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TITLE:

Life cycle assessment of Flax-Pes Fabric in I06 company

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1 Introduction

The work documented in this report is part of the project “Evaluation of the effect of the IPPC application on the sustainable waste water management in textile industries (Towef0)” funded by European Commission as a shared cost RTD project in the 5th Framework Research program, Energy, Environment and Sustainable Development, Key action 1 Sustainable Management and Quality of Water, Treatment and purification technologies, Waste water treatment and reuse.

The project objective is to establish a multicriteria integrated and coherent implementation of Good Environmental Practices (GEP) and to promote the efficient use of resources within textile finishing industries characterized by large use of water, taking into account the treatment of industrial waste water effluent (Urban Waste Water Treatment Directive 91/271 EEC) and the impact of the final discharge to the water recipient bodies (Water Framework Directive COM (98)).

Within this framework ENEA-PROT-INN conducted detailed LCA studies on selected Italian and Belgian industries in order to estimate the potential impact on the environment of specific company processes, evaluate the environmental effects of alternatives scenarios of water management and develop a database of Life Cycle Inventories of textile production processes and chemicals.

Partners of the project were: ENEA, the Italian National Agency for New Technologies, Energy and the Environment, Vito, a Belgian research centre for the industry, Centexbel, a research centre for the Belgian textile federation, the Joint research Centres of Siviglia and Ispra, Lariana Depur S.p.A., a private Italian company, Ecobilan, a private French company and Lettinga Associates Foundation (LeAF), a Dutch foundation for environmental protection and resource conservation.

In this document LCA methodology has been applied to selected Flax-Pes Fabric products within I06 company.

2 Goal and scope definition

2.1 Goal of the study

The main goal of this LCA study is to quantify the environmental performance of selected textile production processes within I06 company identifying the potential environmental critical points.

The results achieved in this study will be used to support the identification of environmental favourable technologies/strategies in textile finishing industries, to evaluate different wastewater management scenarios and to develop a database of inventory data of textile processes and chemicals to be used with a industry specific user friendly environmental assessment software to be developed by Ecobilan within the project Towef0.

This study has been performed according to the requirements of ISO 14040 standards by ENEA-PROT-INN LCA team. The study commissioner was the European Commission which funded the Towef0 project. Researchers and technicians working in textile sector were the intended target of this study.

2.2 Scope of the study

2.2.1 General description of the systems

I06 is an Italian company located in the Como area. Its annual production is over 516000 kg of fabric mainly made of cotton/polyester (33%), polyester (30%), flax/polyester (16%), silk/polyester (16%). The general organisation of the company production departments is highlighted in the following material flowchart.

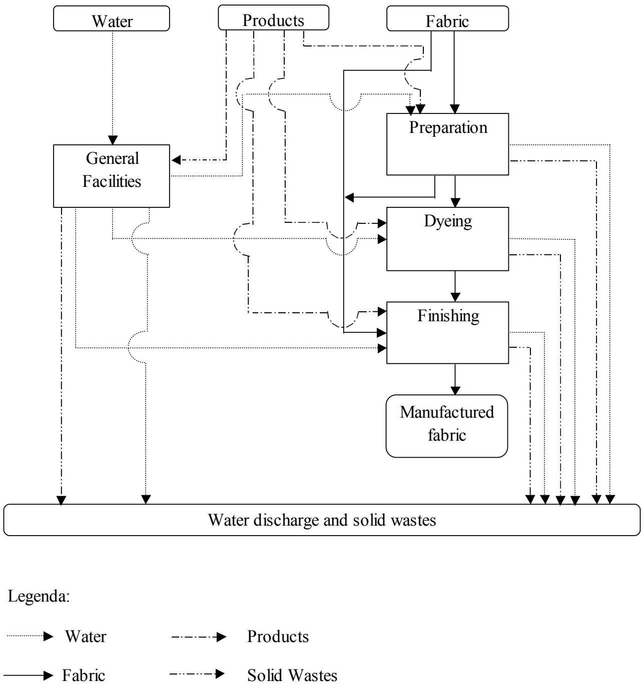

Fig. 2.1 Material flowchart of I06 company.

A more detailed description of I06 company is available in the Process Identification and data Collection Sheet (PIDACS) of the company.
In this study three flax/polyester fabric product alternatives were analysed:

- Sized Flax-Pes Fabric dyed with light colours (System A);
- Sized Flax-Pes Fabric dyed with dark colours (System B);
- Not Sized (for which the glue has been already removed y) Flax-Pes Fabric dyed with light colours (System C).

The three systems have the same flow-chart (Fig 2.2)

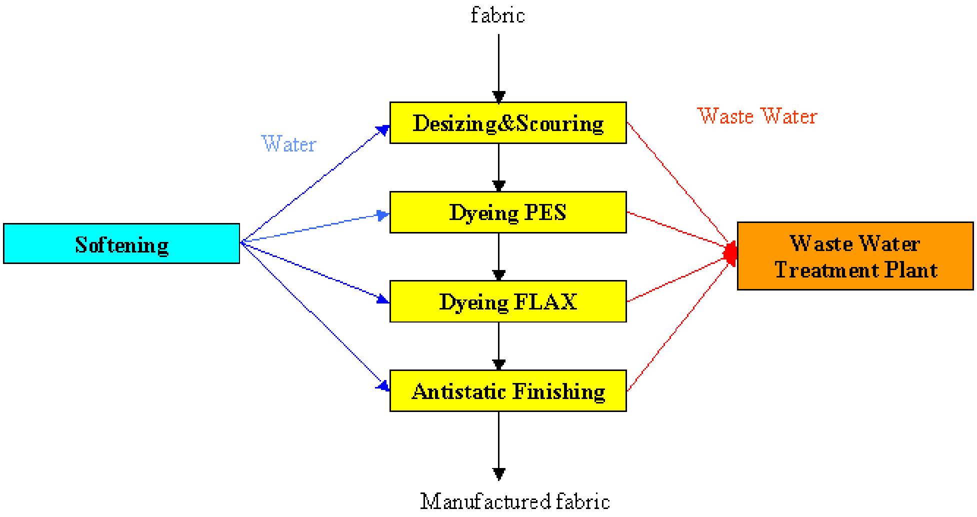

Fig.2.2 Schematic flowchart of analyzed flax-PES products.

Table 2.1 shows the textile wet processes of the three product systems; the processes numbers refer to I06 PIDACS classification.

Product systems	System A	System B	System C
Desizing & scouring	F.3.2	F.3.2	F.1.4
Dyeing PES	G.1.1	G.3.1	G.1.1
Dyeing Flax	G.7.2.	G.8.1	G.7.2
Antistatic finishing	H4	H4	H4

Table 2.1 Textile wet processes of the three product systems.

Light colours dying process compared to dark colour dying uses different type of chemicals and different equipment. The processing of sized Flax-Pes fabric has a different pre-treatment compared to not-sized one because it is necessary to clean the yarn from the glue used in yarn processing: as a consequence, higher COD and TSS are expected in the effluent wastewater.
For a better understanding of the report, a short description of the textile wet processes is presented hereafter. The descriptions are extracted from BREF or other relevant technical literature.

Desizing

Desizing is used for removing from fabric sizing compounds previously applied to warp. It is usually the first wet finishing operation performed on woven fabric.

Desizing techniques are different depending on the kind of sizing agent to be removed. Currently applied techniques can be categorised as follows:

1. techniques for the removal of starch-based sizing agents (water-insoluble sizes)
2. techniques for the removal of water-soluble sizes.

Scouring

Scouring (also known as boiling-off or kier boiling) is aimed at the extraction of impurities present on the raw fibre or picked up at a later stage such as:

- pectins;
- fat and waxes;
- proteins;
- inorganic substances, such as alkali metal salts, calcium and magnesium phosphates, aluminium and iron oxides;
- sizes (when scouring is carried out on woven fabric before desizing);
- residual sizes and sizing degradation products (when scouring is carried out on woven fabric after desizing).

Scouring can be carried out as a separate step of the process or in combination with other treatments (usually bleaching or desizing) on all kind of substrates: woven fabric (sized or desized), knitted fabric and yarn. The action of scouring is performed by alkali (sodium hydroxide or sodium carbonate) together with auxiliaries, which include:

- non-ionic (alcohol ethoxylates, alkyl phenol ethoxylates) and anionic (alkyl sulphonates, phosphates, carboxylates) surfactants;
- NTA, EDTA, DTPA, gluconic acid, phosphonic acids as complexing agents, which are used to remove metal ions (and, in particular, iron oxides, which catalyse the degradation reaction of cellulose when bleaching with hydrogen peroxide)
- polyacrylates and phosphonates as special surfactant-free dispersing agents
- sulphite and hydrosulphite as reducing agents (to avoid the risk of formation of oxycellulose when bleaching with hydrogen peroxide).

Dyeing PES

PES fabrics are dyed almost exclusively using batch dyeing techniques and among these, dyeing under high-temperature conditions is the most commonly applied.
In this system the PES fibres are dyed at 100-130 °C, using disperse dyestuff with the aid of a carrier and acetic acid.

Dyeing FLAX

The dyes used for flax fibres are reactive dyes in batch processes.
In batch dyeing, dye, alkali (sodium hydroxide or sodium bicarbonate) and salt are added to the dye bath in one step, at the start of the process, or stepwise. In the stepwise process the alkali is added only after the dye has absorbed to the fibre. Its amount is determined by the reactivity of the system and the desired depth of shade (cold dyers are applied at lower pH compared to warm and hot dyers). Salt is added to improve bath exhaustion: the used concentration depends on the substantivity of the dye and on the intensity of the shade

Antistatic finishing

The process consists in treating the fabric with hygroscopic substances (antistatic agents) which increase the electrical conductivity of the fibre, thus avoiding the accumulation of electrostatic charge. These finishing treatments are very common for synthetic fibres, but they are also applied to wool in the carpet sector for floor coverings that have to be used in static-sensitive environments.

All these processes use water softened by means of ion exchange resins. The wastewater treatment for all the analyzed Italian companies is performed in a centralised WWTP, which also treats municipal effluents.

A detailed description of the studied systems is available in chapter 3.2.

A general description of the equipment used for all textile processes is given in the Reference Document on Bat for Textile processing which can be downloaded from http://eippcb.jrc.es/pages/FActivities.htm.

2.2.2 System functions

The main function of the studied systems is the pre-treatment, dying and finishing of flax/polyester fabric, processed to reach the required commercial characteristics respecting the worker safety and the emission limits according to the law in air, water and soil.

2.2.3 Functional unit and reference flow

The chosen functional unit is the pre-treatment, dying and finishing of a weight unit of flax/polyester fabric, processed to reach the required commercial characteristics, respecting the worker safety and the emission limits according to the law in air, water and soil.

The reference flow is 100 kg of Flax-Pes fabric

2.2.4 System boundaries of product systems

The system boundaries of the three studied product alternatives are shown in Fig. 2.3 the processes included in the analysis are included in the system bold line.

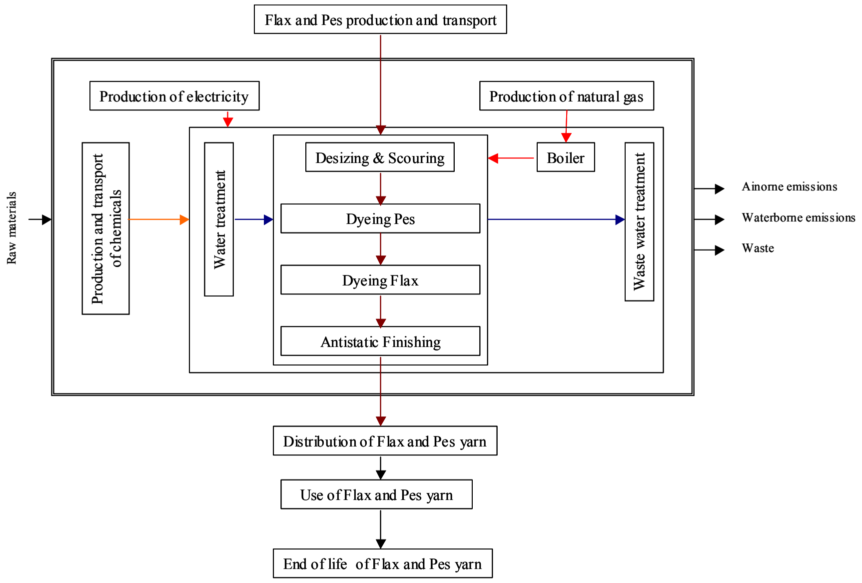

Fig 2.3 System boundaries of I06 product systems.

The processes excluded from the system boundaries are:

- Flax and PES yarn and fabric production processes, including the relative transports;

- All the product life cycle phases external to the company gate;
- The production and manufacturing of all equipment, machinery and capital goods used in the industrial processes, as commonly accepted in LCA

2.2.5 Data categories

The choice of data categories has been made in relation to the impact categories and characterization factors adopted. They include the macro categories of energy, raw materials, chemicals and emissions in air water and soil.
Different data sources were used in this study:

Company specific data:

- Desizing and scouring;
- Dyeing Flax;
- Dyeing Pes;
- Antistatic finishing;
- Water treatment

TEAM 3.0/Ecobilan data:

- production of electricity;
- production of methane;
- transport processes;
- boiler: general model which process parameters and efficiency are adjusted to I06 company;

Detailed hypotheses on the electricity production and on all the models used in this study are available in TEAM 3.0 modules database.

Lariana Depur data:

- All the centralised Waste Water Treatment Plant data.

