

# LCA of two different hand drying systems

## *A Comparative Life Cycle Assessment of non-reusable paper and reusable cotton towels*

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## 1 Introduction

Vendor has commissioned PRé Consultants to do a study on hand drying systems. In this study an environmental analysis of two types of hand drying systems will be carried out.

The environmental analysis of products is carried out using a technique called Life Cycle Assessment (LCA). The conventional way of looking at the environmental effects is focusing solely on one production process of one individual company. On the other hand, within the LCA technique the environmental impact of all processes, which can be related to the production, use, and disposal of a product are assessed. This means that the life cycle includes all processes from the collection or production of raw materials until the final disposal of the hand drying system.

The data used to perform this study was provided by Vendor and by a report on life cycle analysis comparing hand drying systems done by the Öko Institut [1].

This document can not be published in public as it is not a peer reviewed study and it uses single score values to present the environmental impact.

## 2 Goal and scope

This study has three main objectives:

1. The first goal is to compare the environmental profile of two hand drying systems: non-reusable paper towels and reusable cotton towels. The non-reusable hand drying system is manufactured by Vendor. The data for the system of reusable cotton towels is provided by the report performed by the Öko Institut already mentioned above.
2. The second goal of this study is to identify improvement areas in the production phase.
3. The third goal of the study is to provide communication opportunities for Vendor's clients.

### 2.1 Functional unit

To carry out this LCA analysis it is essential to have an identical reference parameter namely a functional unit. The functional unit can be defined as the amount of hand dryings. *The functional unit is 10.000 hand dryings.*

The use of 1 pull per 1 hand drying will be assumed as the default value for every towel system, both reusable and non-reusable. Differences in consumer behavior and absorption capacity can influence this assumption. In the sensitivity analysis this will be analyzed.

Towel type	Amount of paper/cotton needed for the hand drying of one person	Amount of towel needed to fulfill the functional unit
<i>Paper non-reusable</i>	<i>1 pull (3,0g)</i>	<i>30,45kg</i>
<i>Cotton reusable</i>	<i>1 pull (16,2g)</i>	<i>1,62kg (used 100 times)</i>

*Table 1 - Amount of paper/cotton used per functional unit for each hand drying system*

### 2.2 System description and system boundaries

#### A. Reusable cotton hand drying system

A scheme of the life cycle of the reusable cotton towels can be seen in the following figure.

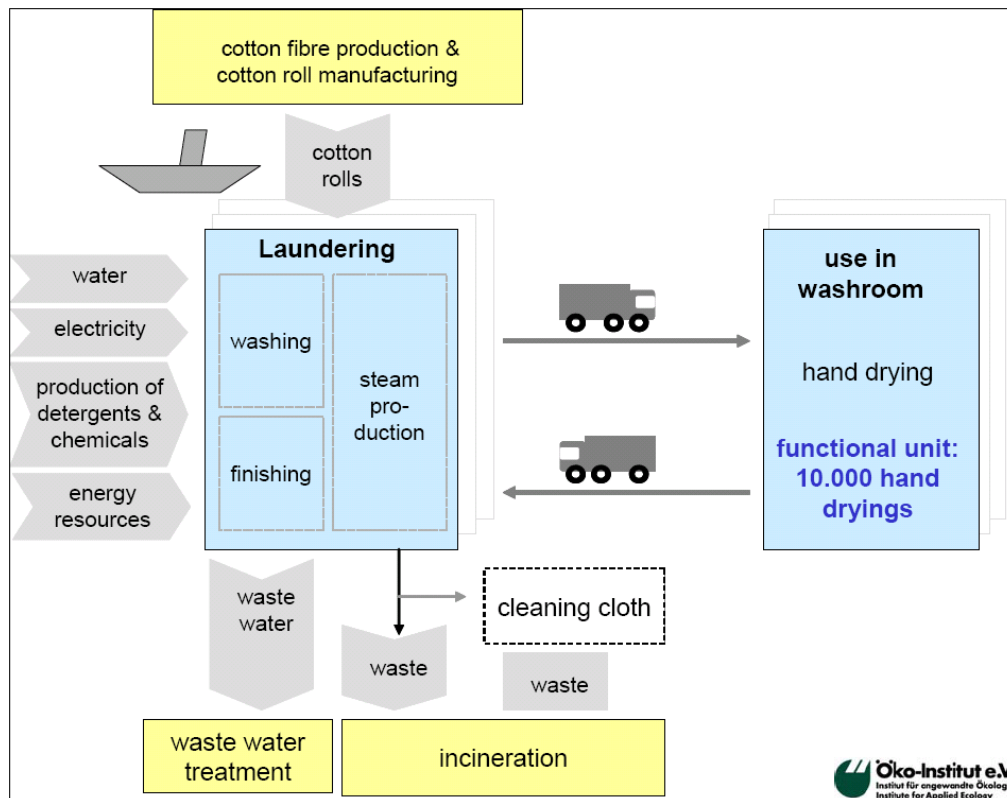


Figure 1 - System description of the reusable cotton towels hand drying system presented by Öko Institut [1]

The cotton roll system uses cotton towels, which are reused by washing in professional laundries. The cotton rolls are produced and manufactured from cotton fibre (“lint”) from conventional agriculture. The processes included for the production of cotton rolls towels are spinning, weaving and wet processes. From the production site the cotton rolls go to laundries for washing and from there they are distributed to washrooms, where they are put into towel roll dispensers and used by washroom clients. After usage the cotton rolls are transported to laundries and washed in washing machines with different types of detergents and chemicals, used for hygiene washing processes. Whereas the electricity used for washing and finishing is provided by grid, the used steam is produced in-house. After 70 - 130 washing cycles the cotton rolls have reached the end of their life-time and are (in most cases) cut and used as disposable cleaning cloths. Both extreme washing times and a default of 100 washing cycles will be analysed. Finally, they are treated within a waste incineration plant.

