Sustainability Profile Professional Textile care in the Netherlands

Main claims:

Sustainable laundry by outsourcing domestic laundry:

- ***“>17% less energy!”***
- ***">24% CO_2 reduction!”***
- ***“Per washing cycle; >15 L of water savings (more than 35%)!"***
- ***"Potentially more than 80% water savings: 3.477 L of water per person per year!"***
- ***"Plastic soup: Domestic laundry more than 33%, professional laundry: 0.1%"***

Subclaims

Professional hygienic laundry:

- *">33% Energy Savings and >38% reduction of CO_2 emissions compared to domestic laundry"*
- *"Potentially 60% CO_2-reduction compared to domestic laundry! (at low temperature)"*

Solvent Cleaning:

- *The current professional textile cleaning has on average a factor 2 - 3 lower environmental impact than domestic laundry.*
- *"Does not contribute to the plastic soup!"*

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<u>Index</u>

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1) Why this report?

In general, everyone agrees that a focus on reducing climate change is important for companies. With climate change becoming increasingly apparent together with the recent reports about problems with micro plastics in the ocean, sustainability has become a major concern for businesses. The government in the Netherlands has set the goal of achieving a reduction in greenhouse gas emissions of 90% compared to 1990 in 2050 [9]. That's why they have set a goal of a green house gas emission reduction of 49% in 2030 [9]. In 1990, emissions were 228 Mton CO_2 equivalent per year. Therefore, to achieve this goal, greenhouse gas emissions must be reduced by 116 Mton CO_2 equivalent in 2030 [9]. In addition to already existing measures, it was established that 48,7 Mton CO_2 must additionally be reduced to achieve this goal, which is why there are multiple extra measures agreed upon in the climate agreement (klimaatakkoord). In this agreement, the savings are distributed over a number of industries, including homes and small businesses. This last sector covers also the consumer energy consumption and therefor also domestic laundry. This sector has the task to reduce an additional 3,4 megatons of CO_2 [9]. So, in addition to the industry, the citizens will also have to take their responsibility for this issue. This can be done by insulating houses, but there are also many opportunities for laundry.

Currently, around 5% of all laundry is washed by the professional textile cleaner. That means that 95% is still washed by ordinary laundry machines at home. There is still a lot to be gained here. The fact that the industrial laundry sector is constantly working on sustainability can also be deduced from the fact that in the last 10 years, energy consumption in the industry has decreased by 25%. In this report we will demonstrate that a professional laundry uses less energy, and that outsourcing of domestic laundry could lead to a significant reduction of CO_2 emissions. The total CO_2 that is emitted because of the laundering of clothes ultimately only contributes a small amount (1%) to the total CO_2 emissions in the Netherlands [2]. We will not solve the entire climate objective of the Netherlands, but outsourcing of domestic laundry can still lead to interesting energy savings.

2) Goal

The information in this rapport will provide a clearer picture of the environmental impact of domestic and professional laundry. The CO_2 emissions of an average person will be used as a reference. The aim is to compare the CO_2 emissions as a result of domestic laundry with data from the professional textile care sector. A distinction will be made here between the present reduction of CO_2 emissions and water and energy savings and the potential for the future.

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3) Collected data

To calculate the CO_2 emissions resulting from domestic laundry, professional laundry and professional cleaning as accurately as possible, data from literature was used as much as possible together with the results of various TKT studies. Below is a summary of the data collected for 3 different sectors:

1. Domestic laundry
2. Retail / textile cleaning
3. Industrial laundry

3.1 Domestic laundry

The energy consumption of the domestic laundry is based on the data presented in the review: "Water and Energy Consumption in Domestic Laundering Worldwide" [1]. This study assumes a laundry machine of 5 kg with an average load of 3,7 kg. This value is also used in 2 previous studies [12, 13]. In [1] an average temperature for domestic laundry of 41°C for the Netherlands is given. The average laundry temperature for a large number of countries is shown in the table below. The values in this table are composed of values in multiple publications [11, 14, 15].

Table 1 Energy consumption in Europe for domestic laundering according to [1]

Country	T/°C (average)	E/kWh cycle^{-1}	T/°C (average)	E/kWh cycle^{-1}
Austria	43.0	0.64		
Belgium	42.1	0.62		
France	39.7	0.57	41.8	0.62
Germany	42.2	0.63	45.0	0.69
Netherlands	41.0	0.60		
Switzerland	42.8	0.64		
Greece	41.5	0.61		
Italy	40.4	0.59	42.2	0.63
Portugal;	36.5	0.50		
Spain	33.9	0.44	33.9	0.44
Turkey	42.5	0.63		
Bulgaria	42.4	0.63		
Czech Republic	44.3	0.67	46.0	0.71
Hungary	41.8	0.62	46.1	0.71
Poland	44.0	0.67	47.4	0.74
Romania	42.8	0.64		
Slovakia	43.5	0.66		
Denmark	43.0	0.64		
Finland	45.1	0.69	46.5	0.72
Norway	45.2	0.69		
Sweden	45.3	0.70	47.3	0.74
Ireland	39.7	0.57		
UK	39.0	0.56	40.5	0.59

The energy consumption for domestic laundry and drying in the Netherlands per kg of laundry is shown in Table 2.

