Cold wash – Tests on the washing performance

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Abstract

Heating-up cold tap water to 30°C, 40°C, 60°C or even 90°C uses the lion's share of washing machines' electricity consumption. «Cold wash» – washing at 15/20°C – saves about 60% electricity compared to a cycle at 40°C. In the EU-27 «cold wash» can save up to 11 TWh per year, which equals 2'200 million Euros or the annual production of the nuclear power plant Emsland.

The EU Ecodesign Regulation requires washing machines to offer a washing cycle at 20°C and a variety of detergent designed for these temperatures are available in Europe. Despite all of this, prejudices and habits prevent most consumers from «cold wash».

Discussions on «cold wash» – especially on the washing performance – run often controversial and emotional. To contribute to the debate with impartial and scientific facts, Topten arranged 24 test situations to measure and compare the washing performance and energy consumption at 40°C and 20°C. Hereby factors influencing the washing result were systematically investigated such as detergent, pre-treatment of stains, washing machines and loading. The tests were carried out in collaboration with the VDE Testing and Certification Institute and with the support of the Elektrizitätswerke des Kantons Zürich and Stiftung Warentest in December 2014.

Good washing performance at 20°C is reached when using a good machine and good detergent. It is assumed that «cold wash» absolutely is appropriate for lightly and normally soiled laundry and that it is worthwhile to encourage consumers to try it out.

The paper concludes with recommendations for various stakeholders such as EU policy makers, manufacturers and retailers, NGOs and academia.

Introduction

The washing of clothes and textiles is part of our everyday routine, but by using energy and water it puts a strain on our environment.

«Cold wash» – washing at 15/20°C – holds a tremendous energy and CO_2 saving potential, as the lion's share of washing machines' electricity consumption is used for heating-up cold tap water to 30°C, 40°C, 60°C or even 90°C.

At EEDAL 2013 Topten presented the paper «Cold Wash – Do Prejudices Impede High Energy Savings?» [1]. It showed that washing machines with a 15/20°C-cycle and appropriate detergent active at these low washing temperatures both are available on the European market. It showed also that in the case a consumer perceives the washing result as insufficient, it is not necessarily the fault of the «cold wash», but may have a number of other causes such as laundry sorting, pre-treatment of stains, loading of the washing machine etc. It was concluded that it is mainly prejudices, but also tradition and custom, that hinder consumers from taking the step towards «cold wash».

According to the Sinner circle the washing performance always depends on the interaction of the four factors temperature, chemistry (e.g. detergent, pre-treating of stains), mechanics (e.g. the agitation of the laundry in the drum) and time. All four factors are interdependent, but inter-changeable in size. If one of the factors is changed, it must be compensated with one or more other factors in order to achieve the same satisfactory washing result.

It is noted repeatedly that discussions on «cold wash» – especially on its washing performance – often run emotional and controversial. To contribute to the debate with impartial and scientific facts, Topten [2] arranged 24 test situations to compare the washing performance at 40°C and at 20°C. Thereby factors influencing the washing performance were systematically investigated at both temperatures such as detergent (three products), pre-treatment of stains (yes and no), washing machines (three models) and loading (half-load and full-load). The measurements followed EN 60456. To the knowledge of the authors, this test arrangement is a novel approach. During the wash cycles also electricity consumption and programme time were recorded. The tests were carried out in December 2014 in collaboration with the VDE Testing and Certification Institute [3] and with the support of the Elektrizitätswerke des Kantons Zürich EKZ [4] and Stiftung Warentest [5].

Hygiene was not part of the tests, although an often noted concern and given argument against «cold wash». The rationale is that hygiene is a complex topic for itself, which should not be correlated only with temperature. One has to be aware that bacteria multiply most rapidly at warm temperatures and not as often feared at 20°C and that it is more relevant how well they get washed out. A research of the University of Bonn and Hochschule Rhein-Waal showed that energy saving washing programmes remove due to their long programme time many germs from the laundry even at low temperatures. Bleach can help hereby. Those bacteria and fungi surviving at low temperatures even with bleach are assumed to be no danger for healthy people [6]. However, it is recommended to frequently wash the laundry at 60°C for persons having a weak immune system, a contagious disease or an allergy on house dust mites [7].