**B. Non-reusable paper hand drying system**

A scheme of the life cycle of the non-reusable hand drying systems manufactured at Vendor can be seen in the following figure.

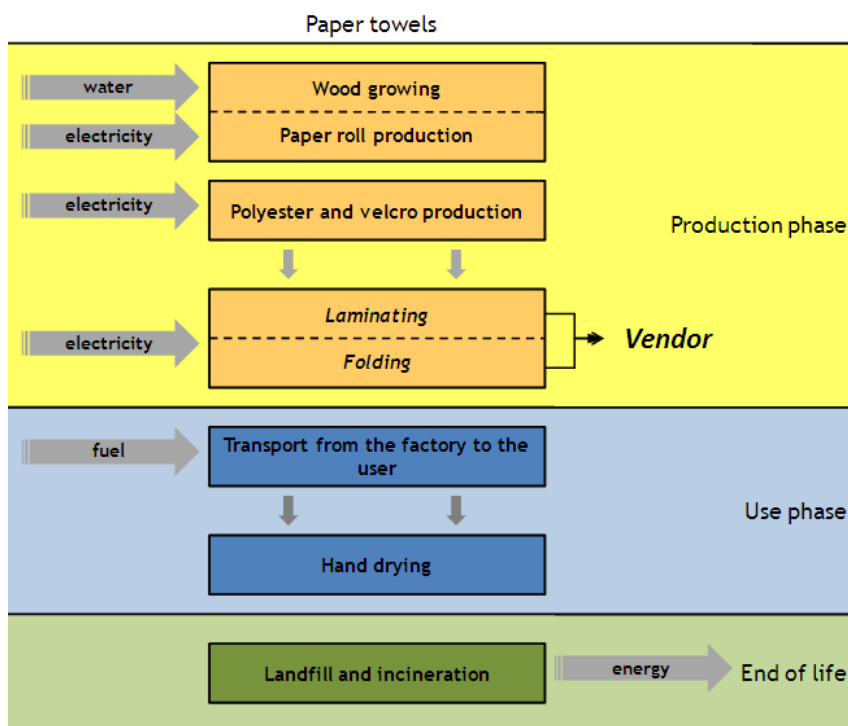


Figure 2 - System description of the non-reusable hand drying systems manufactured by Vendor

In contrast to the reusable cotton rolls described above, the hand drying system supplied by Vendor is a one-way system using paper towels, which is not re-processed. The paper towels investigated are manufactured from fresh pulp. Pulp production and tissue paper manufacturing are the processes included for the paper rolls fabrication. The rolls are transported to Vendor. At Vendor, a laminating process of polyester layered between two paper towels takes place. Then the towels are cut, folded, and Velcro is added to each refill. The towels are transported from Vendor to the user hand dryers. After their use the towels are disposed as municipal waste and, part of it ends up in landfill but most of it is incinerated with energy recovery.

The CO<sub>2</sub> uptake from the trees used for the paper input is included in the analysis.

The packaging input is not included for any of the studies.

The infrastructures needed during the production of the product, like buildings or machinery, are not taken into account in the analysis. The hand drying device is not considered in the analysis.

### 2.2.1 Transport

Transport of paper and cotton to and from the towel manufactory is included in the analysis. However, according to the hand drying system analysed, transport between the provider and the customer differs. A scheme of the transportation routes for the towels is presented in the figure below followed by its description.

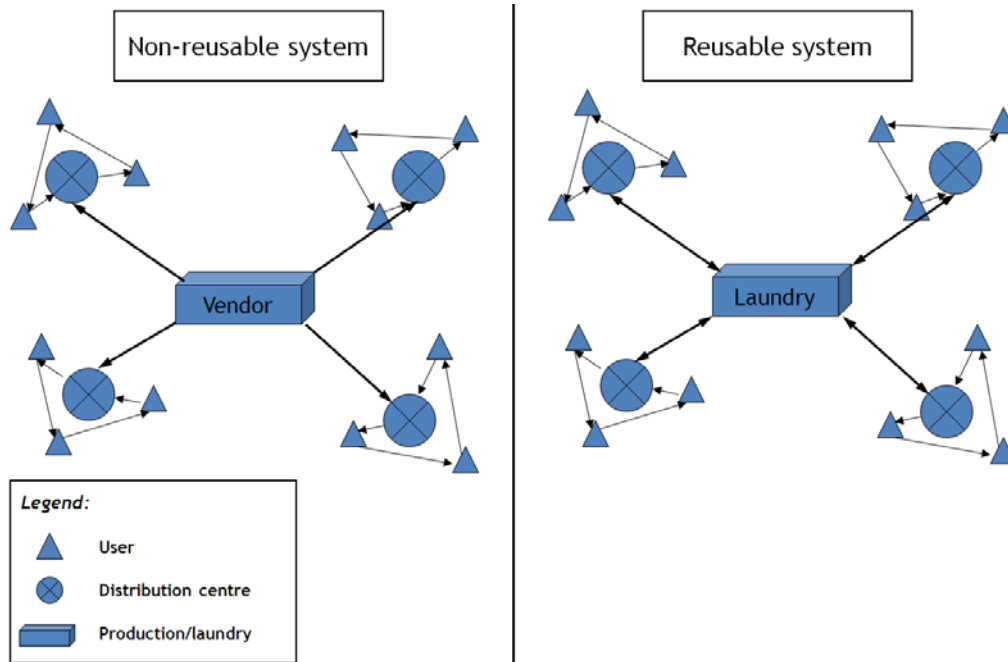


Figure 3 - Scheme of the transport circuit of the towels

For the non-reusable systems, the transport between Vendor and the costumer is done by a transport service.