Production of chemicals:

- TEAM 3.0/Ecobilan
- other LCA commercial databases and literature
- data collection from manufacturers;
- surrogate data (ETH) for performing sensitivity analyses and check the influence of the missed data.

2.2.6 Criteria for initial inclusion of inputs and outputs

All the inputs and outputs available in PIDACS were included in the study. Because of the large amount of base chemicals used for pre-treatment operation in textile wet processing, it was decided to include in the analysis the chemicals production. After a comprehensive review of the chemicals Life Cycle Inventories (LCI) available in commercial databases and direct contacts with the main textile chemicals manufacturers we included in the study the LCI data of 89% of the total chemicals mass used in the company processes. The influence of the missed data has been evaluated by sensitivity analyses.

2.2.7 Data quality requirements

The on site data gathered in this study have the following characteristics:

- Time related coverage: All the I06 data are related to year 2000;
- Geographical related coverage: the data are company specific and reflect the Como area situation;
- Technology coverage: equipment used in this company are 25 years old on average; only the Jigger J145 is more than 30 years old

To model the three product systems several assumptions were necessary:

Main assumptions within the company boundary:

- Steam production

The annual company methane consumption as well as the annual steam consumption are metered and reported on the I06 PIDACS. The 95% of the methane is used for industrial processes described in the PIDACS, the remaining part is used for heating the factory shed (estimation of the company technicians). To evaluate the specific methane consumption for processes desizing&scouring, dyeing flax, dyeing Pes, antistatic finishing, the specific consumption of steam has been calculated (m^3 of steam/bath). The calculation took in account the volume of water to be heated up and the bath temperature and was based on the metered annual steam consumption. To calculate the emissions of methane burning and the natural resources consumption, the TEAM 3.0 model developed by Ecobilan was used, adjusting the water inlet and the steam outlet temperatures on the actual company data and calibrating the steam generator efficiency to meet 95% of the metered company methane consumption.

- Process specific wastewater effluent

The wastewater effluent from the company specific processes has been characterised only with measured COD and TSS concentration, due to unavailability of specific contaminant concentration.

- Electricity consumption

The electricity consumption of specific processes has been calculated as absorbed power * run time. The electricity consumption for lighting and general services has been neglected, as generally accepted in LCA studies, because it is not relevant for the specific objectives of this study.

- Water pre-treatment

The potential impact of the production of the ionic exchange resins, as well as the water consumption for resins bed regeneration has been neglected, due to the very small quantities used. Only the potential impact of the salt production (used for resin regeneration) has been included in the study.

- Solid waste

The annual solid waste production of the company is specified in the PIDACS. The waste has been classified in three main fluxes: recycled waste (divided in packaging, iron and steel, plastic waste), special waste and special dangerous waste. The total waste quantity has been allocated to the analyzed product systems on a mass basis. The solid waste treatment has not been included in the systems, because of lack of specific data and the difficulty to identify reference treatment scenarios.

- Airborne emissions.

I06 PIDACS specifies for each emission source, typically a specific equipment, the chimney flow rate and the contaminants concentration. For LCA purposes the contaminants emissions in the environment have been calculated as: [emission source flow rate]x[equipment run time]x[contaminant concentration]. If the concentration has been indicated as < limit value, the specific limit value has been assumed.

Main assumptions for production of chemicals:
The inventories available in the TEAM 3.0 database have been included in the study; the following databases were checked in addition to the TEAM 3.0 one:

- SimaPro;
- KCL Eco;
- IVAM;
- Boustead model;
- Specific industry data.

Main assumptions for Lariana WWTP:
We assumed that the potential environmental impacts of WWTP processes are mainly due to the production of the energy needed in the plant and to the emission of the treated effluent into the environment; the impact of chemicals production has been neglected. These hypotheses were based on the results of previous LCA studies of ENEA.
The potential environmental impacts for treating the waste water of the studied product systems have been considered proportional to effluent mass.
Direct greenhouse gas emission to the environment from Lariana WWTP processes have not been considered (according to IPPC guidelines).
Because it was not possible to have information on the specific contaminants of the water effluents of the manufacturing processes of the flax-pes fabric, the evaluation of the potential impact connected to the release to the environment of the treated water effluent has been calculated considering the effluent mass of the specific product system and the contaminant concentration of the treated WWTP effluent.

2.2.8 Impact assessment methods

The impact assessment categories used for the analysis of the three product systems are indicated in table.2.2

CML 92-Air Acidification	g eq. H+
CML 92-Aquatic Eco-toxicity	1e3m3
CML 92-Depletion of non renewable resources	fraction of reserve
CML 92-Eutrophication	g eq. PO4
CML 92-Human Toxicity	g
CML 92-Terrestrial Eco-toxicity	t
IPCC-Greenhouse effect (direct, 100 years)	g eq. CO2
WMO-Photochemical oxidant formation (high)	g eq. ethylene
Reminders-Primary energy consumption	MJ

Tab. 2.2 Impact assessment categories

The chosen impact assessment categories are well known and accepted at international level: a short description can be found in TEAM software online documentation.

Because of project limits (detailed analyses of process wastewaters were not available) and methodological limits (characterisation factors are available only for a small part of the manufactured chemicals), the EDIP (Environmental Design of Industrial Products method proposed by Wenzel and Hauschild has been adopted for screening the potential impact of chemicals on ecotoxicity. A short description of the method is reported hereafter.

This EDIP screening method is based on the existing EU hazard classification of substances, available in the list of hazardous substances published by the EEC (1994). A semi-quantitative scoring of the substance in the inventory is obtained by calculating a score for exposure and a score for ecotoxicity, which are multiplied to give a final ecotoxicological impact score.

The idea behind multiplication of separate scores for exposure and ecotoxicity is that if emission of a substances is expected or if undesirable long term effects are possible, and the substance has some form of ecotoxicity, the score for environmental hazardousness will be increased more than by simple addition. This is in agreement with a toxic property being assessed as having a greater environmental significance if the substance is emitted often, is not easily degradable or can undergo bioaccumulation.

Exposure score

The score for the exposure is a combination of expectation concerning emission (yes/no) and the possibility of undesiderable long term effects on the environment (R53 or R58).

The two scoresare added and their sum is multiplied by the score for ecotoxicity.

R53 is a classification assigned to substances which are not easily biodegradable or which are potential bioaccumulators, and where the following values are found for acute toxicity:

96-hour LC_{50} (fish)≤ 10 mg/l, or

48-hour EC_{50} (Daphnia))≤ 10 mg/l, or

72-hour IC_{50} (algae) 10 mg/l.

There are no criteria for assignment of an R58 classification, which refers to undesirable long term effects in environments other than the aquatic environment.

Ecotoxicity score

The score of ecotoxic effects is a combination of ecotoxicity to aquatic organism (R50-R51-R52 alone or in combination with other R phrases) and ecotoxicity to soil-dwelling organism (R54-R55-R54 R56-R57 alone or in combination with other R phrases). The two scores are added to give a total score for the substance’s ecotoxicity (see table 2.3)

Aquatic ecotoxicity		**Terrestrial ecotoxicity**	
(**R50**….) $LC_{50} \leq 1$ mg/l	**4**	R54 Toxic to flora or R55 Toxic to fauna or R56 Toxic to soil organisms or R57 **Toxic to bees**	**4**
(**R51**….) 1mg/l< $LC_{50} \leq 10$ mg/l	**2**		
(**R52**….) 10 mg/l< $LC_{50} \leq 100$ mg/l	**1**		

Tab. 2.3 Ecotoxicity scores

If no ecotoxicity data are available for the substance, it is assigned an ecotoxicity score of 8 (4 for water compartment and 4 for the soil compartment); if the substance is, however, well know and considered to have no significant hazardous effects, it is assigned a score of 0.

Ecotoxicological impact score

The total ecotoxicological impact score for the emissions is calculated by multiplying the score for exposure and the score for ecotoxicity as shown in table 2.4.

	Ecotoxicity score 0	Ecotoxicity score 1	Ecotoxicity score 4	Ecotoxicity score 8
No emission and not classified as R53 0r R58 (score 1)	0	1	4	8
Emission expected or R53 or R58 (score 4)	0	4	16	32
Emission expected and R53 or R58 (score 8)	0	8	32	64

Tab. 2.4 Impact assessment categories

2.2.9 Interpretation methods

In the interpretation phase of this study the potential environmental impact of the different processes has been evaluated, the significant issues have been identified and the contribution of the specific contaminant fluxes has been calculated.

The sensitivity check focused on allocation rules (thermal energy) and lack of inventory data for chemicals.

A comparison of the different product systems has been performed

2.2.10 Critical review

Being a pilot study performed in a research project, this report has not been submitted to a critical review.

3 Inventory analysis

3.1 *Procedures for data collection*

Data were collected from I06 company with the Process Identification and data Collection Sheet (PIDACS) defined and used by the Towef0 project. The PIDACS contains information for the entire Towef0 project and a part of the data was extracted for the LCA study.
Flow-charts of the most representative production lines were identified on the basis of the PIDACS data.
Data collection was performed by Lariana Depur.
More detailed information on specific processes were obtained by Lariana Depur by phone and by e-mail contacts.

Data were implemented using modules of TEAM software. The modules were developed by Ecobilan and were specific for the textile finishing industrial sector.

The product system has been completed using modules of the TEAM database and other bibliographical sources.

3.2 *Qualitative and quantitative description of unit processes*

The next paragraphs describe data collected for the inventory analysis. Data elaboration procedures are explained and assumptions and allocation procedures are documented.

3.2.1 Flax-Pes wet processing and general facilities

Annex 1 describes the general structure and content of the PIDACS. As shown in Table 2.1, the most representative production lines of the studied products were identified in collaboration with Lariana Depur. For each process of the selected production lines, the most productive equipment were identified. Table 3.1 summarizes the annual production of each process and the relative contribution of its equipment. On the basis of these data, some types of machinery were selected for the further inventory analysis:
J144 -T151 for desizing and scouring: 197 kg fabric/run capacity, 149 kg fabric/run capacity;
T154 - T151 for dyeing PES: 54 kg fabric/run capacity , 75 kg fabric/run capacity;
O192 - C146 for dyeing FLAX: 42 kg fabric/run capacity , 53 kg fabric/run capacity;
R161 - R163 for antistatic finishing: 85 kg fabric/hour capacity.

Table 3.1: Selection of equipment on the basis of annual production.

	Desizing&Scouring F.3.2	**Desizing&Scouring F.1.4**	**Dyeing PES G.1.1**	**Dyeing PES G.3.1**	**Dyeing FLAX G.7.2**	**Dyeing FLAX G.8.1**	**Antistatic Finishing H4**
annual production (ton)	52,294	74,291	30,668	4,097	6,899	3,630	165,458
Equipment							
J144	97%	-	-	-	-	10%	-
J145	2%	-	-	-	-	6%	-
C146	1%	-	-	-	-	84%	-
T151	-	62%	40%	57%	-	-	-
T153	-	8%	12%	0%	-	-	-
T154	-	5%	48%	43%	-	-	-
T155	-	25%	0%	0%	-	-	-
O192	-	-	-	-	48%	-	-
O193	-	-	-	-	37%	-	-
O194	-	-	-	-	15%	-	-
R161	-	-	-	-	-	-	50%
R163	-	-	-	-	-	-	50%

Specific data on selected equipment and related processes were extracted from PIDACS. Moreover, data concerning general facilities were analysed, too. These processes are:
Sand filtration of water: **93264 m^3 water/year** capacity;
Ion exchange softening of water: **76251 m^3 water/year** capacity;
Steam production: **6050 ton steam/year** capacity.

The next sub-chapters describe the data available in PIDACS, their elaboration and the main assumptions necessary for the LCA study. Data are always related to the above described capacities of the selected equipment.

3.2.1.1 Water use

Table 3.2 shows the water consumption of the selected processes and equipment .

Table 3.2 Process specific water consumption.

	Water consumption (l/run*h)	**Water consumption (m^3/year)**
Desizing & Scouring F.3.2		
1st bath	2000	514
2nd bath	2000	514
3rd bath	2000	514
continuous washing	4355	1119
washing	2000	514
filling	2000	258
total	14355	3433
Desizing & Scouring F.1.4		
bath	2500	773
continuous washing	1500	464
washing	2500	773
total	6500	2010
Dyeing PES G.1.1		
bath	800	217
washing	800	217
total	1600	434
Dyeing PES G.3.1		
bath	2500	78
washing	2500	78
total	5000	156
Dyeing FLAX G.7.2		
1st bath	4000	316
2nd bath	4000	316
3rd bath	4000	316
continuous washing	1000	79
washing	4000	316
filling	4000	156
total	21000	1499

	Water consumption (l/run*h)	**Water consumption (m^3/year)**
Dyeing FLAX G.8.1		
1st bath	600	34
1st continuous washing	1110	63
1st washing	600	34
2nd bath	600	34
3rd bath	600	34
2nd continuous washing	1110	63
2nd washing	600	34
filling	600	17
total	5820	313
Antistatic finishing H4		
Doping, wringing, thermosetting	144,5	
total	144,5	

Water consumption of general facilities was neglected because of its irrelevant contribution to the total of category

3.2.1.2 Electricity consumption

Table 3.3 describes the electricity consumption of each process.