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Table 2 Energy consumption and CO_2 emissions due to domestic laundry of textiles [2]

$E_{washing}$ in kWh/kg	E_{drying} in kWh/kg	E_{total} in kWh/kg	$E_{primary}$ in MJ/kg	CO_2 in kg CO_2 eq./kg
0,16	0,32	0,48	4,32	0,27

As there are no data presented on drying in the Netherlands in [1], data from Germany have been used here, assuming that the drying process in Germany is comparable to that in the Netherlands.

Table 3 presents an overview of the energy consumption and CO_2 emissions as a result of domestic laundry throughout the Netherlands. After some calculations, as shown in table 4, it follows that approximately 352 kg of laundry is washed per person per year with a CO_2 emission of 96 kg CO_2 equivalent. If we use the value for the number of washes per person per year from table 4, together with the value of 44 litres / wash [2], it follows that 4,180 litres of water per year are used for domestic laundry. In addition, domestic laundry contributes per person per year between 2 and 20 g [5] of fibres to the plastic soup. The domestic laundry is responsible for the more than 33% of microfibers in the ocean [7].

Table 3 CO_2 emissions and energy consumption due to domestic laundry of textiles [2]

N per person per day	M in kg per wash	n	Q in ton per year	$E_{primary}$ in TJ/year	CO_2 in ton CO_2 eq./year
0,26	3,7	17.300.000	6.100.000	26.266	1.669.000

N = number of washing cycles
n = number of Dutch inhabitants
M = Machine load in kg per wash cycle
Q = mass of washed textile

Table 4 The total mass of washed textile (Q) and water consumption (W) for an average person per year.

N per person per day	N per person per year	M in kg per wash	Q in kg per person per year	W in L per wash [2]	W in L per year
0,26	95	3,7	352	44	4.180

3.2 Retail (textile cleaning)

For the data in the retail calculation the numbers for cleaning with PERC are used as described in the TNO reports “Sustainable cleaning” [3] and "Sustainable cleaning II" [19]. A calculation tool on the site of “klimaatplein” (climate square) [4] for the conversion of different energy units was used. It follows from this calculation, that the average amount of textile cleaned in PERC (352 kg per person per year) is equal to 62,22 kg CO_2 equivalents per person per year. This means that the process of the dry cleaner leads to approximately 36% less CO_2 emissions compared to the laundry at home. A number of aspects must be taken into account. The calculation for cleaning with PERC, is based on the assumption that the heated cooling water of the cleaning machines is re-used in another process at the same location, which is for most of the dry-cleaners state of the art [3]. For industrial laundry the logistics are included, it has been decided not to include this for the dry cleaning, since the majority of the garments will be brought by the customer himself. In the dry-cleaning process, the still residue, where the loosened fibres (microplastics) are gathered after each cycle, is burned. This mean that the textile cleaner does not contribute to the plastic soup.

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3.3 Industrial laundry

All the data for the CO_2- and water consumption in the industry were gathered from "Sustainability of professional textile care" [2]. Here also a comparison between industry and domestic laundry was made. In this study, the domestic laundry was compared to a washing process in a washing tunnel with a temperature of 40°C. The energy consumption data used in this study were gathered from a TNO report from 2014 [16]. The effect of temperature on energy consumption per kg of laundry is shown in Table 5.

Table 5 Energy consumption for professional laundry as a function of the process conditions [2, 16]

Proces	$E_{elektrisch}$ in kWh/kg	$E_{gas\ in}$ Nm^3/kg	E in MJ/kg
Wasbuis, 40°C	0,0971	0,0743	3,20
Wasbuis, 60°C	0,0971	0,0772	3,28
Wasbuis, 75°C	0,0971	0,0965	3,89
Wasbuis, 85°C	0,0971	0,1265	4,84
Open-end, 40°C	0,107	0,103	4,56
Open-end, 85°C	0,107	0,176	6,88

**(Wasbuis = Tunnel Washer)*

If the collection and delivery of the textile is included in the calculation, this will result in a CO_2 savings of more than 24% from textile washed by the industry compared to domestic laundry. The average water consumption in industrial laundry is currently 7,6 l / kg [10] which amounts to an average of 28,1 litre per washing cycle when converted to the average size of a home laundry load of 3,7 kg [1]. This amounts to an average of approximately 2.671 litres per person per year. However, there are values for the industrial water consumption reported in which 2 l / kg of water was used, which is 7,4 litres per washing cycle of 3,7 kg. This would be equal to an average of 703 litres per person per year. The contribution of the PTC industry to the plastic soup is negligible at 0,1% [5] .

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4) CO_2 emissions RTC vs. domestic laundry

In order to be able to make a good comparison between the RTC and domestic laundry process, a number of calculations have been used wherein the average is calculated what a single person washes in a year. We then check how much energy is used in both processes and what that means for the CO_2 - emissions. This will result in a value that indicates the difference in sustainability for both processes. This calculation assumes that the dry cleaner will deal as efficiently as possible with its energy by using the heat from the cooling water in another process. The efficiency of the energy generation is included in this calculation.

4.1 Domestic laundry: 96,65 kg CO_2 equivalent per person per year

As shown in Table 4, we can assume 0,26 washing cycles per day for an average person[6]. A load of 3,7 kg [1] is assumed per wash, which is approximately a 75% load of a 5 kg laundry machine. This corresponds to approximately 352 kg of laundry per person per year.