- The transport between the Vendor and the distribution centres is a single trip of 100km done by lorry of 28tons at its full capacity.
- The transport between the distribution centre and the client is a single journey of 50km done by van. We assume the van is half loaded all the way, once it starts the circuit totally full and returns empty.

For the reusable systems,

- The transport between the client and the distribution centre is a single journey of 75km done by van. The van is completely loaded because when it leaves new towel rolls it also collects the ones that have already been used.
- The transport between the distribution centre and the laundry is a return trip of 100km done by lorry of 28tons at its full capacity.

The end-of-life transport is not included for any of the hand drying systems studied as we assume it is the same for every system.

### 2.2.2 End of life

About the end of life of the hand drying systems, two situations occur:

- For the non-reusable systems, the towel rolls under study end up in municipal waste. In the Netherlands, paper waste fractions are not recyclable, 87% is incinerated and the remaining is disposed in landfill [2]. The energy recovery during incineration is taken into account in the scenario 'with benefit' (W).

Material	Energy recovery (MJ/kg)
Paper	4,09
Polyester	10,51
Polypropylene	11,28

Table 2 - Energy recovery during incineration per kg of paper, polyester, and polypropylene

- For the reusable system, we take into account the processes of washing the rolls, the transport between the laundry and the washroom, and the recycling as cleaning cloths. The benefit of recycling is assumed to be part of the life cycle

under study and thus is considered in our results. According to the market prices of the cotton rolls used in the washroom and the cleaning cloths, the recycling benefit is divided over the two purposes.

Product	Market value (€per roll)	Division of the burden (%)
Cotton towel	400	98,6
Cleaning cloth	5,80	1,4

Table 3 - Percentage of the benefit of recycling the cotton towels based on the market value

88% of all cotton towels are being sold as cleaning clothes and the rest is being incinerated. As stated above, according to the market value, 98,6% of the environmental burden caused by the production of the towels sold as cleaning clothes is attributed to the cotton towel. The cleaning clothes are responsible this way for the remaining 1,4% of the environmental impact.

For the environmental burden of the end of life of the cotton towels, a direct waste handling of 12% is taken into account plus the one already mentioned in the paragraph above.

## 2.3 Data

Vendor provided the data regarding the non-reusable hand drying system by the response of questionnaires elaborated by PRé Consultants. Background data and data gaps, for instance for the production of some materials such as polyester, are based on existing and general databases. The background data used for the materials of this study are taken from the ecoinvent database 2.0 produced by the Swiss Centre for Life Cycle Inventories. For screening purposes this is adequate to reveal where in the life cycle of the product systems the environmental hotspots occur and subsequently intensify the data collection on these areas.

The Öko Institut report was used as basis for the reusable cotton towel system with the exception of the following:

- The process of yarn cotton used at the report done by the Öko Institut was replaced by yarn cotton taken from the ecoinvent 2.0 database because it is a better documented and complete process.
- It is taken into account the inefficiency of the refill of the towel dispensers caused by the replacement of rolls that still have part of the roll which has not yet been used. A loss of 10% per roll is the default value.
- The soap from ecoinvent 2.0 was used in replacement of the detergents and chemicals used for the washing of the towels by lack of data.
- The transport of cotton between Pakistan and the Netherlands was added.

In order to be consistent, all the electricity figures included are an average European electricity mix from ecoinvent 2.0 database.

## 2.4 Assumptions and scenarios

As several assumptions need to be taken during the analysis, different scenarios will be analysed to assess the sensitivity of the most important decisions made.

The use of 1 pull per 1 hand drying will be assumed as the default value for every towel system, both reusable and non-reusable. Depending on the results of the default scenario (1pull for both systems), the sensitivity of the assumed functional unit will be assessed. The amount of pulls needed to produce the same environmental load for both systems will be calculated.

There are two possible scenarios concerning the end of life described at the following table.

Scenarios	Assumption	Cotton recycling	Incineration
Scenario 1: Default (W)	Producer of the waste receives all/part of the benefit of waste handling	Division of the benefit of recycling over the different products based on market price	Energy recovery included
Scenario 2: (WO)	Producer of the waste receives no benefit	No division at all; the entire environmental load is attributed to the cotton towel	Energy recovery excluded

Table 4 - End of life scenarios analysed: with recycling benefit and without recycling benefit

Depending on the results and what is the difference between taking or not into account the waste handling benefit, some measures concerning the end of life of the towels might be done.

Different scenarios on the number of times the reusable cotton towels are washed are also analysed. Besides that, a worst case scenario for the cotton towels will be performed.

### 3 Methodology

In this analysis Eco-indicator 99 will be used to calculate the environmental load of the systems under study. Eco-indicator 99 is developed by PRÉ Consultants on commission of the Dutch Ministry for Housing and Spatial Planning (VROM), in collaboration with scientists and industry. With this method, the environmental damage to human health, ecosystem quality and depletion of resources are all taken into account and can be expressed in one single score (Eco-indicator points<sup>1</sup>).

For additional information on the method, see appendix.