Table 3.3 Consumption of electricity

	absorbed power (kW)	**run time (h)**	**electricity (kWh/run)**	**number of run /year**	**working hours/year**	**electricity (kWh/year)**
Desizing & Scouring F.3.2	-	5	-	257	1285	-
Desizing & Scouring F.1.4	22	2,6	57	309	803	17666
Dyeing PES G.1.1	11,2	4,0	44,8	271	1084	12141
Dyeing PES G.3.1	22	4,5	99	31	140	3080
Dyeing FLAX G.7.2	9,35	6,5	60,775	79	513,5	4801
Dyeing FLAX G.8.1	22,4	7	156,8	57	399	8938
Antistatic finishing H4	50	1,7	85	566	-	-

Electricity consumption of boilers for steam production has not been considered because these values are included in the TEAM steam generator model.

3.2.1.3 Methane consumption

Methane is consumed for steam production. 95% of methane is used for heating water of industrial processes described in PIDACS. 5% is used for heating the factory shed (estimation of the company technicians).

There were no process specific data concerning steam consumption. PIDACS contains information on annual methane and steam consumption. Allocation to specific processes of the annual consumption of steam and methane was made by calculating the energy needed for each process with the next formula:

"required heating energy"[kJ] = volume of heated water [m^3] x (bath temperature – initial water temperature) [°C] x density of water [kg/m^3] x specific heat of water [kJ/kg x °C]

where:

- initial water temperature = 25 °C
- density of water = 1 kg/ m^3
- specific heat of water = 4,186 kJ/kg x °C

The value of "required heating energy" was calculated for each equipment of the I06 company and total methane consumption was allocated on the basis of the factor "total methane/ total "required heating energy". Table 3.4 shows the annual consumption of methane and steam, and the factors used for allocation. Table 3.5 describes the calculation procedure for methane and steam consumption of processes of the selected production lines.

Table 3.4 Methane and steam production

	Unit	**Value**	**Comment**
methane consumption of I06	m^3 /yr	923000	
methane consumption for water heating	m^3 /yr	876850	95% of methane consumption in I06
total "required heating energy"	kJ/yr	2483462	
factor "total methane/total "required heating energy"	m^3 /kJ	0,35	
steam consumption	kg/year	6050000	
factor "steam/methane"	kg/m^3	6,9	

Table 3.5 Calculation of steam consumption.

	Heated water	Bath temperature	Required heating energy	Specific consumption of methane	Specific consumption of steam	Total specific consumption of steam /year	Number of run	Specific consumption of steam
	(m^3/year)	(°C)	(kJ/bath)	(m^3 /yr)	(kg /yr)	(kg /yr)	(run/year)	(kg /run)
Desizing&Scouring F3.2								
1st bath	514	70	167	15194	104831			
2nd bath	514	70	167	15194	104831			
3rd bath	514	70	167	15194	104831			
total						314494	257	**1224**
Desizing&Scouring F.1.4								
bath	772,5	60	105	11417	78776			
total						78776	309	**255**
Dyeing PES G.1.1								
bath	216,8	130	267	25634	176867			
total						176867	271	**653**
Dyeing PES G.3.1								
bath	78	110	628	6873	47419			
total						47419	31	**1530**
Dyeing FLAX G.7.2								
1st bath	316	60	167	4670	32224			
3rd bath	316	80	502	14011	96673		79	
total						128897		**1632**
Dyeing FLAX G.8.1								
1st bath	34,2	60	25	505	3488		57	
3rd bath	34,2	80	75	1516	10436		57	
total						13950		**245**

3.2.1.4 Consumption of chemicals

Table 3.6 shows the concentration of chemicals used for each process. The mass of chemicals was calculated based on the volume of consumed water (see Chapter 3.1.1.1) or the wheight of the treated yarn (when concentration is expressed as kg of chemicals/100 kg yarn).

Table 3.6 Concentration of chemicals

	Non ionic surfactant (2057)	Sodium Hydrosulphite (1017)	Soda Solvay (1016)	Non ionic surfactant (1058)	Acetic Acid (2006)	Carrier (2036)	Disperse dyestuffs	Carrier (2068)	Reducing Agent (2067)	Sodium Solphate (2008)	Detergent (2046)	Dispersant agent (2058)	Lubricating agent (1057)	Detergent (2048)	Reactive dyestuffs	Antistatic agent (3045)
	g/l	g/l	g/l	g/l	g/l	g/l	%	g/l	g/l	g/l	g/l	g/l	g/l	g/l	%	g/l
Desizing &Scouring F.3.2																
1st bath	7,5	2														
2nd bath	7,5	2														
3rd bath	7,5	2	0,5	2												
Desizing &Scouring F.1.4																
bath				3												
Dyeing PES G.1.1																
bath					1	1	<0,05									
Dyeing PES G.3.1																
bath					1		>1	1	3							
Dyeing FLAX G.7.2																
1st bath			3							50	0,5	0,5	2		<0,05	
2nd bath					1											
3rd bath													2	2		
Dyeing FLAX G.8.1																
1st bath			3							50	1	1			>0,05	
2nd bath					1											
3rd bath														4		
Antistatic Finishing H4																
Doping, wringing, thermosetting																10

Chemicals used for steam production have not been considered because general data on chemicals and materials consumption are included in the TEAM 3.0 model developed by Ecobilan.

3.2.1.5 Discharged water

Table 3.7 shows the COD and TSS concentrations of discharged waters. Masses of total COD and TSS were calculated by multiplying the concentration values and the consumed water at each process step (see Chapter 3.1.1.1).

Table 3.7 Discharged water.

	COD (mg/l)	**TSS (mg/l)**
Desizing &Scouring F.3.2		
1st bath	10750	185
2nd bath	8600	93
3nd bath	8250	120
continuous washing	950	15
washing	310	20
filling	100	10
Desizing &Scouring F.1.4		
continuous washing	1250	115
bath	810	65
washing	150	12
Dyeing PES G.1.1		
bath	1500	35
washing	450	10
Dyeing PES G.3.1		
bath	1750	85
washing	400	10
Dyeing FLAX G.7.2		
1st bath	750	21
2nd bath	1050	12
continuous washing	2650	25
3rd bath	1950	15
washing	300	10
filling	100	0
Dyeing FLAX G.8.1		
1st bath	1100	51
1st continuous washing	450	15
1st washing	150	0
2nd bath	1050	35
3rd bath	1850	15
2nd continuous washing	500	10
2nd washing	220	3
filling	80	0
Antistatic Finishing H4		
Doping, wringing, thermosetting	14650	200

COD and TSS of water filtration and softening processes were neglected because of their low values.

3.2.1.6 Airborne emission

PIDACS specifies for each emission source, typically a specific equipment, the chimney flow rate and the contaminants concentration. Contaminants emissions in the environment can be calculated as: emission source flow rate*equipment run time* contaminant concentration.

Emission source	Run time (h)	Flow rate (Nm^3/h)	VOC [mg/Nm^3]	Aldehydes [mg/Nm^3]	Ammonia [mg/Nm^3]	Chloridric acid[$mg/N\ m^3$]	Acid acetic [$mg/N\ m^3$]	**Contaminant emission [mg]**
J144 Desizing&Scouring F.3.2	5	70	-	-	0,1	-	-	**35**
			-	-	-	0,5	-	**175**
T151 Dyeing Pes G.3.1	4,5	300	-	-	0,1	-	-	**135**
			-	-	-	0,5	-	**675**
			-	-	-	-	5	**6750**
T151 Desizing&Scouring F.1.4	2,6	300	-	-	0,1	-	-	**78**
			-	-	-	0,5	-	**390**
			-	-	-	-	5	**3900**
T153-T154 Dyeing Pes G.1.1	4	920	-	-	0,1	-	-	**368**
			-	-	-	0,5	-	**1840**
			-	-	-	-	5	**18400**
R161 Antistatic Finishing H4	1,7	15790	3,4	-	-	-	-	**91266**
			-	0,1	-	-	-	**2684**

3.2.1.7 Solid waste

The annual solid waste production of the company is specified in the PIDACS. The total waste quantity has been allocated to the reference flow of the analysed product systems on a mass basis. Table 3.8 describes annual and calculated values.

Table 3.8 Production of waste

	annual production (kg)	**normalised to ref. flow (kg)**	**destination of waste**
Flax/pl	516000	100	
150106 Packaging	25390	4,9	recovery
170405 Iron and steel	10840	2,1	recovery
160209 Transformers and condensers containing PCB and PCT	7910	1,5	-
150102 Plastic	5450	1,1	recovery
190806 Exhaust resins	1980	0,4	-
200121 Wastes containing Hg	440	0,09	-
160214 Electrical disused equipment	860	0,2	-

3.2.1.8 Production and transport of chemicals

Data on the production of chemicals were collected by a comprehensive review of the chemicals Life Cycle Inventories (LCI) available in commercial databases and software

(TEAM 3.0, SimaPro 5, GaBi 3, IVAM, Boustead Model, KCL Eco) and by direct contacts with the main textile chemicals manufacturers.
In case of lack of data, production of chemicals was excluded from the product system.; chemicals were treated as flows and characterised in the impact assessment means of EDIP method (see paragraph 2.2.8).
In the Interpretation phase of the LCA study, a sensitivity check was made on the lack of data on production of chemicals. Surrogate inventory data on the production of organic and inorganic chemicals (ETH) were applied to evaluate the sensitivity of the product system (see Chapter 5.3.2.1).

Table 3.9 summarizes the information on the used chemicals; table 3.10 highlight the sources of the inventory data on chemicals production included in the study.

Table 3.9 Chemicals

Process	Code	Commercial Name	Chemical class	Supplier
Desizing & Scouring F.3.2				
	2057	Zusotex ESL	Non ionic surfactant	Zeta Esse Ti s.r.l
	1017	Sodium Hydrosulphite	Sodium Hydrosulphite	C.P.L Prodotti chimici s.r.l
	1058	Tanaterge EF	Non ionic surfactant	Sybron
	1016	Sodium Carbonate	Soda Solvay	Solvay Italia
Desizing & Scouring F.1.4				
	1058	Tanaterge EF	Non ionic surfactant	Sybron
Dyeing PES G.1.1				
	2006	Acetic Acid 80%	Acetic Acid	C.P.L Prodotti Chimici s.r.l
	2036	Univadine 3 Flex	Carrier	Ciba-Geigy
Dyeing PES G.3.1				
	2006	Acetic Acid 80%	Acetic Acid	C.P.L Prodotti Chimici s.r.l
	2068	Zetesan OH	Carrier	Zeta Esse Ti s.r.l
	2067	Redoxal liq.	Reducing Agent	Datt
			Disperse dyestuffs	
Dyeing FLAX G.7.2				
	2008	Sodium Sulphate	Sodium Sulphate	C.P.L Prodotti Chimici s.r.l
	1016	Sodium Carbonate	Soda Solvay	Solvay Italia
	2046	Remectol B	Sequestering Agent	Clariant
	2058	Chelene DS-E	Dispersant Agent	Clariant
	1057	Antibastonante	Lubricating Agent	Infa s.r.l
	2006	Acetic Acid 80%	Acetic Acid	C.P.L Prodotti Chimici s.r.l
	2048	Laupon LF	Detergent	Lautex s.r.l
Dyeing FLAX G.8.1				
	2046	Remectol B	Sequestering Agent	Clariant
	2058	Chelene DS-E	Dispersant Agent	Clariant
	2008	Sodium Solphate	Sodium Sulphate	C.P.L Prodotti Chimici s.r.l
	1016	Sodium Carbonate	Soda Solvay	Solvay Italia
	2006	Acetic Acid 80%	Acetic Acid	C.P.L Prodotti Chimici s.r.l
	2048	Laupon LF	Detergent	Lautex s.r.l
Antistatic Finishing				
	3045	Perlin	Antistatic Agent	Pertex S.p.a

Tab 3.10 Chemicals inventories included in the study.

Process		kg/f.u.	weight %	Chemical classes	Source
F3.2	Desizing scouring in jigger	22,5	4%	non ionic surfactant	
		6	1%	Sodium Hydrosulphite	KCK Eco
		2	0%	non ionic surfactant	
F3.2	Desizing scouring in jigger	0,5	0%	Soda Solvay	TEAM
G1.1	Light dispersing dyeing in torpedo	1,48	0%	Acetic Acid	TEAM
		1,48	0%	Carrier	
		0,05	0%		
G7.2	Light reactive dyeing in overflow	476	78%	Sodium Solphate	TEAM
		28,56	5%	Soda Solvay	TEAM
		4,76	1%	sequestering agent	
		4,76	1%	Dispersant agent	
		23,8	4%	Lubricating agent	
		0,05	0%	Reactive dye	CIBA
		9,52	2%	Acetic Acid	TEAM
		4,76	1%	Detergent	
H4	Antistatic finishing	0,997	0%	Antistatic agent	
E2	Softening	24,92	4%	NaCl	TEAM
	Total	612,1			
	Percentage of available chemicals		**89%**		

Transport of chemicals was considered on the basis of PIDACS data. Transport modules of the TEAM database were selected on the basis of type of freight. “Ton x km” values were calculated by multiplying transported mass and distance values. (see Table 3.10)

Table 3.11 Types and distances of transport of chemicals

Code	**Chemical class**	**Supplier**	**Type of freight**	**Distance from delivery [km]**
2057	Non ionic surfactant	Zeta Esse Ti s.r.l	3,5 tons<Lorry<12 tons	>100
1017	Sodium Hydrosulphite	C.P.L Prodotti chimici s.r.l	3,5 tons<Lorry<12 tons	<10
1058	Non ionic surfactant	Sybron	3,5 tons<Lorry<12 tons	<10
1016	Soda Solvay	Solvay Italia	3,5 tons<Lorry<12 tons	<50
2006	Acetic Acid	C.P.L Prodotti Chimici s.r.l	3,5 tons<Lorry<12 tons	<10
2036	Carrier	Ciba-Geigy	3,5 tons<Lorry<12 tons	>100
2067	Reducing Agent	Datt	3,5 tons<Lorry<12 tons	<10
2068	Carrier	Zeta Esse Ti s.r.l	3,5 tons<Lorry<12 tons	>100
2008	Sodium Sulphate	C.P.L Prodotti Chimici s.r.l	3,5 tons<Lorry<12 tons	<10
2046	Sequestering Agent	Clariant	3,5 tons<Lorry<12 tons	<50
2058	Dispersant Agent	Clariant	3,5 tons<Lorry<12 tons	<50
1057	Lubricating Agent	Infa s.r.l	3,5 tons<Lorry<12 tons	<50
2048	Detergent	Lautex s.r.l	3,5 tons<Lorry<12 tons	<100
3045	Antistatic Agent	Pertex S.p.a	3,5 tons<Lorry<12 tons	<100

3.2.2 Energy production

Modules of TEAM 3.0 were used for the production processes of electrical, thermal and mechanical energy.