Biofilm was also not part of the tests. This film of bacteria and fungi multiplies in the humid environment of the washing machine and likes to settle especially on plastic parts, hard to reach areas and on the washing machine's drum. However, it can be avoided with simple measures such as taking the laundry as soon as possible out of the machine after washing, leaving the door of the washing machine and of the detergent compartment open so that the residual moisture can evaporate and running a load of laundry at 60°C with heavy-duty detergent occasionally [6], [7].

This paper first describes the methods and test conditions. Then it presents and discusses the results and concludes with recommendations for various stakeholders such as EU policy makers, manufacturers and retailers, NGOs and academia.

Methods and test conditions

The measurements followed EN 60456 [8] with the accordingly test laundry existing of cotton towels, pillowcases and sheets, with the accordingly test strips soiled with the five standardized stains sebum/pigment, mineral oil/black carbon, blood, chocolate/milk and red wine, with the accordingly number of laundry pieces for the loadings «half» and «full» etc. The measurements were carried out under normative test conditions. Details are described in the test report [9].

24 situations were arranged (each 12 at 40°C and at 20°C) to investigate the influence on the washing performance by detergent, pre-treatment of stains, washing machine and loading (Table 1). As some situations could be used multiple times[1] in total 18 tests were carried out (each 9 at 40°C and at 20°C).

[1] Situation S1 is the same as S5; Situation S2 is the same as S8 and S11.

Table 1 Overview on the test arrangement

	Fix	Varying	Temp.	Test		Situation
Influence of detergent	no stain remover good machine half-load	good detergent	40°C	Test 2a	T2	S1
			20°C	Test 2a		
		medium detergent	40°C	Test 3a	T3	S2
			20°C	Test 3b		
		sufficient detergent	40°C	Test 5a	T5	S3
			20°C	Test 5b		
Influence of pre-treatment of stains	good detergent good machine half-load	plus stain remover	40°C	Test 1a	T1	S4
		plus stain remover	20°C	Test 1b		
		no stain remover	40°C	Test 2a	T2	S5
		no stain remover	20°C	Test 2b		
	sufficient detergent sufficient machine half-load	plus stain remover	40°C	Test 8a	T8	S6
			20°C	Test 8b		
		no stain remover	40°C	Test 9a	T9	S7
			20°C	Test 9a		
Influence of washing machine	no stain remover medium detergent half-load	good machine	40°C	Test 3a	T3	S8
			20°C	Test 3b		
		medium machine	40°C	Test 6a	T6	S9
			20°C	Test 6b		
		sufficient machine	40°C	Test 7a	T7	S10
			20°C	Test 7b		
Influence of loading	no stain remover medium detergent good machine	half-load	40°C	Test 3a	T3	S11
			20°C	Test 3b		
		full-load	40°C	Test 4a	T4	S12
			20°C	Test 4b		

Products were selected as followed:

- Detergent: For the tests three detergent were used – a good, medium and sufficient one. The «good» and the «sufficient» detergent were selected with regard to their washing performance according to test results published by Stiftung Warentest [10]. The «medium» detergent corresponded to the standard-detergent «IEC A*» according to EN 60456 [8]. All three detergent were heavy-duty powders with bleach.

- Stain remover: The stain remover was selected on an expert's recommendation and is assumed to be a wide spread product on the European market.

- Washing machines: For the tests three washing machines were used – a good, medium and sufficient one. All washing machines were selected with regard to their washing performance according to test results published by Stiftung Warentest [6]. They are of different brands, but do

all have the same rated capacity, are all rated in the best Energy efficiency class A+++ according to the EU Energy Label [11] and fulfil the EU Ecodesign requirements regarding the washing performance [12].[2]

Test-programmes were the 40°C-standard cotton programme and the 20°C-programme.

- The tested 40°C-standard cotton programme corresponds to the one which is also tested and used for the EU Energy Label [11] and the EU Ecodesign Regulation [12] to calculate the Energy Efficiency Index, water consumption, remaining moisture content and Washing Efficiency Index.
- The tested 20°C-programme is the one, which is mandatory according to the generic Ecodesign requirements since end 2013 [12][3].

With the exception of the tests at full-load (T4a and T4b) it always was tested at half-load[4]. Rationales are: The 40°C-standard cotton programme at half-load is part of the tests needed to calculate the Washing Efficiency Index in accordance with the Ecodesign Regulation [12]. Furthermore half-load better reflects real consumer behaviour: average washing-load in European households is assumed to be between 3 and 4 kg [1].