## 4 Results

### 4.1 Default scenario

Comparison between the different hand drying systems using default scenarios

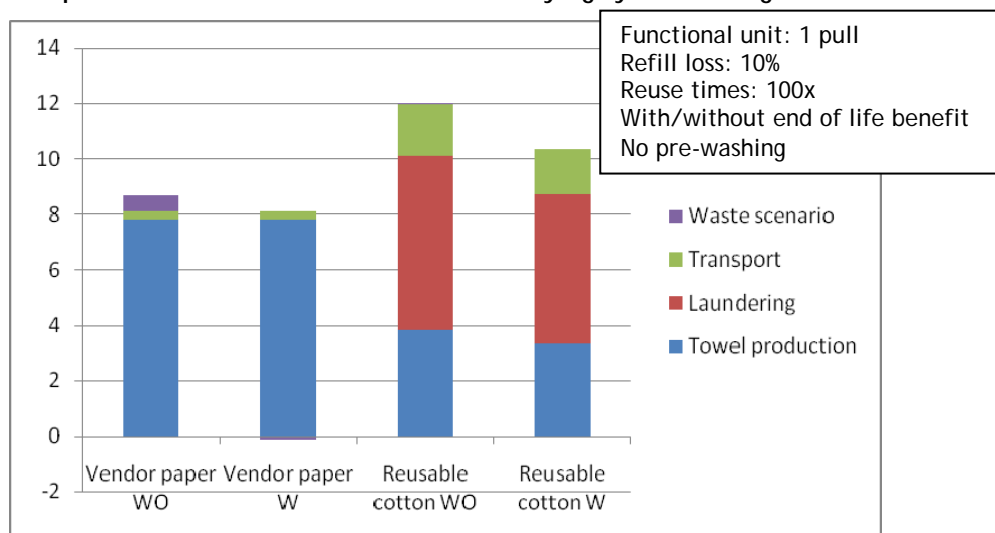


Figure 4 - Comparison between the environmental impacts of the different towel systems analysed per functional unit using default scenarios with Eco-indicator 99 H/A (in Points)

For the paper non-reusable towels the biggest burden is caused by the paper production. Less than 7% is attributed to transport.

<sup>1</sup> An European inhabitant scores in average 1000 Eco-Indicator points.

The non-reusable paper towels have the lowest impact, although the difference with the reusable towels is not very large. At first sight it is unclear if the difference is significant. Consequently, an uncertainty analysis will be made to clarify this issue (see paragraph 4.4).

The reusable cotton towels hotspot is the laundering process (heat, soap and electricity), with around 54% of the environmental load. The transport also has, in comparison with the non-reusable system, a high contribution to its total environmental performance. This difference appears at the use phase because the reusable cotton rolls are heavier (in Table 1). The fact that the vans do the delivering route two times the distance (collection and deliver) also contributes to a bigger environmental impact.

The transport impact is not relevant and thus no sensitivity analysis will be carried out on it. Furthermore, the waste scenario doesn't influence the results obtained.

For further information see the network of the three types of towels in the appendix.

#### Detailed analysis on the environmental impact for which Vendor is responsible

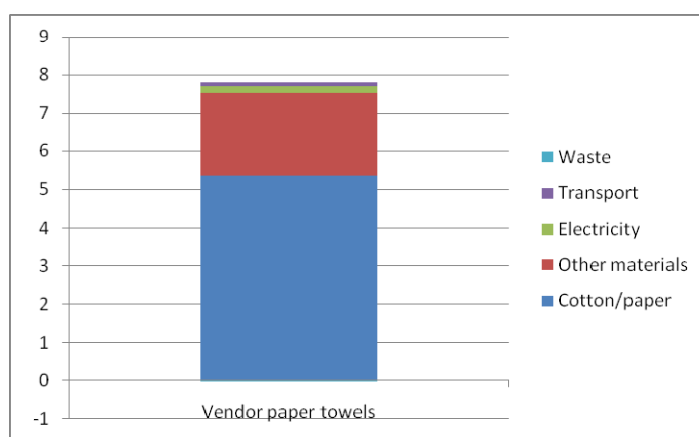


Figure 5 - Detailed environmental impact of the towels at production phase at Vendor per functional unit with Eco-indicator 99 H/A (in Points)

The electricity, mentioned in figure 5, corresponds to the electricity used to transform the paper rolls supplied to Vendor into paper towels used at the hand drying dispensers. The transport figure is the transport of the materials, paper and others, from the supplier to Vendor. The waste presented is the one produced during the manufacturing of the towels at Vendor.

The pulp contribution is responsible for over 68% of the burden and 27% is due to the other materials input. This way, around 40% of the production's environmental impact is fossil fuels and 33% is land use.

## 4.2 Washing cycles

### Comparison between Vendor paper towels and the reusable cotton towel with different times of washing cycles

According to the report produced by the Öko Institut the reusable cotton towels were reused between 70 and 130 times. This way, a default value of 100 cycles was used. A sensitivity analysis on this will be done to see whether the results change with the number of washing cycles or not.