To calculate the emissions of methane burning and the natural resources consumption of the boiler, the TEAM 3.0 model developed by Ecobilan was calibrated.
As table 3.4 highlight, the boiler of I06 consumes 0.1449 m^3 of methane for the production of 1 kg steam. This amount of consumed methane corresponds to 4,72 MJ of energy input calculating with the next values:
0,72 kg/ m^3 of density of the consumed methane,
1,13 kg natural gas extracted from the environment for supplying 1 kg combustible gas,
0,025 kg natural gas extracted from the environment for supplying 1 MJ consumable energy by combustion (TEAM).
The model predefines some technical variables that influence methane consumption. Concerning I06 company, the next variables were modified:
Initial temperature of water 18 ^{o}C
Final temperature of steam: 140 ^{o}C
Boiler yield: 0.55
These variables result the consumption of 4,72 MJ of energy / 1 kg of steam.

3.2.3 Waste water treatment plant

We assumed that the potential environmental impacts of WWTP processes are mainly due to the production of the energy needed in the plant and to the emission of the treated effluent into the environment; the impact of chemicals production has been neglected. These hypotheses were based on the results of previous LCA studies of ENEA.
The potential environmental impacts for treating the waste water of the studied product systems have been considered proportional to effluent mass.
Direct CO_2 emissions to the environment from Lariana WWTP processes have not been considered (according to IPCC guidelines).
Because it was not possible to have information on the specific contaminants of the product systems water effluents, the evaluation of the potential impact connected to the release to the environment of the treated water effluent has been calculated considering the effluent mass of the specific product system and the contaminant concentration of the treated WWTP effluent.
Table 3.12 shows the data used to model WWTP.

Table 3.12 Data for modelling the WWTP

	Units	Value
Wastewater	litre/year	8.87E+09
Electricity	MJ/year	2.90E+07
Transport: Road (diesel oil, kg.km)	kg.km/year	8.99E+08
(w) Ammonia (NH4+, NH3, as N)	g/year	6.00E+07
(w) COD (Chemical Oxygen Demand)	g/year	5.19E+08
(w) Nitrates (NO3-)	g/year	7.89E+07
(w) Nitrites (NO2-)	g/year	1.77E+06
(w) Nitrogenous Matter (unspecified, as N)	g/year	1.40E+08

3.3 Results of inventory analysis

Tables 3-13 trough 3-15 show the inventories of systems A, B and C. Only the main fluxes are showed (fluxes which sum reaches 99% contribution to the total of each environmental impact category)

Table 3.13 Results of inventory analysis of I06 light dyeing (only main flows are listed)

Flow	Units	Total	Desizing & Scouring	Dyeing Pes	Dyeing Flax	Finishing	Softening	WWTP	Eletricity WWTP	Transport
INPUT										
(r) Iron (Fe, ore)	kg	2.79841	0.404618	0.764685	1.55344	0.044626	1.27E-03	0	0.0297403	0
(r) Natural Gas (in ground)	kg	659.692	81.2073	154.404	414.674	5.54273	1.62E-01	0	3.69375	0
(r) Oil (in ground)	kg	194.671	12.2793	16.3304	142.134	14.1098	1.44E-01	0	9.39419	0
(r) Potassium Chloride (KCl, as K2O, in ground)	kg	21.6145	0.072853	0	21.5417	0	0.00E+00	0	0	0
(r) Uranium (U, ore)	kg	0.001773	0.000262	0.000294	0.001211	4.93E-07	5.23E-06	0	3.28453E-07	0
Water (out of gate)	litre	3879.08	175.982	284.273	3266.87	69.8694	34.41059	0	46.5263	0
Water (gate to gate)	litre	60349.8	0	0	0	0	60349.76	0	0	0
OUTPUT										
(a) Alkane (unspecified)	g	74.5209	10.2281	19.2424	42.0235	1.79242	3.41E-02	0	1.19437	0
(a) Ammonia (NH3)	g	36.0508	0.675491	0.720296	34.6228	0.018829	8.88E-04	0	0.0125487	0
(a) Arsenic (As)	g	0.089755	0.008037	0.011175	0.055681	0.008817	1.65E-04	0	0.00587572	0
(a) Benzene (C6H6)	g	10.6392	1.51336	2.82537	5.86841	0.252522	9.00E-03	0	0.168215	0.001155
(a) Butane (n-C4H10)	g	39.863	4.40166	7.35484	24.1628	2.33817	2.72E-02	0	1.55759	0
(a) Cadmium (Cd)	g	0.18644	0.014836	0.019688	0.121701	0.018005	1.88E-04	0	0.0119986	3.63E-05
(a) Carbon Dioxide (CO2, fossil)	g	1992020	248736	441410	1186970	67660.4	1.27E+03	0	45062	3624.031
(a) Ethane (C2H6)	g	254.821	24.7238	38.4818	159.61	19.033	2.19E-01	0	12.6822	0
(a) Ethylene (C2H4)	g	263.792	40.0865	76.5739	141.946	3.04334	1.10E-01	0	2.02812	0
(a) Heptane (C7H16)	g	2.72314	0.214096	0.279517	1.80029	0.253124	2.58E-03	0	0.168527	0

Flow	Units	Total	Desizing & Scouring	Dyeing Pes	Dyeing Flax	Finishing	Softening	WWTP	Eletricity WWTP	Transport
(a) Hexane (C6H14)	g	5.44734	0.428582	0.559716	3.60053	0.506273	5.16E-03	0	0.337071	0
(a) Hydrocarbons (except methane)	g	1378.17	164.94	189.98	856.446	97.7086	1.09E+00	0	65.0069	6.036933
(a) Hydrocarbons (unspecified)	g	667.438	5.23988	7.25763	654.843	0.056887	2.36E-03	0	0.0379064	0
(a) Lead (Pb)	g	0.596923	0.037663	0.051158	0.443672	0.03821	6.78E-04	0	0.0254633	0.000156
(a) Methane (CH4)	g	6883.81	653.466	949.506	4424.48	509.022	6.72E+00	0	339.191	0.203649
(a) Nickel (Ni)	g	3.67513	0.292533	0.388568	2.39898	0.354723	3.70E-03	0	0.236399	0
(a) Nitrogen Oxides (NOx as NO2)	g	2719.81	229.985	334.737	1932.77	125.88	2.18E+00	0	83.5415	45.30404
(a) Propane (C3H8)	g	67.0534	6.75492	10.6808	41.5501	4.79177	6.11E-02	0	3.19276	0
(a) Sulphur Oxides (SOx as SO2)	g	15010.8	663.745	861.303	12315.8	696.522	8.83E+00	0	464.162	2.318882
(a) Toluene (C6H5CH3)	g	6.31349	0.814921	1.47743	3.63805	0.225634	4.08E-03	0	0.15027	0
(a) Vanadium (V)	g	14.5922	1.15471	1.52633	9.53828	1.41463	1.46E-02	0	0.942753	0
(a) VOC (Volatile Organic Compounds)	g	63.4916	0.328934	0	0	63.1626	0.00E+00	0	0	0
(s) Arsenic (As)	g	0.004365	0.000666	0.001276	0.002348	4.4E-05	1.31E-06	0	0.00002931	0
(s) Chromium (Cr III, Cr VI)	g	0.054661	0.008343	0.015979	0.029405	0.000551	1.64E-05	0	0.000366939	0
(s) Zinc (Zn)	g	0.164065	0.025044	0.047968	0.088248	0.001653	4.93E-05	0	0.00110152	0
(w) Ammonia (NH4+, NH3, as N)	g	415.435	0.568921	0.817554	5.03082	0.613371	8.51E-03	407.965	0.407998	0
(w) Benzene (C6H6)	g	2.11145	0.168229	0.23834	1.3972	0.181444	1.87E-03	0	0.120804	0
(w) Cadmium (Cd++)	g	0.006273	0.000518	0.000783	0.004139	0.000486	5.50E-06	0	0.000322963	0
(w) Chromate (CrO4--)	g	0.197234	0.001401	0	0.195833	0	0.00E+00	0	0	0
(w) Chromium (Cr III)	g	0.114729	0.017514	0.033546	0.061708	0.001156	3.45E-05	0	0.000770324	0
(w) Chromium (Cr III, Cr VI)	g	0.038221	0.002911	0.004024	0.025604	0.003348	3.88E-05	0	0.00222891	0
(w) COD (Chemical Oxygen Demand)	g	3614.52	2.24115	9.57204	69.8478	0.682268	8.62E-03	3531.67	0.453317	0
(w) Nitrogenous Matter (unspecified, as N)	g	962.435	0.702587	0.978365	7.72825	0.777655	7.93E-03	951.717	0.518073	0
(w) Oils (unspecified)	g	33.928	4.33097	7.64591	19.8134	1.2589	1.73E-02	0	0.83822	0

REMINDERS

Flow	Units	Total	Desizing & Scouring	Dyeing Pes	Dyeing Flax	Finishing	Softening	WWTP	Eletricity WWTP	Transport
COD (mass)	kg	79.5834	29.401	2.88889	45.8333	1.46021	0.00E+00	0	0	0
TSS (mass)	kg	1.24559	0.451777	0.066667	0.707143	0.02	0.00E+00	0	0	0
E Feedstock Energy	MJ	551.322	76.4394	107.811	289.982	45.9254	5.60E-01	0	30.6	-48.7162
E Fuel Energy	MJ	37134.5	4057.44	7268.76	24224.1	932.122	1.93E+01	0	620.824	48.71622
E Non Renewable Energy	MJ	37123.3	4058.94	7276.57	24260.1	898.143	19.49298	0	598.172	0
E Renewable Energy	MJ	560.275	74.8302	99.8325	252.322	79.7742	0.342151	0	53.1657	0
E Total Primary Energy	MJ	37686.8	4133.78	7376.43	24515.5	977.917	19.89866	0	651.337	0
Electricity	MJ elec	2842.43	347.941	435.393	1505.95	330.774	1.89514	197.4	23.0451	0

Table 3.14 Results of inventory analysis of I06 dark dyeing (only main flow are listed)

Flow	Units	I06 TOTAL	Desizing & Scouring	Dyeing Pes	Dyeing Flax	Finishing	Softening	WWTP	Electricity WWTP	Transport
INPUT										
(r) Iron (Fe, ore)	kg	2,08404	0,404618	1,28594	0,335726	0,044626	0,000526	0	0,012584	0
(r) Natural Gas (in ground)	kg	416,404	81,2073	259,974	68,0476	5,54273	0,067308	0	1,56292	0
(r) Oil (in ground)	kg	121,864	12,2793	26,6658	64,6562	14,1098	0,059843	0	3,97493	0
(r) Potassium Chloride (KCl, as K2O, in ground)	kg	2,63347	0,072853	0	2,56061	0	0	0	0	0
(r) Uranium (U, ore)	kg	0,000909	0,000262	0,000499	0,000145	4,93E-07	2,17E-06	0	1,39E-07	0
Water (out of gate)	litre	1380,28	175,982	475,138	624,842	69,8694	14,27437	0	19,6865	0
Water(gate to gate)	litre	25034,6	0	0	0	0	25034,57	0	0	0
OUTPUT							0			0
(a) Aldehyde (unspecified)	g	1,89391	0,005055	0,008018	0,025695	1,85503	1,22E-05	0	0,0001	0
(a) Alkane (unspecified)	g	56,0328	10,2281	32,4265	11,0638	1,79242	0,014132	0	0,505368	0
(a) Arsenic (As)	g	0,073929	0,008037	0,018041	0,036478	0,008817	6,85E-05	0	0,002486	0
(a) Benzene (C6H6)	g	8,14175	1,51336	4,74763	1,55233	0,252522	0,003734	0	0,071176	0,000458
(a) Butane (n-C4H10)	g	30,3983	4,40166	12,1903	10,789	2,33817	0,01127	0	0,659057	0
(a) Cadmium (Cd)	g	0,144967	0,014836	0,031523	0,075438	0,018005	7,79E-05	0	0,005077	1,45E-05
(a) Carbon Dioxide (CO2, fossil)	g	1,45E+06	248736	738559	370117	67660,4	528,0774	0	19066,9	1437,946
(a) Ethane (C2H6)	g	195,89	24,7238	63,2204	83,4254	19,033	0,090883	0	5,36619	0
(a) Ethylene (C2H4)	g	200,119	40,0865	128,91	27,1731	3,04334	0,045814	0	0,858152	0
(a) Heptane (C7H16)	g	2,06104	0,214096	0,448446	1,07088	0,253124	0,00107	0	0,071308	0
(a) Hexane (C6H14)	g	4,12368	0,428582	0,897985	2,14184	0,506273	0,00214	0	0,142624	0
(a) Hydrocarbons (except methane)	g	1038,7	164,94	314,382	432,441	97,7086	0,452232	0	27,5061	2,387014
(a) Hydrocarbons (unspecified)	g	99,6139	5,23988	16,2676	78,0324	0,056887	0,000977	0	0,016039	0
(a) Lead (Pb)	g	0,351869	0,037663	0,082776	0,182132	0,03821	0,000281	0	0,010774	6,27E-05
(a) Methane (CH4)	g	5114,99	653,466	1555,92	2249,67	509,022	2,7877	0	143,521	0,080388
(a) Nickel (Ni)	g	2,85756	0,292533	0,622223	1,48642	0,354723	0,001533	0	0,100027	0
(a) Nitrogen Oxides (NOx as NO2)	g	1605,8	229,985	553,95	655,202	125,88	0,902906	0	35,3486	17,98253
(a) Propane (C3H8)	g	51,6698	6,75492	17,5723	21,1653	4,79177	0,025334	0	1,35094	0