During the wash cycle electrical energy consumption and programme time were recorded. Also recorded but in this paper not considered were water consumption, amount of alkalinity remaining in the textiles, temperature, maximum spin speed and residual moisture.

After washing the test strips were dried and the reflectance of each of the five stains was measured by a spectral photometer (Figure 1, next page, down right). After the completion of a test cycle the average reflectance-values were derived, which then were summed up to the total reflectance (C_{test}).[5]

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[2] All three tested washing machines have a Washing Efficiency Index I_W of > 1.03 as required by the Ecodesign Regulation for washing machines with a capacity > 3 kg. This requirement corresponds to class A according to the former EU Energy Label for washing machines. On the current EU Energy Label the washing performance is not indicated anymore.

[3] Annex I of the Ecodesign Regulation [12]: «Household washing machines shall offer to end-users a cycle at 20°C. This programme shall be clearly identifiable on the programme selection device of the household washing machines or the household washing machines display, if any, or both.»

[4] Named «partial load» in [11] and [12].

[5] Example Test 1b (20°C): average reflectance-value of sebum/pigment: 71.19, mineral oil/black carbon: 47.18, blood: 75.76, chocolate/milk: 71.35 and red wine: 75.54. → Total reflectance Test (C_{test}): 341.02

Fig. 1: test strips with the five standard stains are sewed on the test laundry (top left), the stains get pre-treated with a stain remover (top middle), loading in accordance with EN 60456 (top right), unloading of the washing machine and tearing-off the test strips (down left), drying the test strips (down middle), measuring the reflectance of the stains (down right)

Washing Efficiency Index

The values of the total reflectance by themselves do not have an explanatory power on the washing performance. Relevant for conclusions is the so called «Washing Efficiency Index».

Therefore the total reflectance (C_{test}) was compared with the total reflectance of a reference machine at 60°C ($C_{ref,\ 60°C}$)[6]. This is the same procedure as applied for the calculation of the Washing Efficiency Index I_W in accordance with the Ecodesign Regulation. However, there it is applied for the combined test series of the three standard programmes 60°C full-load (3x), 60°C half-load (2x) and 40°C half-load (2x), while we here applied it on the tested programmes 40°C half-load (same as used for the EU Energy Label and Ecodesign), 40°C full-load, 20°C half-load and 20°C full-load.

The Ecodesign Regulation requires for washing machines with a capacity > 3 kg a Washing Efficiency Index I_W of > 1.03 for the combined test series of the three standard programmes [12].

In this study the value of «> 1.03» is taken as definition and threshold for «clean» in the sense of the Ecodesign Regulation.

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[6] Example Test 1b (20°C): total reflectance Test (C_{test}): 341.02, total reflectance of reference machine at 60°C ($C_{ref,\ 60°C}$): 330.37 → Washing Efficiency Index (C_{test} / $C_{ref,\ 60°C}$) = 1.032

Results and discussion

About 60% less electric energy consumption per kg load at 20°C than at 40°C

A key finding of this study is: washing at 20°C consumes between 53% and 80% less electrical energy per kg load than washing at 40°C (average: 64%, Figure 2). «Cold wash» thus holds a high saving potential.