Scenarios analysed	Washing cycles assumed
Scenario 1: Default	100x
Scenario 2	70x
Scenario 3	130x

Table 5 - Scenarios analysed according to the amount of times the reusable towel is used by the client

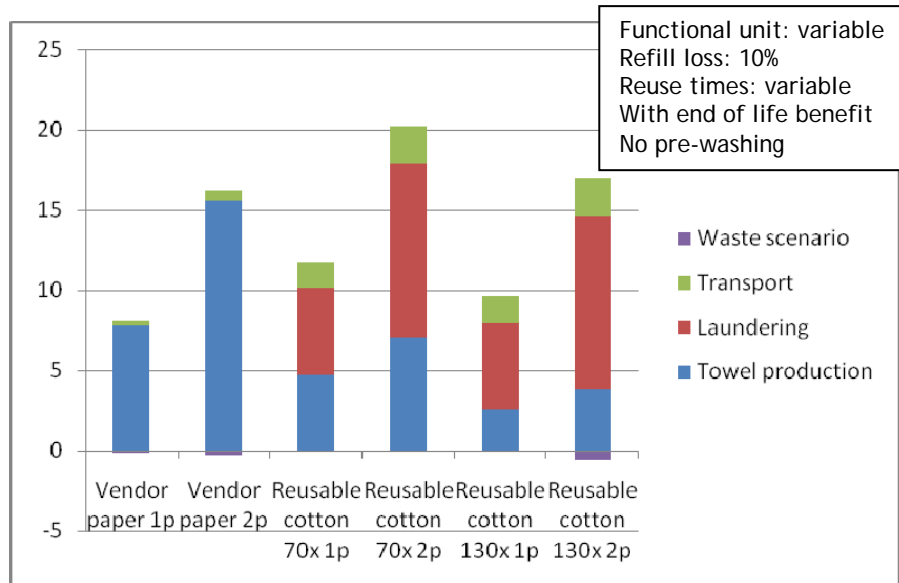


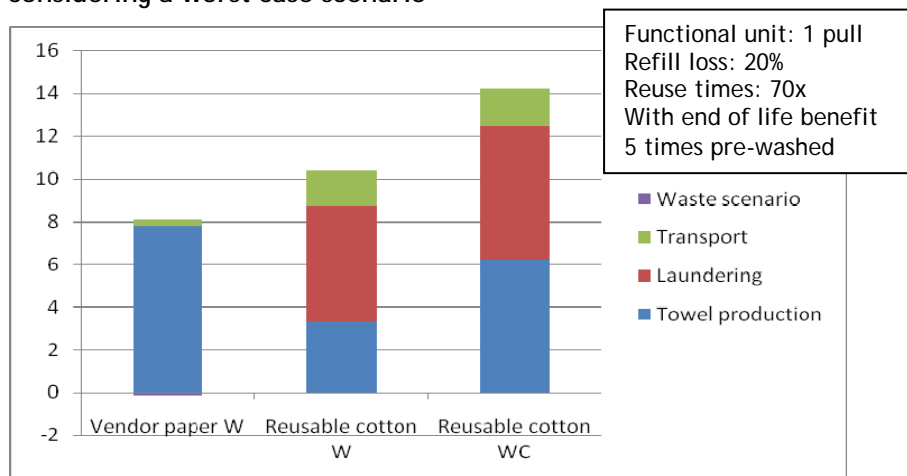
Figure 6 - Comparison between the non-reusable paper towel with the reusable cotton towel per functional unit changing the amount of times the towels are reused, with Eco-indicator 99 H/A (in Points)

The number of washing cycles doesn't influence the results obtained. Though, with the increase of washing cycles per cotton towel, the demand for towel production is smaller and the waste generation also decreases. Even with 130 reuse times of the cotton towels, paper towels are apparently better than the reusable towels.

The absorption capacity of cotton is over two times higher than paper's. Consequently, we could assume that the consumer would use at least two pulls of paper per each cotton pull. However, it is important to mention that the absorption capacity of the reusable cotton towels decreases with the washing although we have no information to what extent this happens. Furthermore, the number of pulls also depends on the length and width of one pull and on the consumer behaviour<sup>2</sup>. Based on these variables, it is difficult to draw conclusions. We can say that, if the number of non-reusable paper pulls is 1.2 times higher it still has a lower or same environmental load as the reusable towels (depending of the scenario).

### 4.3 Worst case scenario

Comparison between non-reusable paper towel and reusable cotton towel, considering a worst case scenario



<sup>2</sup> No information about the reusable towels was available.

Figure 7 - Comparison between the worst case scenario of the reusable towels WC (worst case scenario) and the default scenarios W (with end-of-life benefit) per functional unit with Eco-indicator 99 H/A (in Points)

The cotton reusable towels are collected periodically at the client to go to the laundry being replaced by new rolls. When the used rolls are collected the portion of the towel that has not yet been used by the client is taken anyway to wash. This way, an inefficiency of the hand drying device is taken into account. A default value of 10% losses is taken into account but this value can reach 20%. This will be modelled in a worst case scenario.

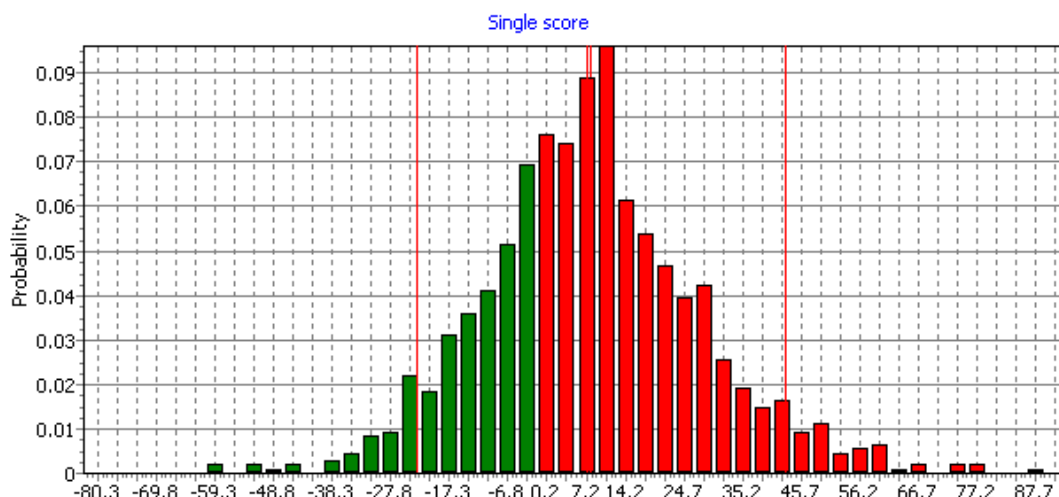
The worst case scenario was assumed to have: 5 times pre-washing of the towels before use phase; 70 times reuse; with waste handling benefit; 20% use loss due to refill inefficiency. In the worst case scenario, the environmental load of reusable cotton towels can rise around 37% in comparison with the default (figure 7, Reusable cotton W).