(a) Sulphur Oxides (SOx as SO2)	g	6770,93	663,745	1387,8	3822,6	696,522	3,664019	0	196,399	0,902059
(a) Toluene (C6H5CH3)	g	4,77986	0,814921	2,47645	1,19627	0,225634	0,001695	0	0,063583	0
(a) Vanadium (V)	g	11,3415	1,15471	2,44211	5,92471	1,41463	0,006036	0	0,398904	0
(a) VOC (Volatile Organic Compounds)	g	63,4916	0,328934	0	0	63,1626	0	0	0	0
(s) Arsenic (As)	g	0,0033	0,000666	0,002149	0,000428	4,40E-05	5,44E-07	0	1,24E-05	0
(s) Chromium (Cr III, Cr VI)	g	0,04132	0,008343	0,026907	0,005357	0,000551	6,81E-06	0	0,000155	0
(s) Zinc (Zn)	g	0,124038	0,025044	0,080771	0,016083	0,001653	2,04E-05	0	0,000466	0
(w) Ammonia (NH4+, NH3, as N)	g	178,022	0,568921	1,35999	2,67302	0,613371	0,003528	172,621	0,172635	0
(w) Benzene (C6H6)	g	1,57407	0,168229	0,390685	0,780311	0,181444	0,000775	0	0,051115	0
(w) Cadmium (Cd++)	g	0,004591	0,000518	0,001306	0,002135	0,000486	2,28E-06	0	0,000137	0
(w) Chromate (CrO4--)	g	0,024679	0,001401	0	0,023278	0	0	0	0	0
(w) Chromium (Cr III)	g	0,086743	0,017514	0,056486	0,011247	0,001156	1,43E-05	0	0,000326	0
(w) Chromium (Cr III, Cr VI)	g	0,028164	0,002911	0,006581	0,014336	0,003348	1,61E-05	0	0,000943	0
(w) COD (Chemical Oxygen Demand)	g	1527,88	2,24115	19,8193	10,5816	0,682268	0,003577	1494,34	0,191811	0
(w) Nitrogenous Matter (unspecified, as N)	g	409,586	0,702587	1,63218	3,55191	0,777655	0,003289	402,696	0,21921	0
(w) Oils (unspecified)	g	25,3954	4,33097	12,8176	6,61628	1,2589	0,00717	0	0,354673	0
REMINDERS							0			0
COD (mass)	kg	40,2156	29,401	7,16667	2,18774	1,46021	0	0	0	0
TSS (mass)	kg	0,876928	0,451777	0,316	0,089151	0,02	0	0	0	0
E Feedstock Energy	MJ	522,472	76,4394	197,031	189,895	45,9254	0,23226	0	12,9477	-19,335
E Fuel Energy	MJ	23475,8	4057,44	12175,6	6034,89	932,122	8,022696	0	262,687	19,33499
E Non Renewable Energy	MJ	23358,8	4058,94	12211,5	5924,07	898,143	8,08619	0	253,102	0
E Renewable Energy	MJ	638,252	74,8302	160,84	300,166	79,7742	0,141933	0	22,4958	0
E Total Primary Energy	MJ	23997,2	4133,78	12372,4	6224,25	977,917	8,254482	0	275,598	0
Electricity	MJ elec	3276,36	347,941	704,317	1799,25	330,774	0,786153	83,5251	9,75101	0

Table 3.15 Results of inventory analysis of I06 non sized (only main flows are listed)

Flow	Units	Total	Desizing & Scouring	Dyeing Pes	Dyeing Flax	Finishing	Softening	WWTP	Electricity WWTP	Transport
INPUT										
(r) Iron (Fe, ore)	kg	2,515	0,123	0,764	1,553	0,045	0,001	0,000	0,029	0,000
(r) Natural Gas (in ground)	kg	601,857	23,639	154,324	414,611	5,543	0,157	0,000	3,576	0,000
(r) Oil (in ground)	kg	188,840	6,761	16,330	142,134	14,110	0,140	0,000	9,096	0,000
(r) Potassium Chloride (KCl, as K2O, in ground)	kg	21,542	0,000	0,000	21,542	0,000	0,000	0,000	0,000	0,000
(r) Uranium (U, ore)	kg	0,002	0,000	0,000	0,001	0,000	0,000	0,000	0,000	0,000
Water (out of gate)	litre	3762,520	62,278	284,161	3266,740	69,869	33,317	0,000	45,048	0,000
Water (gate to gate)	litre	58432,100	0,000	0,000	0,000	0,000	58432,090	0,000	0,000	0,000
OUTPUT										
(a) Alkane (unspecified)	g	67,506	3,269	19,233	42,016	1,792	0,033	0,000	1,156	0,000
(a) Ammonia (NH3)	g	35,439	0,064	0,720	34,623	0,019	0,001	0,000	0,012	0,000
(a) Arsenic (As)	g	0,086	0,004	0,011	0,056	0,009	0,000	0,000	0,006	0,000
(a) Benzene (C6H6)	g	9,598	0,480	2,824	5,867	0,253	0,009	0,000	0,163	0,001
(a) Butane (n-C4H10)	g	37,201	1,796	7,352	24,161	2,338	0,026	0,000	1,508	0,000
(a) Cadmium (Cd)	g	0,180	0,009	0,020	0,122	0,018	0,000	0,000	0,012	0,000
(a) Carbon Dioxide (CO2, fossil)	g	1825690,000	84272,000	441210,000	1186810,000	67660,400	1232,556	0,000	43630,100	3010,319
(a) Ethane (C2H6)	g	241,240	11,574	38,472	159,602	19,033	0,212	0,000	12,279	0,000
(a) Ethylene (C2H4)	g	235,383	11,816	76,535	141,915	3,043	0,107	0,000	1,964	0,000
(a) Heptane (C7H16)	g	2,625	0,121	0,280	1,800	0,253	0,002	0,000	0,163	0,000
(a) Hexane (C6H14)	g	5,250	0,243	0,560	3,601	0,506	0,005	0,000	0,326	0,000
(a) Hydrocarbons (except methane)	g	1268,660	57,711	189,934	856,409	97,709	1,056	0,000	62,941	4,971

(a) Hydrocarbons (unspecified)	g	662,229	0,033	7,258	654,843	0,057	0,002	0,000	0,037	0,000
(a) Methane (CH4)	g	6517,250	298,365	949,276	4424,290	509,022	6,507	0,000	328,413	0,167
(a) Nickel (Ni)	g	3,545	0,170	0,389	2,399	0,355	0,004	0,000	0,229	0,000
(a) Nitrogen Oxides (NOx as NO2)	g	2574,420	87,855	334,626	1932,680	125,880	2,107	0,000	80,887	37,667
(a) Propane (C3H8)	g	63,248	3,059	10,678	41,548	4,792	0,059	0,000	3,091	0,000
(a) Sulphur Oxides (SOx as SO2)	g	14678,800	346,888	861,220	12315,700	696,522	8,552	0,000	449,413	1,832
(a) Toluene (C6H5CH3)	g	5,773	0,281	1,477	3,638	0,226	0,004	0,000	0,145	0,000
(a) Vanadium (V)	g	14,080	0,673	1,526	9,538	1,415	0,014	0,000	0,913	0,000
(a) VOC (Volatile Organic Compounds)	g	63,160	0,000	0,000	0,000	63,160	0,000	0,000	0,000	0,000
(s) Arsenic (As)	g	0,004	0,000	0,001	0,002	0,000	0,000	0,000	0,000	0,000
(s) Chromium (Cr III, Cr VI)	g	0,049	0,002	0,016	0,029	0,001	0,000	0,000	0,000	0,000
(s) Zinc (Zn)	g	0,146	0,007	0,048	0,088	0,002	0,000	0,000	0,001	0,000
(w) Ammonia (NH4+, NH3, as N)	g	402,193	0,304	0,817	5,031	0,613	0,008	395,001	0,395	0,000
(w) Benzene (C6H6)	g	2,030	0,091	0,238	1,397	0,181	0,002	0,000	0,117	0,000
(w) Cadmium (Cd++)	g	0,006	0,000	0,001	0,004	0,000	0,000	0,000	0,000	0,000
(w) Chromate (CrO4--)	g	0,196	0,000	0,000	0,196	0,000	0,000	0,000	0,000	0,000
(w) Chromium (Cr III)	g	0,102	0,005	0,034	0,062	0,001	0,000	0,000	0,001	0,000
(w) Chromium (Cr III, Cr VI)	g	0,037	0,002	0,004	0,026	0,003	0,000	0,000	0,002	0,000
(w) COD (Chemical Oxygen Demand)	g	3500,670	0,636	9,571	69,847	0,682	0,008	3419,450	0,439	0,000
(w) Nitrogenous Matter (unspecified, as N)	g	931,850	0,376	0,978	7,728	0,778	0,008	921,475	0,502	0,000
(w) Oils (unspecified)	g	31,043	1,480	7,643	19,811	1,259	0,017	0,000	0,812	0,000

REMINDERS							0,000			0,000
COD (mass)	kg	53,867	3,685	2,889	45,833	1,460	0,000	0,000	0,000	0,000
TSS (mass)	kg	1,104	0,310	0,067	0,707	0,020	0,000	0,000	0,000	0,000
E Feedstock Energy	MJ	499,070	25,204	107,796	289,971	45,925	0,542	0,000	29,628	-40,494
E Fuel Energy	MJ	34380,000	1329,760	7265,370	24221,400	932,122	18,725	0,000	601,097	40,494
E Non Renewable Energy	MJ	34353,200	1314,970	7273,180	24257,400	898,143	18,874	0,000	579,164	0,000
E Renewable Energy	MJ	523,650	39,924	99,822	252,314	79,774	0,331	0,000	51,476	0,000
E Total Primary Energy	MJ	34880,000	1354,900	7373,030	24512,800	977,917	19,266	0,000	630,640	0,000
Electricity	MJ elec	2655,840	168,518	435,340	1505,900	330,774	1,835	191,127	22,313	0,000

4 Life cycle impact assessment

Classification and characterisation were done on the basis of the impact assessment methods selected during scope definition of the study (see Chapter 2.2.8).

5 Life cycle interpretation

5.1 Identification of significant issues and Contribution analysis for system A

In the following paragraphs the graphs of the selected impact assessment categories and inventory data are presented for system A (light colours) to highlight significant issues. Contributions of electricity production, steam production and chemical production, as well as the main contaminant flows are reported in tables for each impact category.

5.1.1 Water consumption

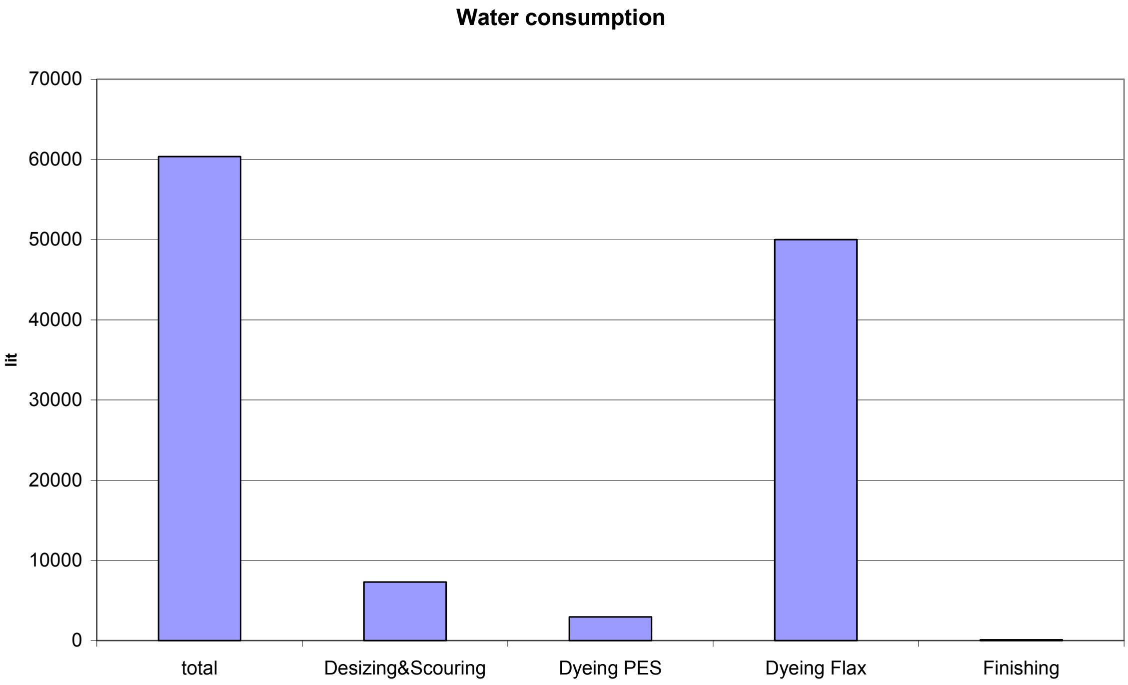

Fig. 5.1 Water consumption within the company.