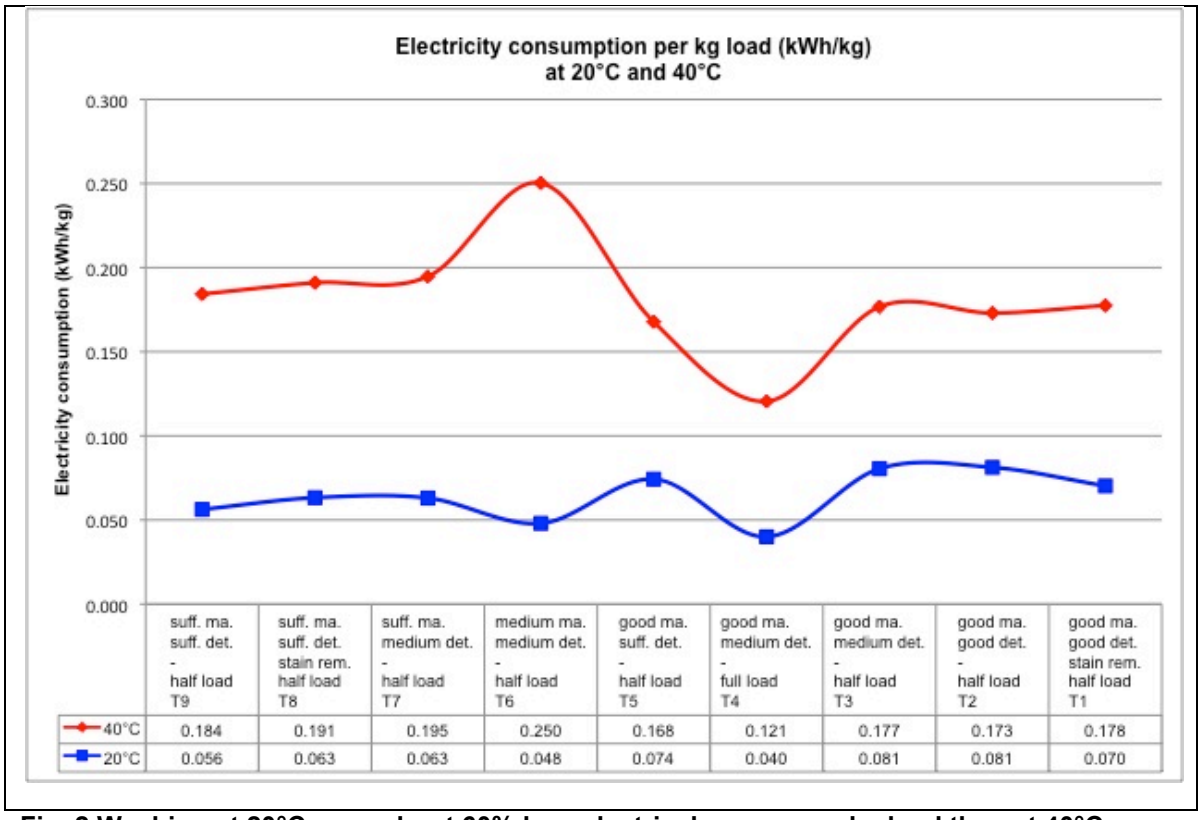


Fig. 2 Washing at 20°C uses about 60% less electrical energy per kg load than at 40°C

Good washing performance at 20°C is possible

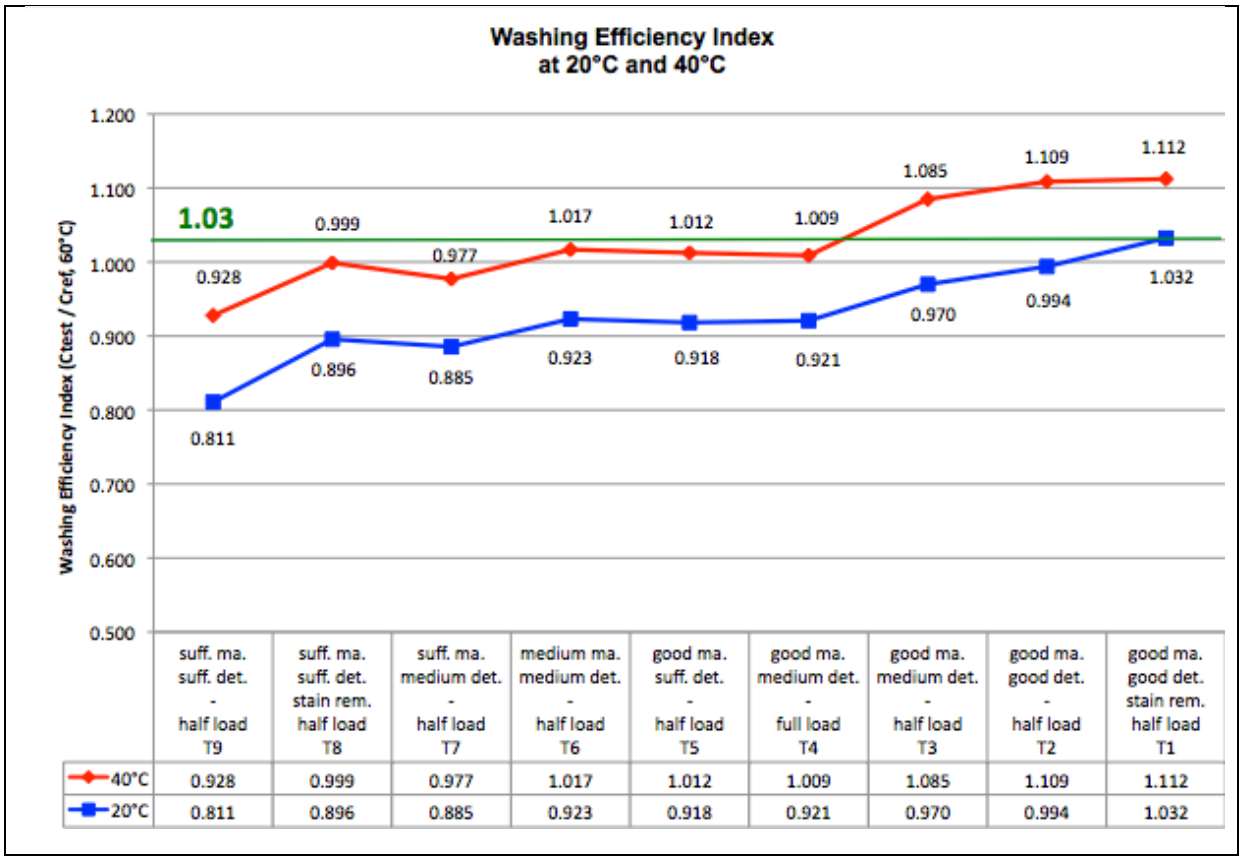
Looking at Figure 3 shows that the Washing Efficiency Index at 20°C is lower than the one at 40°C (in average 0.1). However, this is mainly due to the shorter programme times of the 20°C-programmes compared to the 40°C-standard cotton programmes, which are optimized for the EU Energy Label and Ecodesign requirements (details see below).