The amount of energy used per kg of laundry in the washing process for the Netherlands is 0,16 kWh / kg [2], which results in 56,32 kWh per person per year. Using the German energy consumption for the drying, which is 0,32 kWh / kg [11], this results in an energy consumption of 112,64 kWh per person per year for the drying of laundry. In the calculation of this average energy consumption for domestic drying, a correction was incorporated for the fact that a part of domestic laundry is line dried. The total energy consumption for laundry and drying is then 168,96 kWh per person per year.

Currently 0,572 kg CO_2 is released in the Netherlands for the production of 1 kWh of electricity [2]. This results in on average emission of 96,65 kg of CO_2 per person per year coming from domestic washing!

4.2 RTC: 62,22 kg CO_2 per person per year

For professional cleaning, the data for PERC cleaning have been used as determined by TNO [3]. For a load of 80%, the energy consumption is 2,88 $MJ_{primary}$ per kg of textile for a steam-heated machine. However, approximately 1,72 MJ per kg of heat can be recovered from this machine by reusing the cooling water in another process. The corrected energy consumption is then 1,16 MJ per kg of laundry, which is 408,32 MJ per person per year (for 352 kg of laundry per year). With 38,7 MJ/m^3 from the "Natural gas conversion guide" [18], this corresponds to 10,55 m^3 of gas per person per year. This is equivalent to 19,94 kg of CO_2 emissions [4].

For drying (electric) you end up with a consumption of 0,15 kWh per kg. The remaining energy used (including electrical) is equal to 0,06, kWh per kg. The total consumption of electrical energy will be 0,21 kWh per kg = 73,92 kWh per person per year. Assuming the same value for the number kg CO_2 per kWh we used in the domestic wash calculation, then this amounts to 42,28 kg CO_2 per person per year for the industrial cleaning.

For professional cleaning this results in an emission of 62,22 kg CO_2 per person per year. So, this is a savings of an average of 34,43 kg of CO_2 (36%) per person per year compared to the CO_2 emissions as a result of domestic laundry! This savings is only possible if the warm cooling water can be reused in the wet cleaning process. Any logistical

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contribution due to the collection / delivery of the laundry is not included here. It is, of course, not realistic to assume that the entire domestic wash is going to be cleaned in solvents in the future, this calculation is merely meant as an illustration in order to compare the sustainability of both processes with each other. The contribution to the plastic soup for solvent cleaning is 0, because the plastic microfibers end up in the distillation residue which is burned.

4.3 RTC: Environmental impact on avg. a factor 2-3 lower

The environmental impact of the different professional textile cleaning processes compared to that of domestic laundry was also examined by TNO in 2010 [3] with a follow-up in 2012 [19]. In the first study an environmental impact analysis was made of the following textile cleaning processes:

- Professional textile cleaning with perchlorethylene (PERC)
- Professional textile cleaning with hydrocarbon (HCS)
- Professional wet cleaning
- Laundry at home comparable to an average household (47% of the laundry is dried by machine and 53% on the line)
- Washing at home like households that have a laundry machine and tumble dryer (72,5% of the laundry is dried by machine and 27,5% on the line)

In the follow-up study [19], a number of other dry cleaning processes were added, such as iPura HCS, iPura Siloxane D5, Siloxane D5, Rynex E3 and Solvon K4.

The following environmental effects were included in the analysis:

- of the production of consumed resources (cleaning agent, solvent, water);
- of the generation of the energy used in the cleaning;
- of emissions (water, solvent, cleaning agent).

The environmental impact of the different aspects is expressed in costs using the shadow cost method. The total environmental effect is the summation of the shadow costs of 10 different environmental effects. These costs provide an indication of the social costs of combating the consequences (emission and exhaustion) of material use. The 10 different effects are: depletion of abiotic raw materials (ADP), acidification (AP), eutrophication (EP), climate change (GWP), ozone depletion (ODP), human toxicity (HT), aquatic ecotoxicity (FAETP), marine ecotoxicity (MAETP), terrestrial ecotoxicity (TETP) and photochemical oxidant formation (POCP). The efficiency of the steam generation, which is used for the (indirect) heating in the PERC / HCS process, is estimated at 80% [3]. The distillate is cooled with cooling water, which is heated from 10 to 37°C [3]. This heated cooling water, which after storage / transport still has a temperature of on average 30°C [3], is assumed to be reused in the wet cleaning or laundry machines. To fully reuse this, approximately 3x as much laundry production is required as PERC production [3]. Most dry cleaners are set-up for this [3]. Almost all the solvent used is recovered, the only loss is the residue PERC / HCS that is still in the garments, this is a maximum of 10 g / kg of cleaned laundry [3].

For the professional wet cleaning, a temperature of 40°C is maintained, this is the same temperature as chosen for the domestic wash. In this calculation assumes an intake temperature of 15°C of the water. In practice, pre-heated cooling water will be used from the PERC / HCS machines. However, this savings has already been allocated to the PERC / HCS machines. In this study, it was assumed that steam was used to heat the tumble dryer and not the more energy-efficient gas heated dryers.

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The results for the different processes are shown schematically in the figures below. Figure 1a+b shows the shadow costs per process as presented in the TNO report from 2010 [3] and the follow-up report respectively [19]. Figure 2 shows the greenhouse effect, expressed in kg CO_2-equivalents. In the figures 1a and 1b it is shown, that the total shadow costs caused by the professional cleaning methods are 40-65% lower than the average shadow costs of domestic washing.