5.1.2 COD and TSS

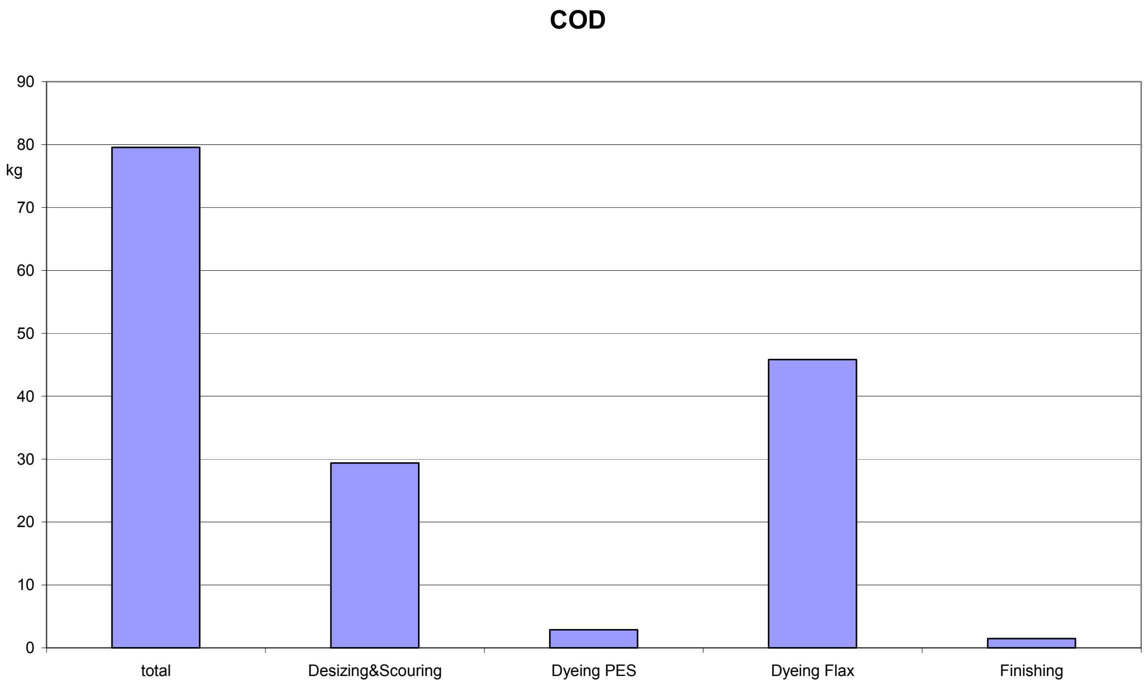

Fig. 5.2 COD emissions to WWTP for specific processes.

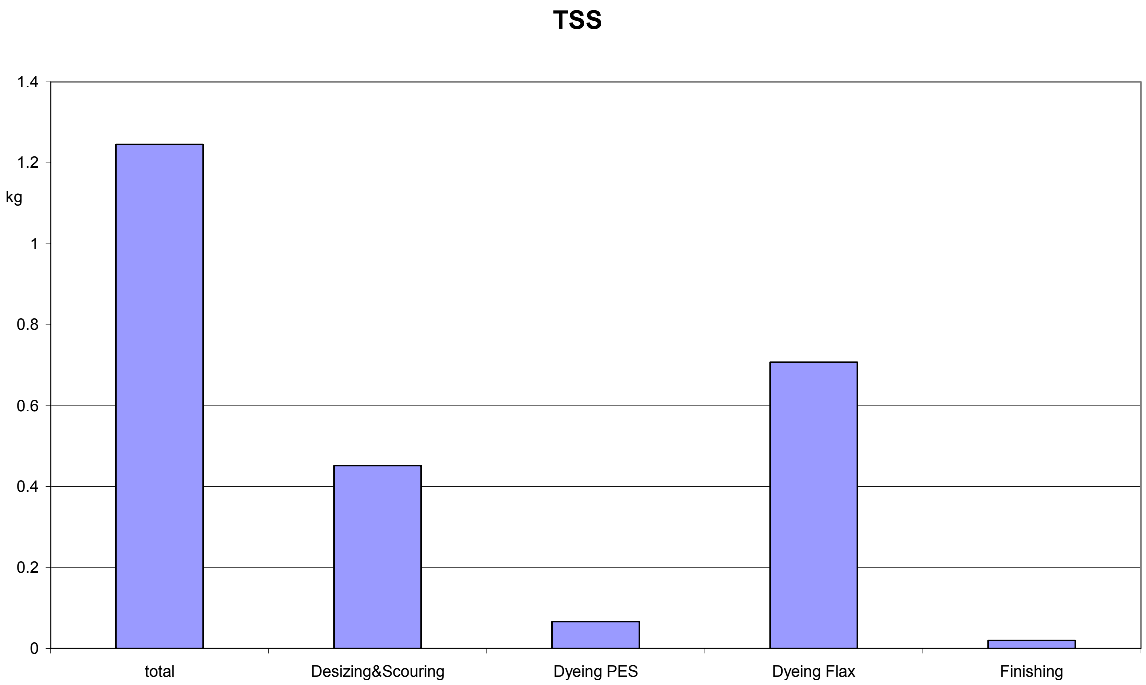

Fig. 5.3 TSS emissions to WWTP for specific processes

5.1.3 Energy indicators

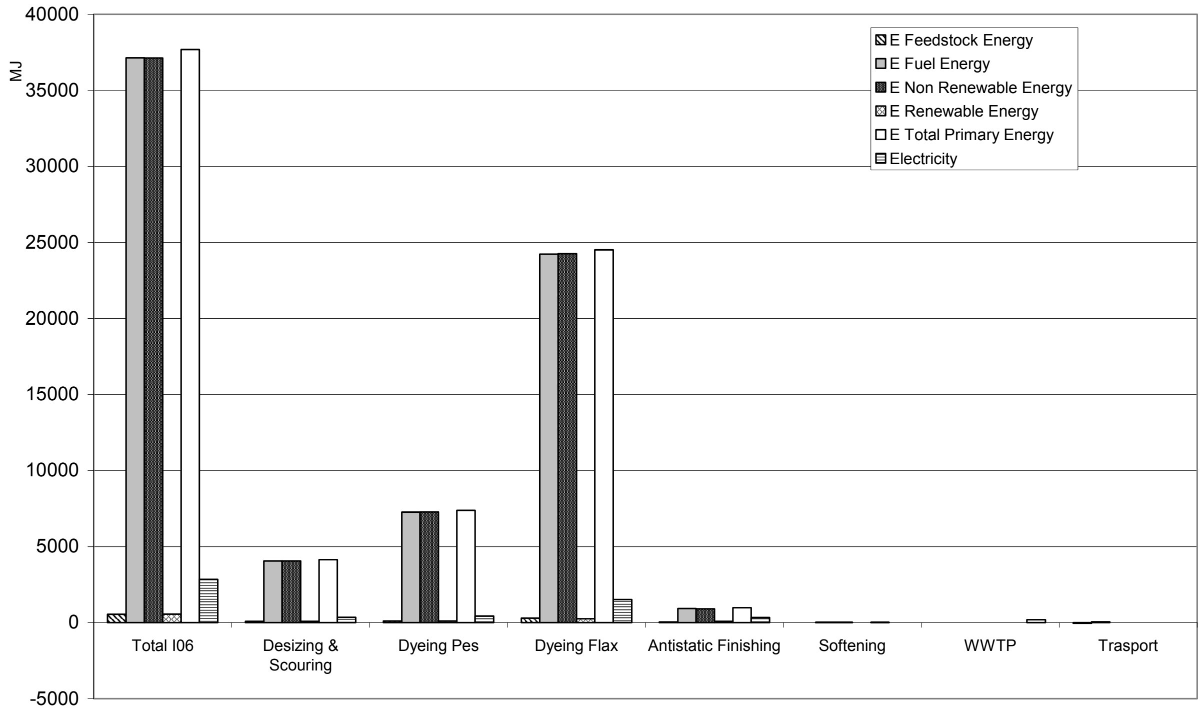

Fig. 5.4 Energy indicators.

Primary energy is the energy embodied in natural resources (e.g. coal, crude oil, natural gas, uranium) that has not undergone any anthropogenic conversion or transformation. It is an indicator of the efficiency of the use of energy natural resources in the overall system. Feedstock energy is the energy embodied in natural resources that are used as raw materials (not used as fuel) in the system.

Impact categories	**Units**	**Chemicals production**	**Steam production**	**electricity production**	**Transport**	**WWTP**
Total primary energy	**Mj**	29%	56%	13%	0%	0%

Table 5.1 Main contributors to the total of category.

5.1.4 Air Acidification

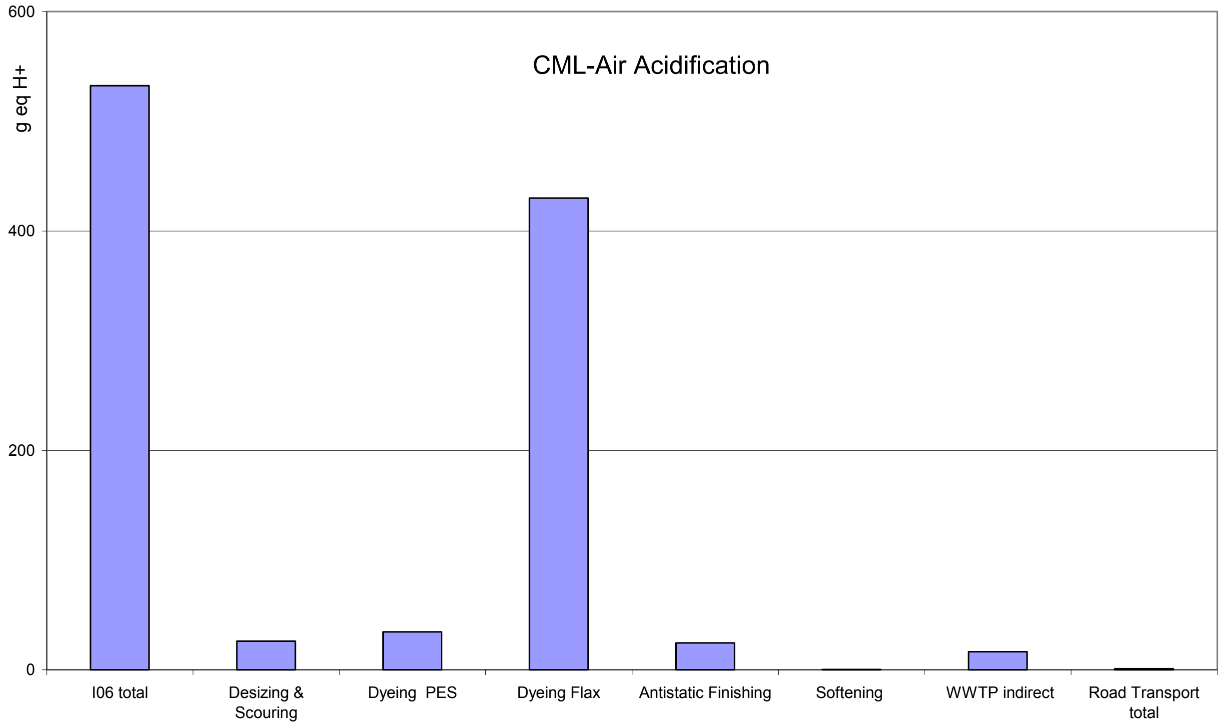

Fig. 5.5 CML 92 Air acidification.

Impact categories	***Units***	***Chemicals production***	***Steam production***	***electricity production***	***Transport***	***WWTP***
CML-Air Acidification	**g eq. H+**	67%	6%	24%	0%	0%

Table 5.2 Main contributors to the total of category.

Impact assessment	**Unit**		**%**
CML-Air Acidification	**g eq. H+**	**532.45**	**100%**
(a) Sulphur Oxides (SO_x as SO_2)	g eq. H+	469.09	88%
(a) Nitrogen Oxides (NO_x as NO_2)	g eq. H+	59.13	11%
(a) Ammonia (NH_3)	g eq. H+	2.12	0%

Table 5.3 Main contaminant fluxes.