It further can be seen, that the washing performance at 40°C as well as at 20°C steadily increases from the worst tested scenario (left, T9: sufficient machine, sufficient detergent, no stain remover, half-load) to the best tested scenario (right, T1: good machine, good detergent plus stain remover, half-load).

However, the most important result of this study is: the combination of a good machine and a good detergent at half-load with or without stain remover reach at 20°C a Washing Efficiency Index of 1.032 (T1) and 0.994 (T2) respectively[7]. These values would comply with the minimum requirements for cleanliness in the sense of the Ecodesign Regulation (> 1.03 = clean, green horizontal line Figure 3).

[7] Annex III of the Ecodesign Regulation [12]: Verification tolerances for the Washing Efficiency Index: the measured value shall not be less than the rated value of the Washing Efficiency Index (I_W) by more than 4%.

For a 20°C-programme these results are remarkable because the level of about 1.03 is usually reached by the 40°C-standard cotton programmes at half-load (experience by VDE).[8]
Another interesting finding is: washing at 20°C can reach approximately the same or even better washing results than washing at 40°C.[9]



	suff. ma. suff. det. - half load T9	suff. ma. suff. det. stain rem. half load T8	suff. ma. medium det. - half load T7	medium ma. medium det. - half load T6	good ma. suff. det. - half load T5	good ma. medium det. - full load T4	good ma. medium det. - half load T3	good ma. good det. - half load T2	good ma. good det. stain rem. half load T1
40°C	0.928	0.999	0.977	1.017	1.012	1.009	1.085	1.109	1.112
20°C	0.811	0.896	0.885	0.923	0.918	0.921	0.970	0.994	1.032

Fig. 3 Washing at 20°C provides good washing results when using a good machine and a good detergent (with or without additional stain remover)

Overall-influence by detergent, pre-treatment of stains, washing machine and loading is higher than the influence by temperature

Figure 4 and Table 2 illustrate that detergent, pre-treatment of stains, washing machine and loading do have an influence on the washing performance at 40°C as well as at 20°C. Summarized:

- Using a good detergent increases the washing result.
- Pre-treating stains raises the washing result, too, especially when using a sufficient detergent.
- The washing result increases with the washing performance of the washing machine.
- The washing performance is better at half-load than at full-load (due to higher mechanical action at half-load).

8 Note: The tests for the calculation of the Washing Efficiency Index according to the Ecodesign Regulation are carried out with the medium detergent (IEC A*, EN 60456), while the results of T1 and T2 base on the usage of the good detergent.

9 Examples: T1 at 20°C (1.032) reaches in six cases better washing results than at 40°C (T4 to T9). T2 at 20°C (0.994) washed in three cases better or approximately as well as at 40°C (T7 to T9).

The overall-influence on the washing performance by detergent, pre-treatment of stains, washing machine and loading is about double than the influence on the washing performance by temperature. (Table 2: From T9 to T1: at 40°C: +0.184 / at 20°C: +0.222; From 20°C to 40°C in average +0.1).