A comparison between the non-reusable paper towels and the worst case scenario for the reusable cotton towels was made. Considering worst case scenario, about 1,5 pulls of the paper towel would be necessary to have a higher damage than the reusable cotton towels.

## 4.4 Uncertainty analysis

A comparison between paper towels and cotton reusable towels was made to analyse whether the small difference (see figure 4) is significant. The scenarios used were the default scenarios with end-of-life benefit. Uncertainty analysis was run in all Ecoinvent data used and also on the data available at the Öko report for the reusable cotton towels. The results on normalization level are presented at figure 8.

The Eco-indicator single score (used in all presentations above) is expressed as a sum up of three damage categories, depending on a set of weighting factors. These damage categories are: Resources, Ecosystem Quality and Human Health. To go more in depth, the uncertainty analysis is also run for these three categories.



Uncertainty analysis of 1 p 'Öko cotton with' (A) minus  
1 p 'Vendor paper with' (B),  
method: Eco-indicator 99 (H) V2.05 / Europe EI 99 H/A , confidence interval: 90 %

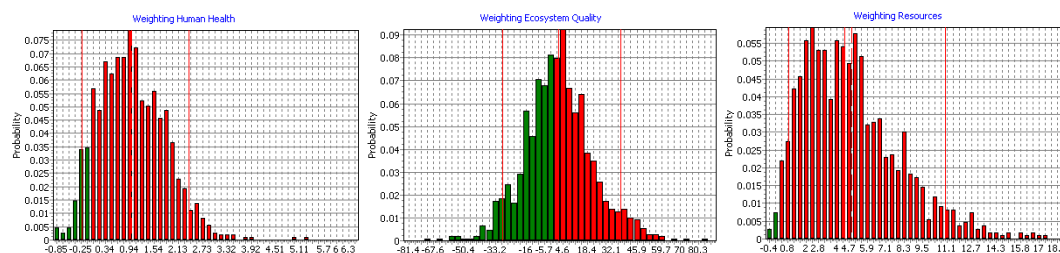


Figure 8 - Uncertainty analysis comparing the paper towels with the reusable cotton towels with Eco-indicator 99 H/A (with a 90% confidence interval): with underneath Human Health on the left, Ecosystem Quality in the middle, and Resources on the right)

According to the uncertainty analysis for human health and resources, paper has a better environmental profile than the reusable cotton towels. No information can be thrown about the ecosystem quality performance because the uncertainty is too high. The high uncertainty is mainly due to land use uncertainty data.

On the uncertainty analysis run for the single score, the paper has a 67% probability of having a better environmental performance than the reusable cotton towels. This is due to Ecosystem Quality, as stated above. Consequently, we cannot affirm that the paper towels have a significantly better environmental performance than the reusable cotton towels.

## 5 Areas of improvement

Based on the environmental analysis presented above, several suggestions and areas of improvement can be mentioned:

- Try to influence and reduce the towel consumption by:
  - adding a comment at your paper towel device with the text - "Pull only once"
  - Adapting the towel device, for example by enhancing the break when the towel is pulled.
- Explore the use of recycled materials:
  - Use a certain percentage of recycled pulp, in order to make the difference with cotton towels larger and thus more significant.
  - Add other recycled material such as polyester, if possible.

## 6 Items of communication

- Put attention on only using one pull per hand drying!
  - Only when consumers pull once, you assure that your on-reusable paper towels are not worst than any type of cotton towels.

## 7 Conclusions

Based on a comparison of the environmental burden per pull of roller towel, the paper non-reusable towels manufactured by Vendor are on environmental level not worse than any cotton towel system analysed. Though, the difference in environmental burden between the vendor paper towels and the cotton reusable towels is small. This difference is significant with only 67% probability. Paper towels are though better in what comes to Resources and Human Health damage categories. The number of non-reusable paper pulls can be 1.2 times higher in order to obtain the lower or same environmental load than the reusable towels (depending of the scenario).

