commercial Laundry	20 min	>95%	70°C
Speciality Laundry	20 min	>95%	70°C
D6: Professional tumble dryer, > 40 kg			
Coin & Card / AHL	n.a.	n.a.	n.a.
Hospitality	30 min	60%	60°C
Health care Hospital	30 min	60%	60°C
Health care Nursing home	30 min	60%	60°C
Commercial Laundry	**15–20 min**	**80%**	**60°C**
Speciality Laundry	20 min	80%	60°C
D7: Pass-trough (transfer) tumble dryer[41]			
Coin & Card / AHL	n.a.	n.a	n.a.
Hospitality	n.a.	n.a.	n.a.
Health care Hospital	n.a.	n.a.	n.a.
Health care Nursing home	n.a.	n.a.	n.a.
Commercial Laundry	**15–25 min**	**> 90 min**	**Fresh air ~200°C Exhaust air ~100°C**
Speciality Laundry	n.a.	n.a.	n.a.

n.a. = not applicable or no information available so far
(Source: specified manufacturers' data and stakeholder feedback from survey)

[41] Transfer time of a transfer dryer