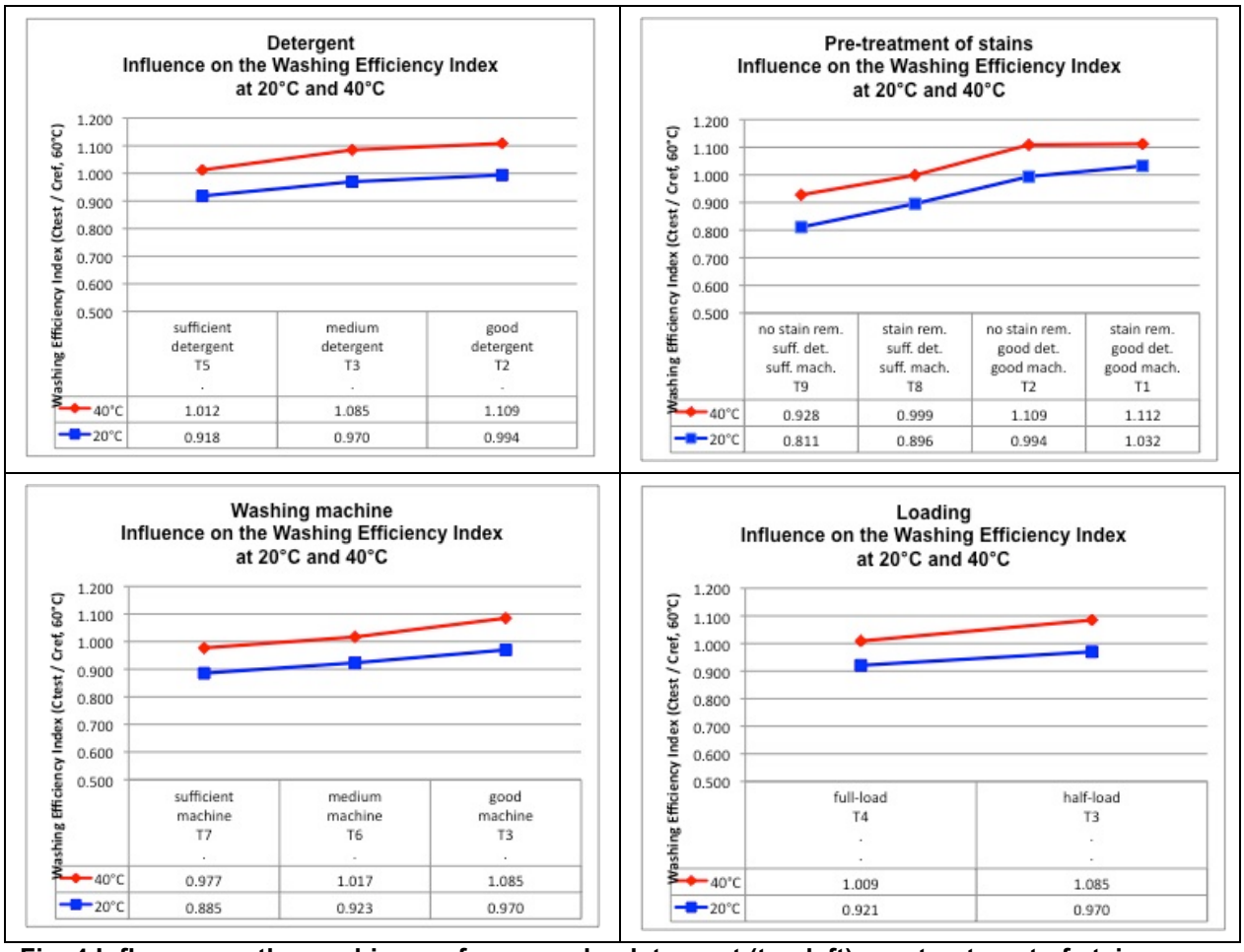


Fig. 4 Influence on the washing performance by detergent (top left), pre-treatment of stains (top right), washing machine (down left) and loading (down right)

Table 2 Overview on the influence on the Washing Efficiency Index by detergent, pre-treatment of stains, washing machine, loading, all parameters together and temperature