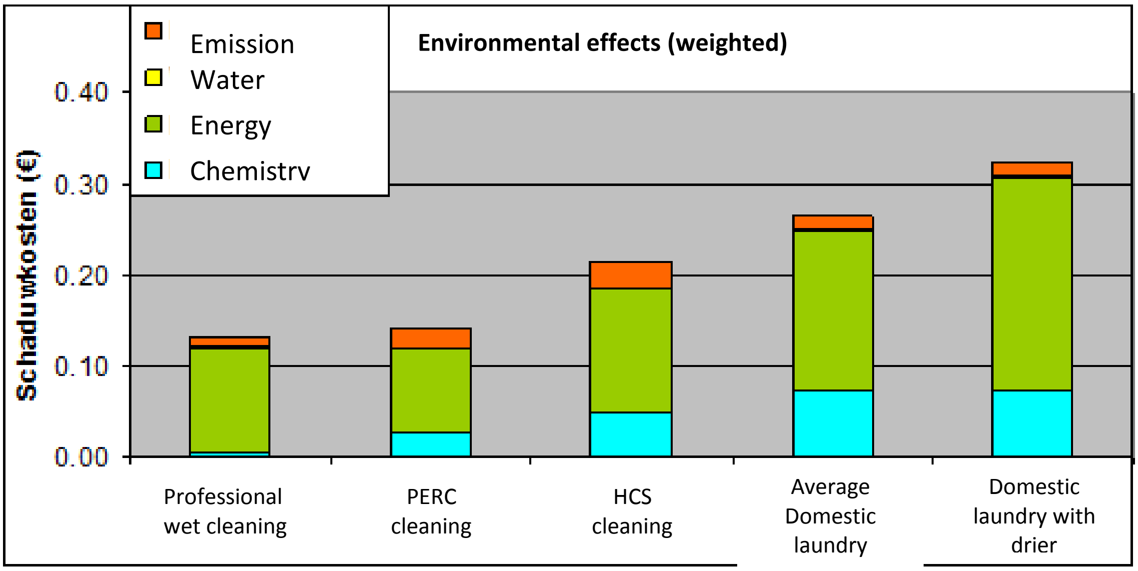

Figure 1a Total shadow costs of 10 different environmental effects for 5 types of cleaning for 4 kilograms of laundry [3]

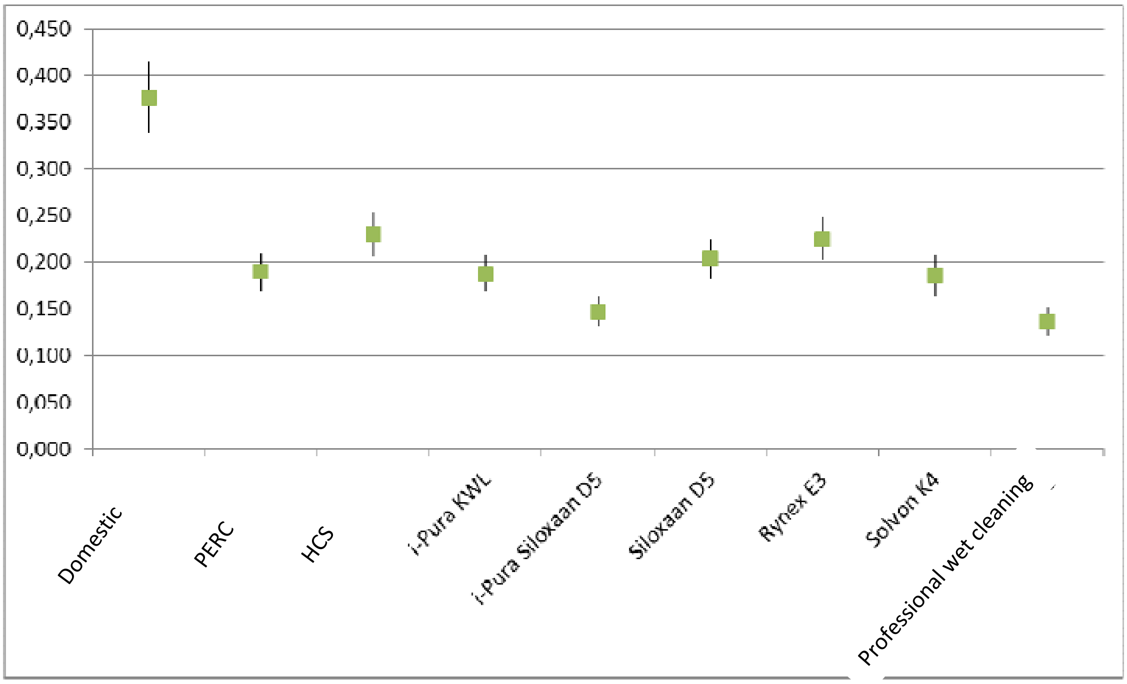

Figure 2b Total shadow cost of 10 different effects on the environment for cleaning and drying of 4 kilograms of laundry [19]

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Figure 2 shows the greenhouse effect caused by the professional cleaning processes expressed in CO_2 equivalents. It can be concluded from the figure below that this is 25-45% [3] lower compared to the average greenhouse effect of domestic laundry. This corresponds to the average values calculated in Chapter 4.2.