5.1.5 Depletion of non renewable resources

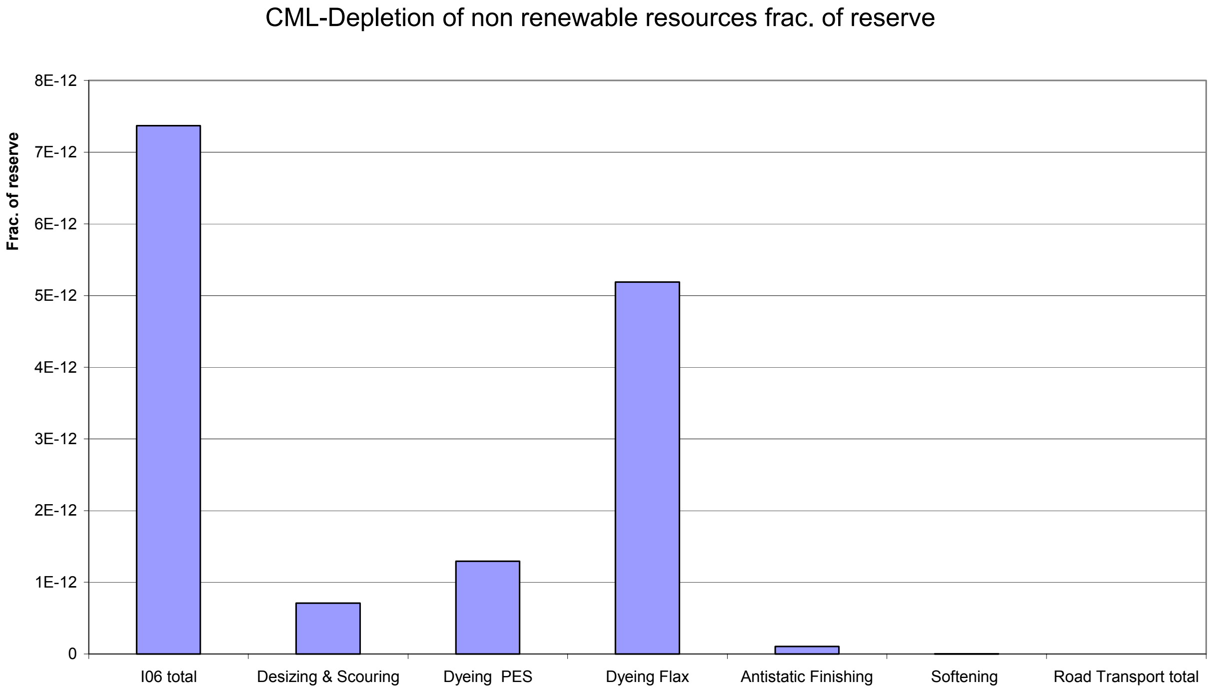

Fig. 5.6 CML 92 Depletion of non renewable resources.

Impact categories	***Units***	***Chemicals production***	***Steam production***	***electricity production***	***Transport***	***WWTP***
CML-Depletion of non renewable resources	**frac. of reserve**	38%	53%	7%	0%	0%

Table 5.4 Main contributors to the total of category.

Impact assessment	**Unit**		**%**
CML-Depletion of non renewable resources	**frac. of reserve**	**7.37E-12**	**100%**
(r) Natural Gas (in ground)	frac. of reserve	5.08E-12	69%
(r) Potassium Chloride (KCl, as K_2O, in ground)	frac. of reserve	1.27E-12	17%
(r) Oil (in ground)	frac. of reserve	8.15E-13	11%

Table 5.5 Main contaminant fluxes.

5.1.6 Eutrophication

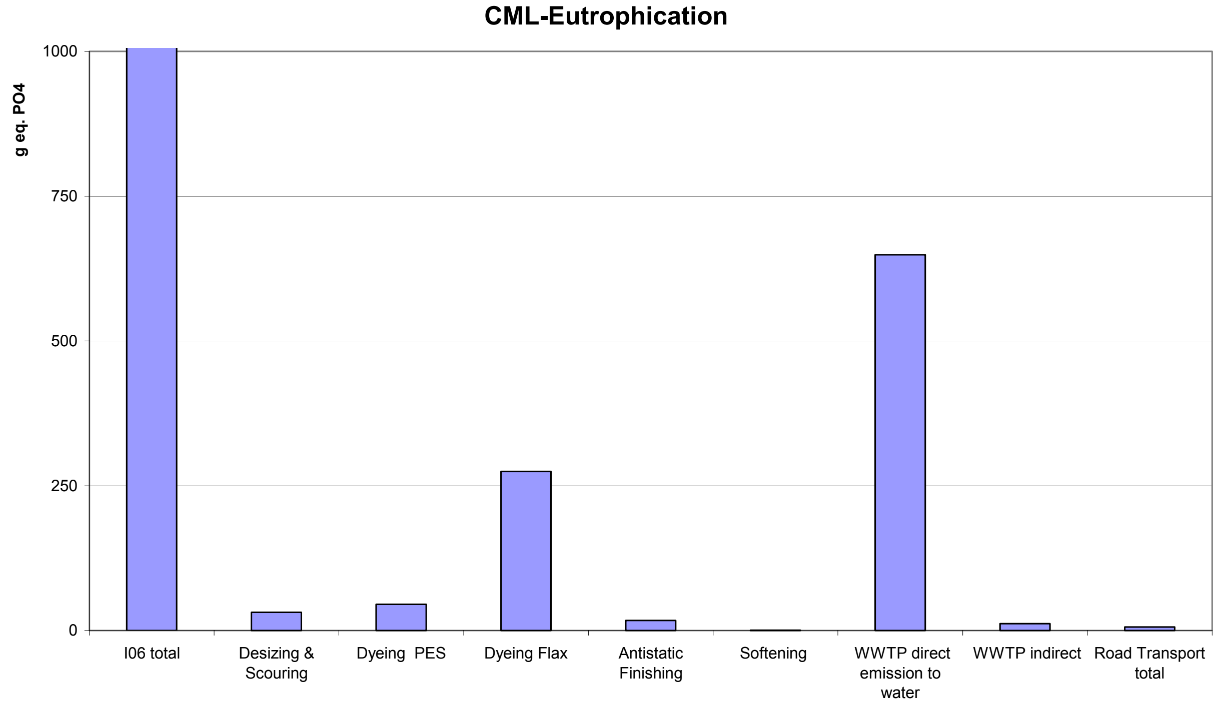

Fig. 5.7 CML 92 Eutrophication.

Impact categories	*Units*	*Chemicals production*	*Steam production*	*electricity production*	*Transport*	*WWTP*
CML-Eutrophication	**g eq. PO_4**	18%	9%	9%	1%	63%

Table 5.6 Main contributors to the total of category.

Impact assessment	Unit		%
CML-Eutrophication	**g eq. PO_4**	**1030.45**	**100%**
(w) Nitrogenous Matter (unspecified, as N)	g eq. PO_4	404.22	39%
(a) Nitrogen Oxides (NO_x as NO_2)	g eq. PO_4	353.58	34%
(w) Ammonia (NH4+, NH3, as N)	g eq. PO_4	174.48	17%

Table 5.7 Main contaminant fluxes.

5.1.7 Greenhouse effect (100 years)

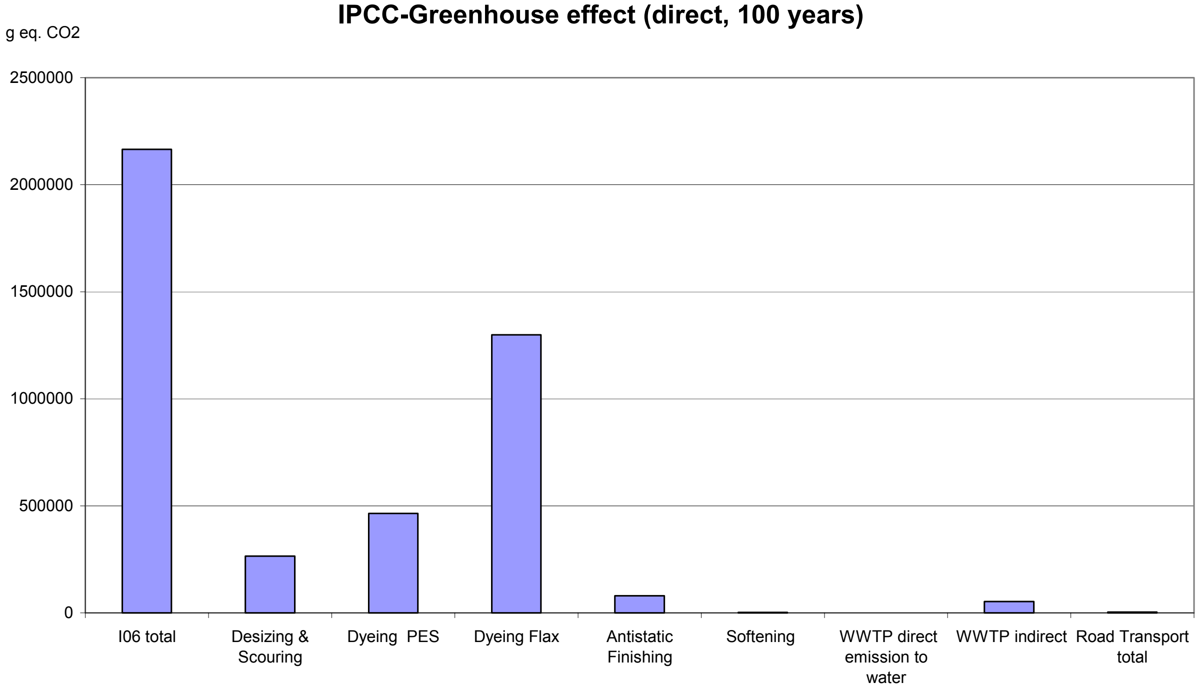

Fig. 5.8 CML 92 IPCC Greenhouse effect.

Impact categories	*Units*	*Chemicals production*	*Steam production*	*electricity production*	*Transport*	*WWTP*
IPCC-Greenhouse effect (direct, 100 years)	**g eq. CO_2**	19%	59%	19%	0%	0%

Table 5.8 Main contributors to the total of category.

Impact assessment	Unit		%
IPCC-Greenhouse effect (direct, 100 years)	**g eq. CO_2**	**2164447.00**	**100%**
(a) Carbon Dioxide (CO_2, fossil)	g eq. CO_2	1992020.00	92%
(a) Methane (CH_4)	g eq. CO_2	165211.4	8%
(a) Nitrous Oxide (N_2O)	g eq. CO_2	6991.52	0%

Table 5.9 Main contaminant fluxes.

5.1.8 Aquatic toxicity

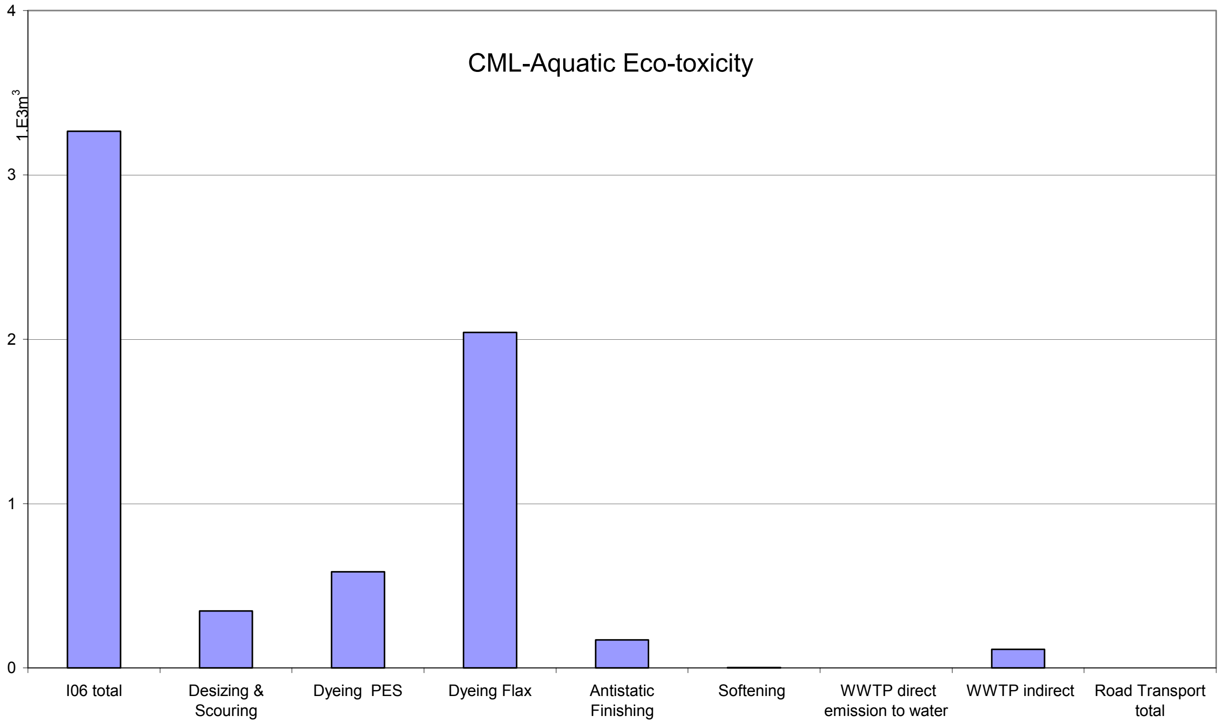

Fig. 5.9 CML 92 Aquatic ecotoxicity.

Impact categories	***Units***	***Chemicals production***	***Steam production***	***electricity production***	***Transport***	***WWTP***
CML-Aquatic Eco-toxicity	**$1e^3m^3$**	28%	40%	27%	0%	0%

Table 5.10 Main contributors to the total of category.