Variation of the washing performance due to changes in …	**Washing Efficiency Index**	
	at 40°C	**at 20°C**
Detergent: from sufficient (T5) to good (T2)	+0.096	+0.076
Pre-treatment of stains a) Sufficient detergent + sufficient machine: from «no stain remover» (T9) to «with stain remover» (T8) b) Good detergent + good machine: from «no stain remover» (T2) to «with stain remover» (T1)	 +0.071 +0.004	 +0.085 +0.038
Washing machine: from sufficient (T7) to good (T3)	+0.108	+0.084
Loading: from full-load (T4) to half-load (T3)	+0.076	+0.049
All parameters: from worst scenario (T9) to best scenario (T1)	**+0.184**	**+0.222**
Temperature: from 20°C to 40°C: in average **+0.1**		

Programme time also influences the washing performance

Programme time differed between the 40°C-standard cotton programmes and the 20°C-programmes. The 20°C-programmes were shorter than the 40°C-programmes (Figure 5). They only lasted between 1.5 and 2.5 hours while the 40°C-standard cotton programmes run between 2 and 3 hours. The 40°C-standard cotton programmes are usually optimized to get a good energy efficiency classification on the EU Energy Label and to meet the Ecodesign requirements on the washing performance. Long programme times help to achieve it (Sinner circle).

Furthermore, programme time differed between the three tested washing machines. The good machine (T1 to T5, Figure 5) had considerably longer wash times than the sufficient one (T7 to T9). It washed at 40°C up to 51 minutes longer and at 20°C up to 1 hour longer than the sufficient one.

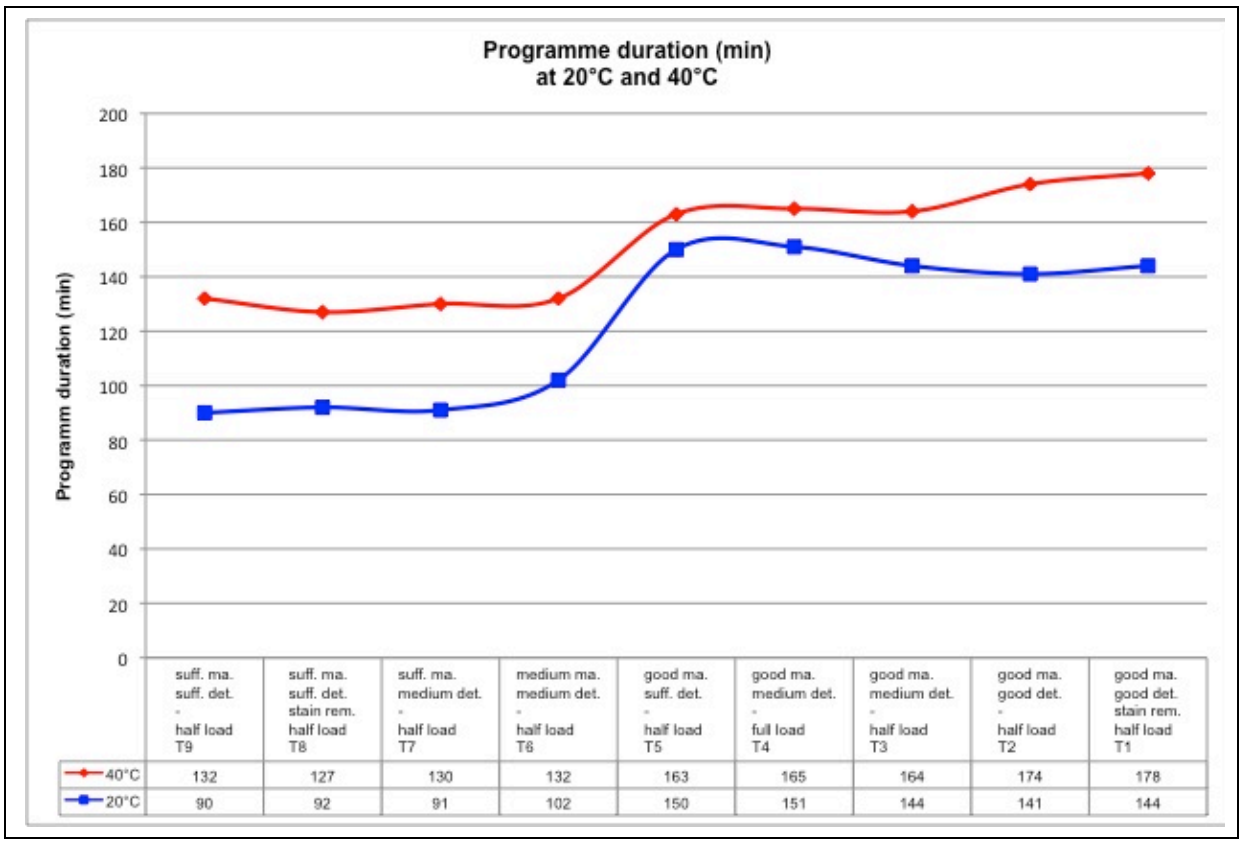


Fig. 5 Programme time differs between the 40°C- and 20°C-programmes and between the washing machines