## Appendix

### Eco-Indicator 99

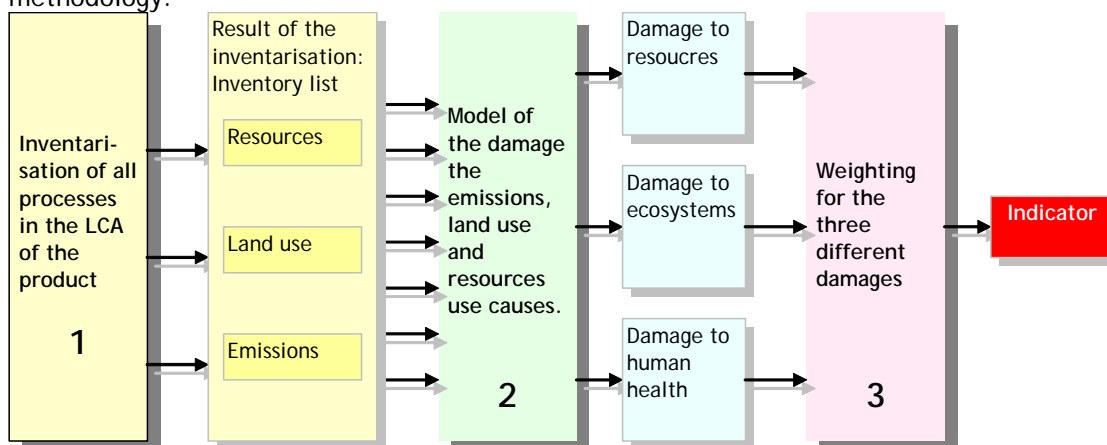
The Eco-indicators calculated here have been calculated with a specially developed methodology. The details of this methodology can be found in the Eco-indicator 99 methodology report that is available from [www.pre.nl](http://www.pre.nl).

#### Overview

The Eco-Indicator methodology is a damage oriented method. Not only the emission effects are taken into account, but also the real damage that appears due to the emission is considered. The Eco-Indicator method can be divided in three steps:

1. Inventory of all relevant emissions, resource extractions and land-use in all processes that form the life cycle of a product. This is a standard procedure in Life Cycle Assessment (LCA)
2. Calculation of the damages these flows cause to Human Health, Ecosystem Quality and Resources
3. Assessing how serious the damage to ecosystems, human health or resources is compared to each other. Weighting of these three damage categories.

The figure below gives an overview of the three different steps taken in Eco-Indicator 99 methodology:



#### Step 2: Damage

For each impact a damage model is developed. All impacts to human health are expressed in the same unit, Disabled adjusted life years (DALY). For ecosystems all impacts are expressed in potentially disappeared fraction of species (PDF) and for resources in Surplus Energy. In order to be able to use the weights for the three damage categories a series of complex damage models had to be developed and linked. In figure underneath these models are represented in a schematic way.

#### Step 3: Weighting

The most critical and controversial step in a methodology as this is the weighting step. For a panel of experts or non-experts it is very difficult to give meaningful weighting factors for such a large number and rather abstract impact categories. In Eco-Indicator 99 weighting is performed on the three damage categories human health, ecosystem damage and resource depletion. A panel of 365 persons from a Swiss LCA interest group [Mettier 1999] was asked to assess the seriousness of three damage categories. The reason for choosing this group was the assumption that such a group would better understand the questions posed to them. In spite of this limitation, we still use the results. The results from this group indicate that the panellist find damage to Human Health and damage to Ecosystem Quality about equally important while damage to Resources is considered to

be about half as important. This gives us an average weighting set of 40/40/20% respectively.