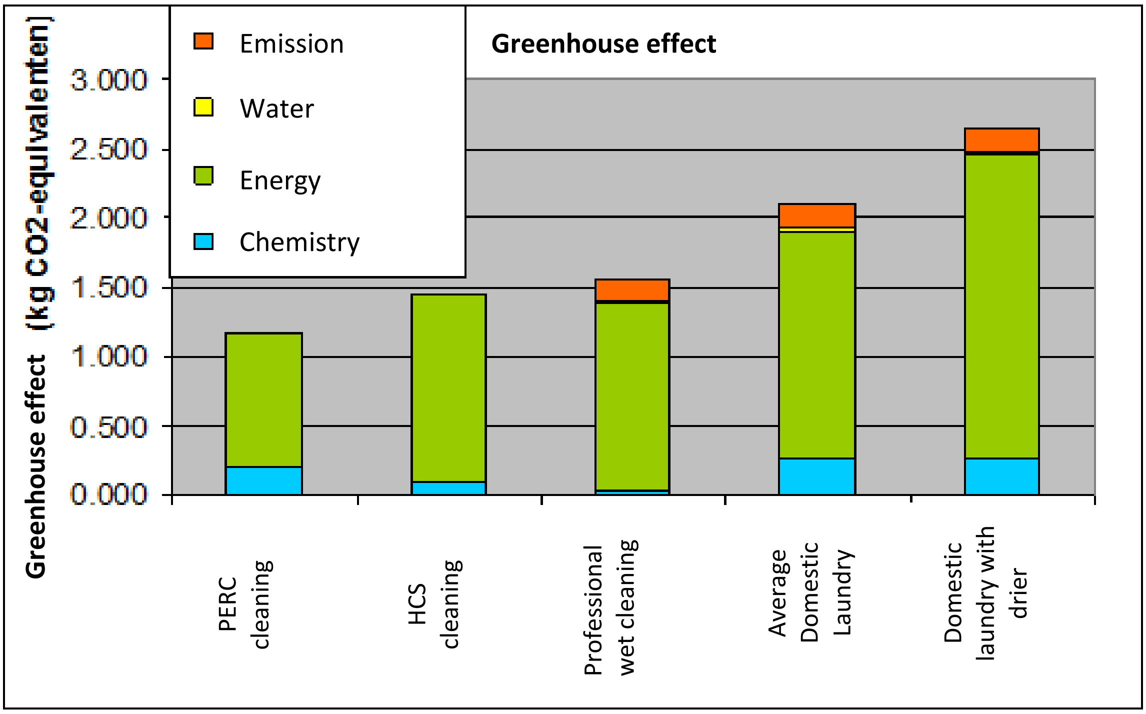

Figure 3 Comparative greenhouse effect of 5 types of cleaning of 4 kg of laundry [3]

The general conclusion of the analysis in the TNO report [3, 19] is that the current professional textile cleaning has on average a 2-3 times lower environmental impact than domestic laundry. Within professional cleaning, professional wet cleaning and perchlorethylene cleaning have relatively the lowest environmental impact. This is true for:

- the mild professional wet cleaning as described in ISO 3175-4, which has been developed for relatively lightly soiled sensitive garments (such as wool);
- the perchlorethylene cleaning according to the latest state of the art (so-called 6th generation). This limits the loss and emissions of perchlorethylene to less than 10 grams per kilogram of cleaned laundry;
- the situation in which PERC cleaning is combined with wet cleaning and/or laundering. As a result, the cooling water used for perchlorethylene cleaning and the heat contained therein can be successfully used in the wet cleaning or laundering machines. In practice, the combination of wet cleaning/laundering with perchlorethylene and / or hydrocarbon cleaning almost always occurs.

The environmental impact of domestic laundry appears to be relatively strongly influenced by the drying method applied. The more laundry is machine dried in tumble dryers, the greater the environmental impact. Currently, on average 46% of the washed laundry is machine

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dried. This percentage shows an upward trend over time. More and more households are getting access to a machine tumble dryer. Households who have access to a machine tumble dryer, use it to dry 72,5% of the washed laundry.

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5) CO_2 ITS vs. domestic laundry

5.1 2-3x more environmentally friendly

In a report from TNO from 2011 [8] a comparison has already been made of the sustainability aspects between domestic laundry and industrial wet laundry. In this study, the focus was the work clothes for hospital staff. The energy consumption was compared with the assumption, that the same quality requirements were set for both processes. This means that in order to ensure the same hygienic standards and bacteria reduction, a temperature of 92°C for the domestic laundry must be maintained [8]. This study showed that energy consumption, as shown in Table 6, is 2-3 times higher for domestic laundry.

Table 6 Specific energy consumption E (in MJ primary energy per kilo of laundry) for wet laundry and drying of two types of laundry [8]

	$E_{Domestic}$ in MJ/kg	$E_{Industrial\ Laundry}$ in MJ/kg
Workwear Hospital staff	11,7	4,1
Workwear Industrial staff	9,4	4,7

5.2 24,2% reduction in CO_2 emissions

In the report "Sustainability of professional textile care" [2] calculations have been made for domestic laundry in comparison with measured data from the Industrial Textile Service. Table 7 and Figure 3 show the values for CO_2 emissions of the Dutch laundry sector in recent years. These values were measured in the context of the annual monitoring for the LTA methodology [10]. A reasonable assumption made in [2] is that it covers around 85% of the total market.