It is striking that the good washing machine with the comparatively long programme times also reached a better washing performance than the sufficient washing machine with the shorter washing times (Figure 3). Once again this demonstrates well the correlation between programme time and washing performance. The above mentioned differences in the washing performance between 40°C and 20°C can mainly be explained by the shorter programme times of the 20°C-programmes.

Conclusions

- Across the washing arrangements tested, washing at 20°C saved on average about 60% electrical energy compared to the 40°C-programme. Thus, «cold wash» – washing at 15/20°C – holds a tremendous electricity and CO_2 savings potential, which cannot be reached as easily by any other measure in the whole washing process. With an estimated stock of washing machines of about 180 million units in EU-27 and a total electricity consumption of 19 TWh per year[10], «cold wash» could save 11 TWh per year. This equals 2'200 million Euros[11] or the annual production of the German nuclear power plant Emsland [14]. It thus may be worthwhile to rethink our everyday washing routine.

- Washing results depend on a variety of factors: unsurprisingly, washing performance increases with the quality of detergent and with the quality of the washing machine. Pre-treating stains increases washing performance, just as washing at half-load (as opposed to full-load). Also longer programme times positively affect the washing result.

- Good washing performance at 20°C – which would be in compliance with the EU Ecodesign requirements (> 1.03) – is reached when using good machines and good detergent (with or without additional stain remover).

- Though not part of the test, it can be assumed that the potential of «cold wash» is not yet scooped and that the washing performance can be even higher, e.g. with washing machines offering an even better washing performance than the tested one (e.g. as also presented in [6]), even better detergent and with longer programme times at 20°C.

- It has to be kept in mind, that the tests were carried out with standard test laundry, which is heavily soiled. However, our everyday clothing only worn for a few hours or one day usually are only lightly and normally soiled. It therefore is assumed that «cold wash» absolutely is appropriate for this typical type of laundry.

Recommendations

The tremendous but still dormant electrical energy savings potential when using the 20°C-programme is unmatched in the whole washing process and represent an opportunity not to be missed. While the recently launched campaign «I prefer 30»[12] follows the approach to downshift the washing temperature gradually, Topten recommends to reduce the wash temperature right to 15/20°C for lightly and normally soiled laundry. To promote «cold wash», we suggest:

- EU policies: the running revision of the EU Ecodesign Regulation shall include requirements on the washing performance at 20°C. For the consumers it has to be guaranteed that the 20°C-programme – which is required by the Ecodesign Regulation – leads to good washing results.

- Washing machine manufacturers, detergent manufacturers and retailers: active and continued advertisement of «cold wash» for lightly and normally soiled laundry and encouragement of consumers to try it out. Ongoing optimization of the 15/20°C-cycles and of detergent active at these temperatures.

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[10] Assumptions according to [13]: 185 cycles per unit per year and 0.57 kWh per cycle based on average 40°C-programme half-load plus 12% for slightly higher load (+10%) and 1°C higher wash temperature. Note by the authors: Electricity consumption would be higher if the assumptions would be based on the EU Energy Label instead (220 cycles and inclusion of the 60°C-programme).

[11] Assumption electricity tariff: 0.20 €/kWh. However, there can be large differences depending on country or electric utility.

[12] The campaign «I prefer 30» was launched by the International Association for Soaps, Detergents and Maintenance Products A.I.S.E. in 2014 and is supported by a broad range of stakeholders. It aims to raise awareness of the benefits and to support consumers in lowering their wash temperatures. www.iprefer30.eu

- Environmental organizations, consumer organizations, energy agencies: active and continued consumer information on «cold wash» (e.g. with flyers such as «Washing at 20°C is Cool» [7]) and encouragement of consumers to try it out.

- Academia, research institutes, testing laboratories: Publication of studies (consumer and technical), continuing tests on «cold wash», especially for lightly and normally soiled laundry.

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