## Reusable cotton towels

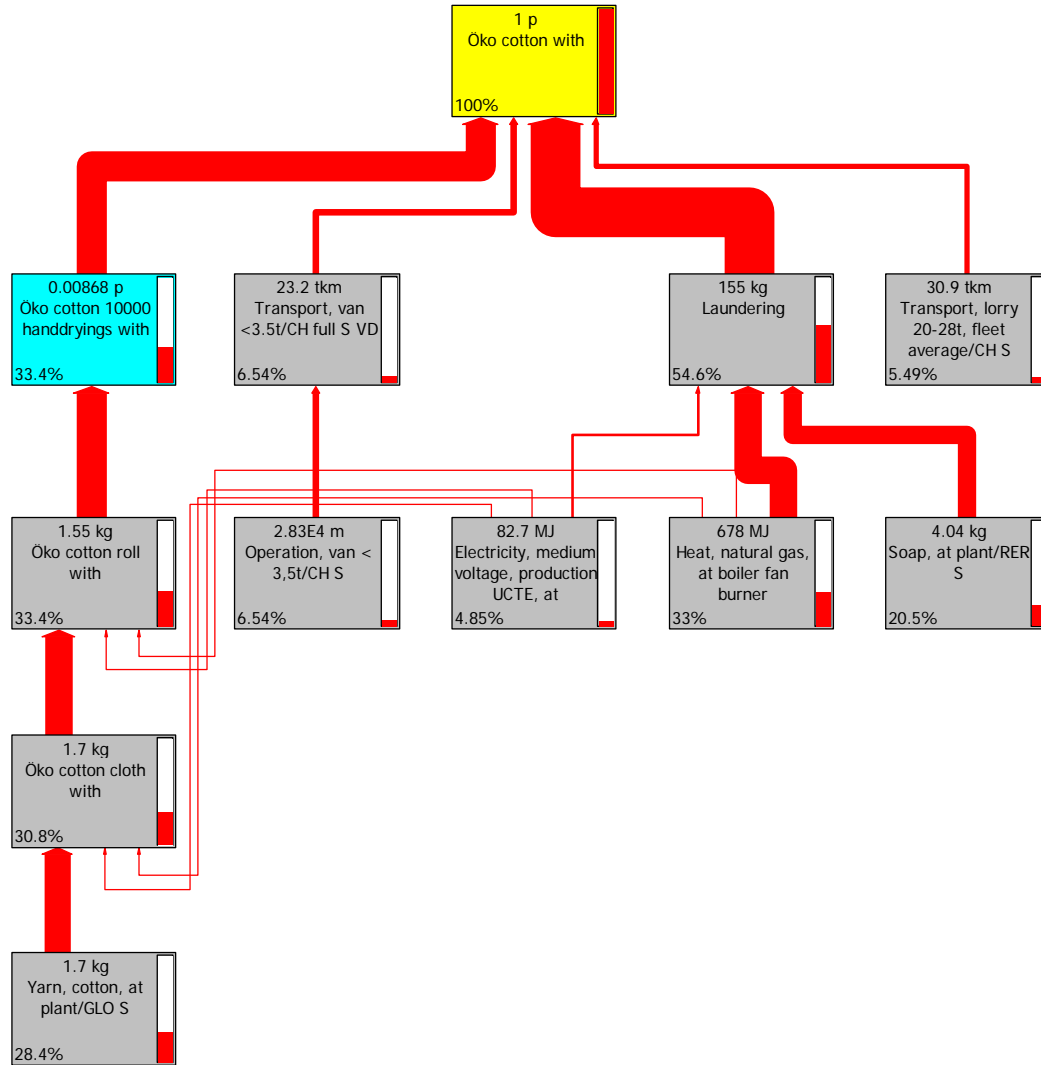


Figure 9 - Network of the reusable cotton towels with Eco-indicator 99 (cut-off of 1%)

## Non-reusable paper towels

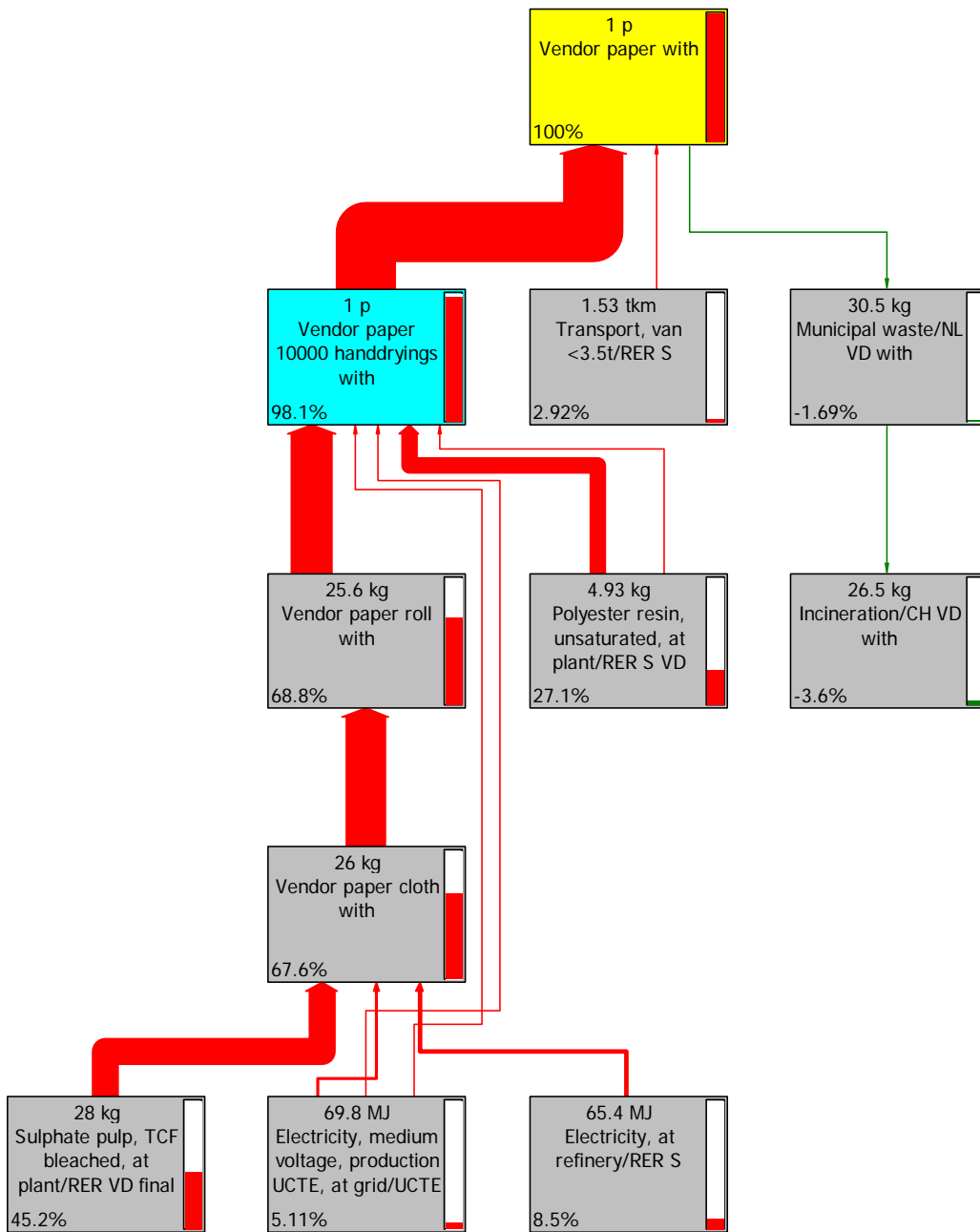


Figure 10 - Network of the non-reusable paper towels manufactured by Vendor with Eco-indicator 99 (cut-off of 2%)

## References

- [1] Eberle, U., Möller, M. 2006. "Life Cycle Analysis of hand-drying systems: A comparison of cotton towels and paper towels". *Technical report*. Öko Intitut e.V. Freiburg, Germany.
- [2] SenterNovem 2005. "Nederlands afval in cijfers: gegevens 2000-2004. Uitvoering Afvalbeheer". 3UO0602, 185 p., Utrecht, The Netherlands - ISBN 90-5748-044-1.