Table 7 Historical development of energy consumption and CO_2 emissions by professional textile care [2, 10]

	2012	2013	2014	2015	2016	2017
E in MJ/kg	5,95	5,77	5,45	5,39	5,27	5,08
E in kWh/kg	0,17	0,16	0,16	0,15	0,16	0,15
E in Nm3/kg	0,14	0,14	0,13	0,13	0,12	0,12
CO_2 in kg CO_2 eq./kg	0,35	0,34	0,32	0,31	0,31	0,30

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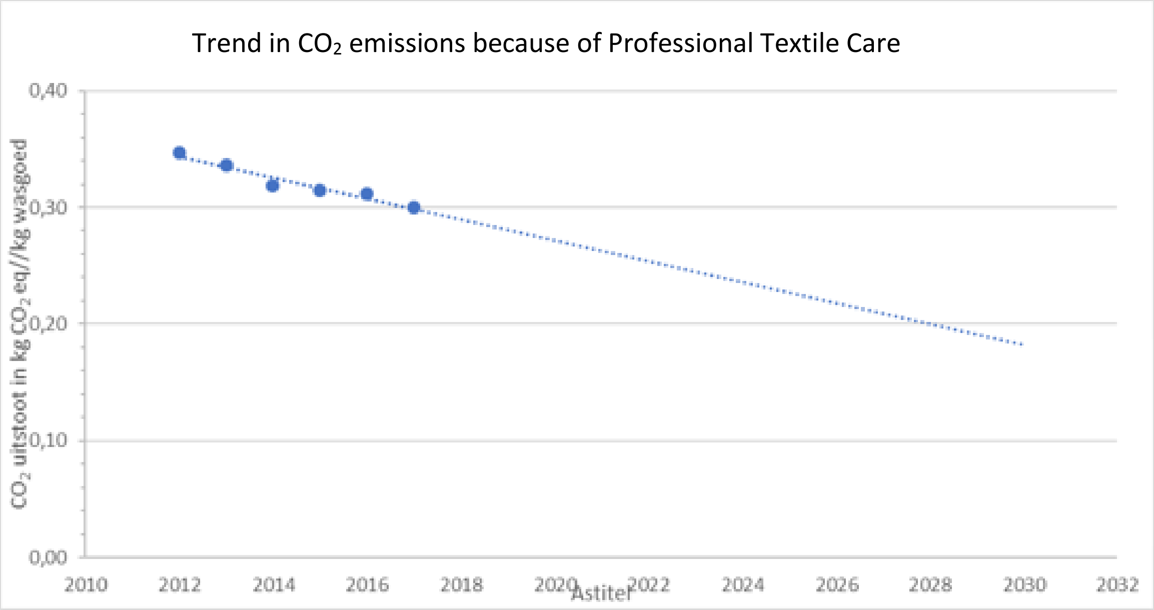

Figure 4 Trend in CO_2 emissions from professional textile care [2]

A trend can be seen from these figures which, if it continues, shows a CO_2 emission of 0,35 kg CO_2 eq./kg in 2012 to around 0,18 kg CO_2 eq./kg in 2030 [2]. This would be a reduction of CO_2 emissions of almost 50% in 2030 compared to 2012.

In [2], the energy use and the resulting CO_2 emissions were compared for the average professional laundry process in a washing tunnel at 40°C compared to the domestic wash. The results are shown in Table 8. It can be concluded from this data, that if consumers outsource their laundry to a professional textile launderer, energy savings of 17,5% and a reducing of 24,2% in CO_2 emissions can be achieved.

Table 8 Energy consumption and CO_2 emissions domestic laundry compared to professional laundry [2]

	$E_{electric}$ in kWh/kg	E_{gas} in Nm³/kg	$E_{logistic}$ in MJ/kg	E in MJ/kg	Savings in %	CO_2 in kg CO_2 eq./kg	Savings in %
Professional 40°C	0.0971	0.0743	0.34	3.57	17.5	0.21	24.2
Domestic	0.48			4.32		0.27	

5.3 3.477 litres of water saving

For the Netherlands, a water consumption of 44 litres per wash was noted for domestic laundry [2, 17]. For this value it is assumed that the water consumption in Germany, which is shown in the table 9, is comparable to that of the Netherlands. The different columns correspond to various papers from which these data have been collected [2]. The data for Germany originates from [17].

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Table 9 Overview of water consumption in domestic laundering in l / cycle worldwide [2]

Country	Water/L cycle^{-1}	Water/L cycle^{-1}	Water/L cycle^{-1}	Water/L cycle^{-1}
Australia	60			
Canada	144			
China	99			
Japan	120		110	
Korea	140			
Turkey	60			
USA	144	157	160	
Europe			75	
Germany				44

From the MJA-monitoring (Multiple Year Agreement), an average water consumption of 7,6 litres per kg is found, which amounts to 28,3 litres per washing cycle of 3,7 kg. If we again assume 0,26 washes per person per day [6], that comes out to around 95 washes per year. That means that at present, the professional laundry of textiles saves on average more than 1.491 L of water per person per year. From measurements at companies [10], it appears the water consumption for laundering can be reduced down to 5 or even 2 litres / kg. A tunnel washer which uses 2 L / kg, would use 7,4 litres per (home) wash load of 3,7 kg. This would result in a saving of 44 – 7,4 = 36,6 litres per washing cycle (83,2%). The water saving as a result of outsourcing of domestic laundry can therefore potentially grow to more than 80%. The results of these calculations are shown in Table 10. This means that if eventually the newest tunnel washers are used with water usages of 2 L / kg, then per year up to 3.477 litres of water per person can be saved!

Table 10 Potential for saving water when replacing textile laundry at home with professional laundry [2].

	W in L/kg	M washing cycles in kg	W in L/cycle	Saving in L/cycle	Saving in %
Domestic			44	0	0
FTN 2016	7,6	3,7	28,3	15,7	35,8
Professional 40°C	5	3,7	18,5	25,5	58,0
Potential	2	3,7	7,4	36,6	83,2

W = Water usage

5.4 Contribution of 12% to the climate agreement

In the table 11 is displayed, the CO_2 reduction is presented for different percentages of outsourcing of domestic laundry. In this table the CO_2 emission as a result of domestic laundry is compared with that of professional laundry in a washing tunnel at 40°C. When Dutch consumers decide to outsource 100% of the domestic laundry of textiles to the professional textile care, it provides a reduction of more than 400.000 tonnes of CO_2-eq. emissions.

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This reduction of 400.000 tonnes of CO_2 would then account for 12% of the additional reduction of 3,4 Mton CO_2 as agreed upon in the Dutch climate agreement for the domestic sector.

Table 11 Energy saving and CO_2 reduction if part of the domestic laundry were professionally washed [2]

% thuis was -> professioneel		Q in ton per jaar	E in TJ/jaar	Besparing in TJ/jaar	CO_2 in ton CO_2 /jaar	Besparing CO_2 in ton CO_2 /jaar
5 %	Professioneel 40 °C	304002	1084	229	63242	20225
	Thuis	304002	1313		83467	
10%	Professioneel 40 °C	608004	2168	459	126483	40450
	Thuis	608004	2627		166934	
15%	Professioneel 40 °C	912006	3252	688	189725	60675
	Thuis	912006	3940		250400	
20%	Professioneel 40 °C	1216008	4336	917	252967	80901
	Thuis	1216008	5253		333867	
50%	Professioneel 40 °C	3040021	10840	2293	632417	202251
	Thuis	3040021	13133		834668	
75%	Professioneel 40 °C	4560031	16260	3439	948625	303377
	Thuis	4560031	19699		1252002	
100%	Professioneel 40 °C	6080041	21680	4586	1264833	404503
	Thuis	6080041	26266		1669336	

5.5 60% energy reduction for hygienic laundry

To get the same hygienic quality in domestic laundry, a high temperature of 92°C is necessary [8]. The same hygienic quality can however be achieved with a lower temperature in the professional process. Therefore, professional laundering of textiles, which require an hygienic cleaning treatment, currently results in an energy savings of 33,2% and a reduction of 38,6% in CO_2 emissions, which is equivalent to a reduction of greenhouse gas emissions of 64.000 tonnes of CO_2 equivalent per year for the Netherlands [2].

In Table 12 it is shown, that if the Dutch professional laundry sector for hygienic cleaning would switch to full hygienic laundry at low temperatures, which is now already technically possible with the newest processes, this would result in energy savings of 56,5% and a reduction of 60,0% in CO_2 emissions, or a reduction in greenhouse gas emissions of 100.000 tonnes of CO_2 equivalent per year [2].

Table 12 Potential energy savings and CO_2 reductions through professional hygienic laundry at 40°C [2]

	$E_{electric}$ in kWh/kg	E_{gas} in Nm^3/kg	$E_{logistic}$ in MJ/kg	E in MJ/kg	Savings in %	CO_2 in kg CO_2 eq./kg	Savings in %

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Professional Batch washer 40°C	0,0971	0,0743	0,34	3,57	56,5	0,21	60
Hygienic Domestic laundry	1,037			8,19		0,52	

6) Contribution to the Plastic Soup negligible

In a study by the OSPAR, a committee that is committed to protecting and preserving the North - East Atlantic Ocean, from 2017 [5] an overview is given of the origin of the microparticles (microplastics) that end up in the ocean. The participating countries in this study are: Belgium, Denmark, the European Union, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. The microplastics sources comprise several segments, including fibres released from the wash (laundry fibres). It also covers the emission of a larger plastic waste that is dumped in nature. The estimated source emissions are shown in Figure 4. With a domestic washing cycle, a lot of small fibres will enter the wastewater. This is because in every washing cycle, small fibres of your clothes will break off and because the laundry machine at home has no filter, they will all end up in the sewer.

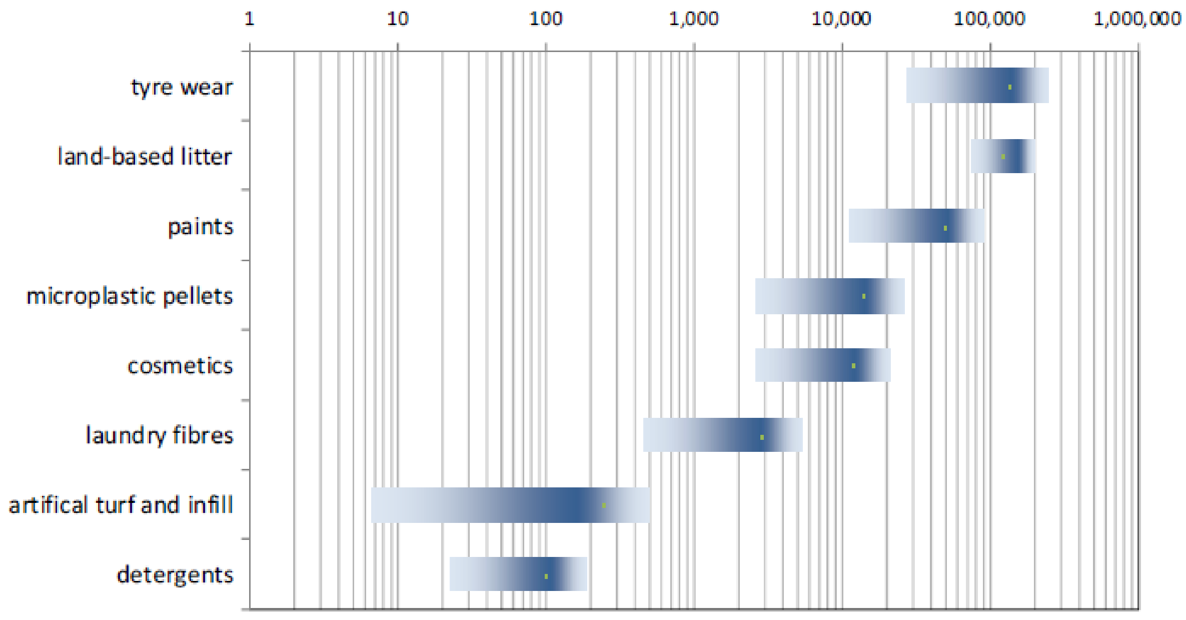

Figure 5 Estimated emissions or microplastics in OSPAR catchments (tonnes / year). The bars represent the uncertainty margins of the emission, white dots represent the midpoint [5]

In a study by the IUCN (International Union for Conservation of Nature), Switzerland [7], it was found that home and professional laundry of textiles contributes almost 35% (34,8%) to the amount of microfibres that end up in the ecosystem. Industrial cleaning hardly contributes to this. This is only approx. 0,1% [5] of the total! This value is based on an estimate that around 9 tonnes of synthetic fibres per year are contributed by the industry (compared to the approximately 8.500 tonnes for domestic laundry as presented in Table 13). According to

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this study, a person contributes between 2 and 20 g of fibres to the surface water per year by doing the laundry at home [5]. The total fibre emissions emitted per year can be seen in Table 13. These values are an average for all participating countries. It is believed that about 2/3 of the fibres remain behind in the sewage sludge, which can eventually can find its way into nature when this sludge is spread out over the fields.

Table 13 Estimated laundry fibre emissions [tonnes / year] in the OSPAR Maritime Area for the reference year 2015 [5]

	OSPAR countries	OSPAR catchment
fibres in laundry effluent	**10,400** (1,600-19,200)	**8,500**(1,300-15,700)
fibres directly to surface water	**1,100** (160-1,900)	**800** (120-1,400)
fibres in STP effluent	**2,600** (410-4,800)	**2,200**(340-4,000)
total laundry fibre emission to water	**3,700** (570-6,800)	**2,900** (460-5,400)
fibres in sewage sludge	**6,700** (1,000-12,400)	**5,600** (880-10,300)

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7) Conclusions

The general conclusion is that the current professional textile cleaner performs in terms of sustainability in many aspects better than domestic laundry. For professional laundry, a reduction in CO_2 emissions of 24,2% is possible compared to domestic laundry.

If we look at workwear that must be hygienically cleaned, laundering in an industrial laundry machine (Batch washer) is even 2 to 3 times more environmentally friendly compared to laundering at home. At present, laundry hygienic textiles counts for energy savings of more than 33% and a reduction of CO_2 emissions of more than 38% CO_2 eq. This number can still be improved. If all the textiles which has to be hygienically clean are cleaned with a cleaning process using a low temperature process , this can result in energy savings of 56%and 60% reduction of CO_2 emissions.

The dry cleaning process is a factor of 2 more environmentally friendly than laundry at home. This is mainly due to the fact that the losses of the solvent are minimized. Innovations in the field of textile cleaning have led to the fact that nowadays a large part of the laundry is wet cleaned (with soap and water) by professional textile cleaners. This method of cleaning has since been described in the international standard ISO 3175-4. This cleaning method appears to have a relatively low environmental impact and the use therefore contributes to a reduction in the total environmental impact. If purely the CO_2 emissions are considered from textile cleaning in the two processes, PERC vs. domestic laundry, this results in 36% less CO_2 emissions. However, the value of 36% is highly dependent on the ability of the cleaner to make the most efficient use of its energy by using the cooling water of the cleaning machines in a different process.

For water consumption, almost 1.500 l of water per person per year is currently saved by the textiles that are washed by the professional. If eventually the latest tunnel washers are used which can reach 2 l / kg, then up to 3.477 litres of water can be saved per person per year compared to the domestic laundry. This is mainly due to the fact that a lot of water can be recycled in the industry, in some cases 70 - 85% of the water can be reused.

The contribution of laundry to the plastic soup is negligible for the industry. As a result of domestic laundry 2 - 20 g plastic microfibres per person per year are disposed to the sea. This results in a 35% contribution to the micro-plastics in the ocean from the laundering of clothes.

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