Impact assessment	**Unit**		**%**
CML-Aquatic Eco-toxicity	**$1e^3m^3$**	**3.27**	**100%**
(w) Oils (unspecified)	$1e^3m^3$	1.70	52%
(w) Cadmium (Cd++)	$1e^3m^3$	1.25	38%
(w) Chromium (Cr III)	$1e^3m^3$	0.11	4%

Table 5.11 Main contaminant fluxes.

5.1.9 Human toxicity

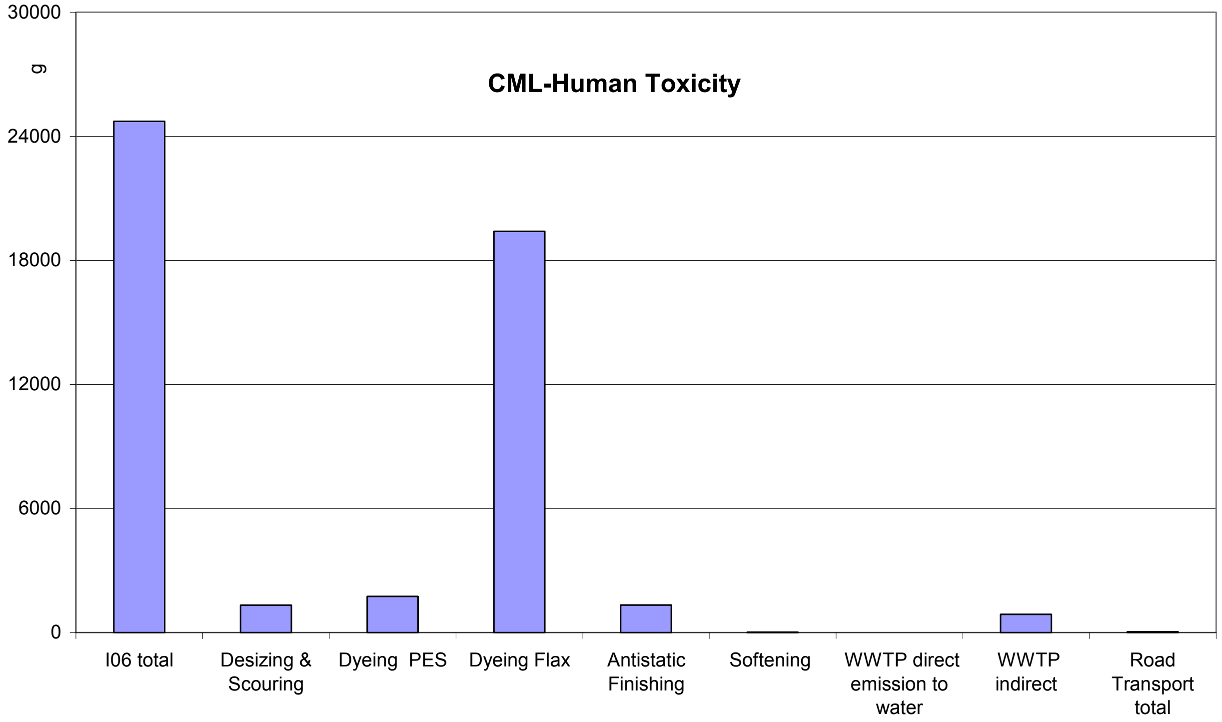

Fig. 5.10 CML 92 Human ecotoxicity.

Impact categories	*Units*	*Chemicals production*	*Steam production*	*electricity production*	*Transport*	*WWTP*
CML-Human Toxicity	**g**	63%	5%	28%	0%	0%

Table 5.12 Main contributors to the total of category.

Impact assessment	Unit		%
CML-Human Toxicity	**g**	**24726.75**	**100%**
(a) Sulphur Oxides (SO_x as SO_2)	g	18012.96	73%
(a) Nitrogen Oxides (NO_x as NO_2)	g	2121.45	9%
(a) Vanadium (V)	g	1751.06	7%

Table 5.13 Main contaminant fluxes.

5.1.10 Terrestrial Ecotoxicity

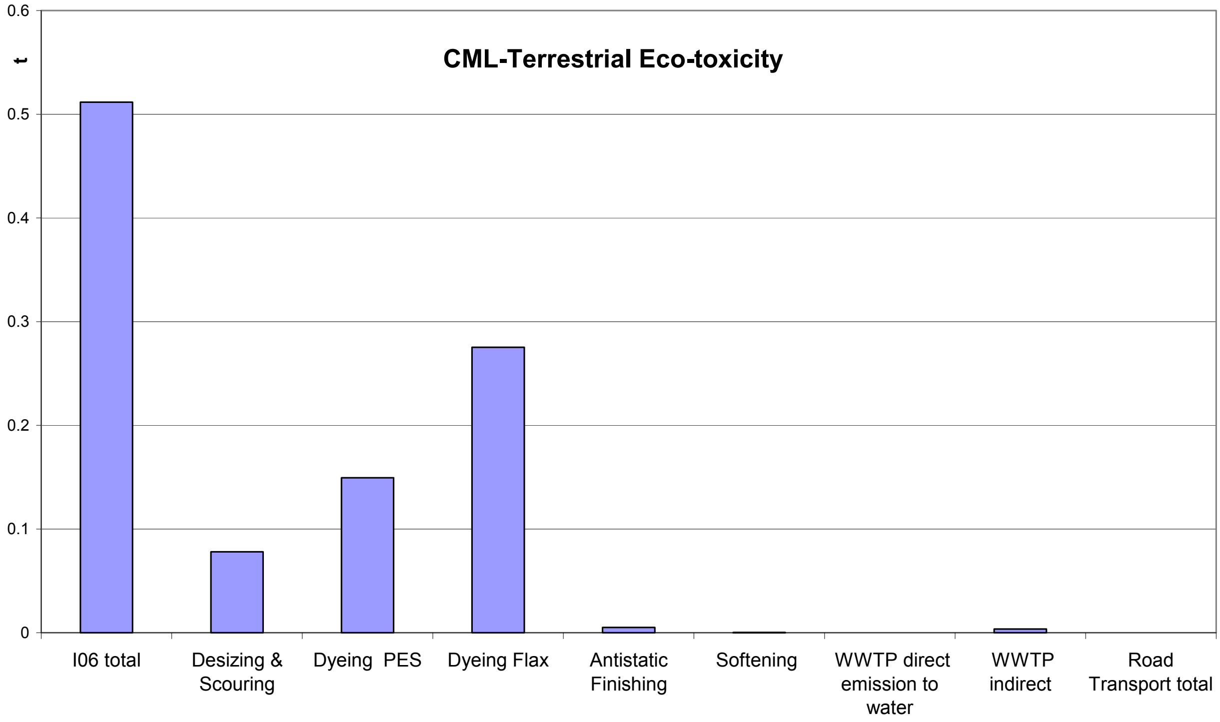

Fig. 5.11 CML 92 Terrestrial ecotoxicity.

Impact categories	*Units*	*Chemicals production*	*Steam production*	*electricity production*	*Transport*	*WWTP*
CML-Terrestrial Eco-toxicity	**t**	0%	94%	5%	0%	0%

Table 5.14 Main contributors to the total of category.

Impact assessment	**Unit**		**%**
CML-Terrestrial Eco-toxicity	**t**	**0.51**	**100%**
(s) Zinc (Zn)	t	0.43	83%
(s) Chromium (Cr III, Cr VI)	t	0.02	4%
(s) Chromium (Cr III, Cr VI)	t	0.02	4%
(s) Chromium (Cr III, Cr VI)	t	0.02	4%

Table 5.15 Main contaminant fluxes.

5.1.11 Photochemical oxidant formation

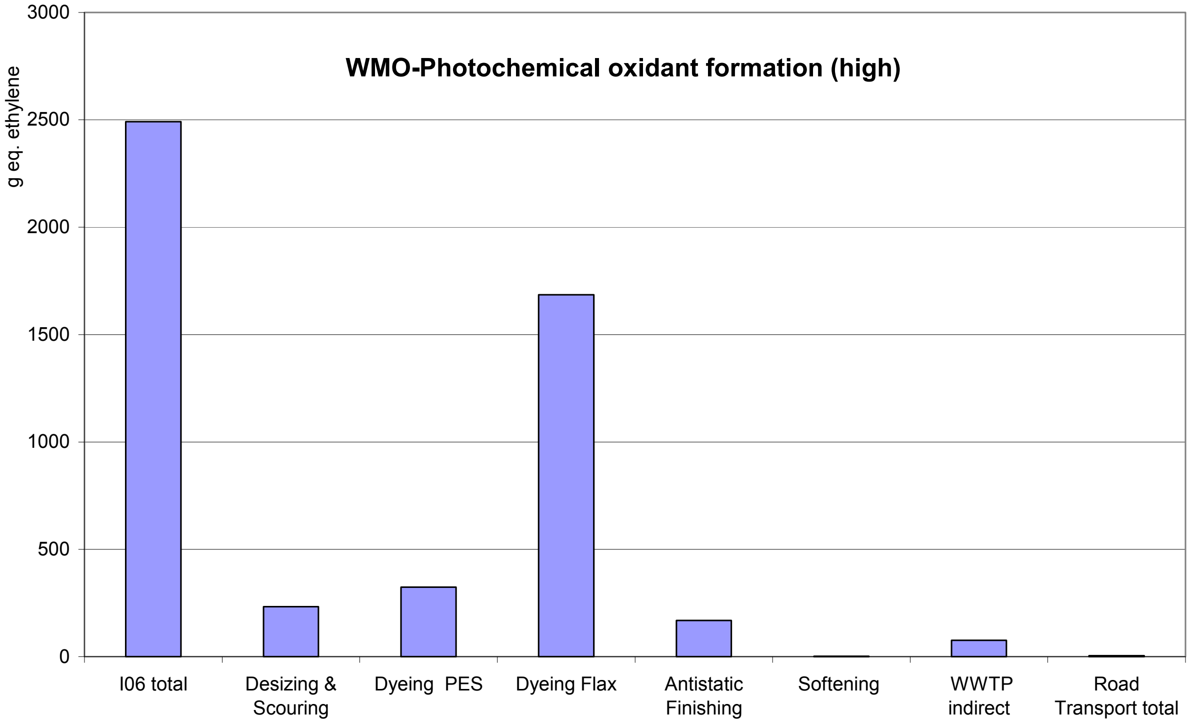

Fig. 5.12 WMO Photochemical oxidant formation (high).

Impact categories	*Units*	*Chemicals production*	*Steam production*	*electricity production*	*Transport*	*WWTP*
WMO-Photochemical oxidant formation (high)	**g eq. ethylene**	44%	26%	24%	0%	0%

Table 5.16 Main contributors to the total of category.

Impact assessment	**Unit**		**%**
WMO-Photochemical oxidant formation (high)	**g eq. ethylene**	**2490.99**	**100%**
(a) Hydrocarbons (except methane)	g eq. ethylene	1101.16	45%
(a) Hydrocarbons (unspecified)	g eq. ethylene	539.29	22%
(a) Ethylene (C_2H_4)	g eq. ethylene	263.79	11%

Table 5.17 Main contaminant fluxes.

5.1.12 Impact of chemicals production

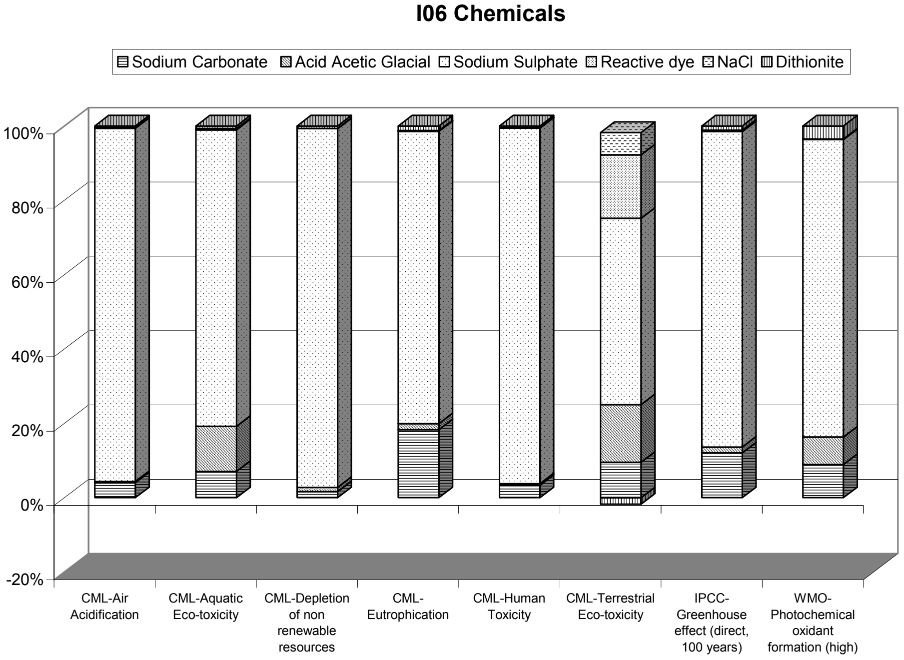

Fig. 5.13 Chemicals production contribution to impact assessment categories.

5.1.13 Chemicals ecotoxicity (screening)

Processes in systems A, B or C do not use chemicals classified with risk phrases R50, R51, R52, R53, R54, R55, R56, R57, R58 and so the total score of the three systems is 0.

5.2 Comparison of System A, System B and System C

Inventory and impact assessment results of System A (light colours) have been compared to the results of System B (dark colours) and C (no sized fabric).

5.2.1 Energy indicators and water consumption, COD and TSS emissions.

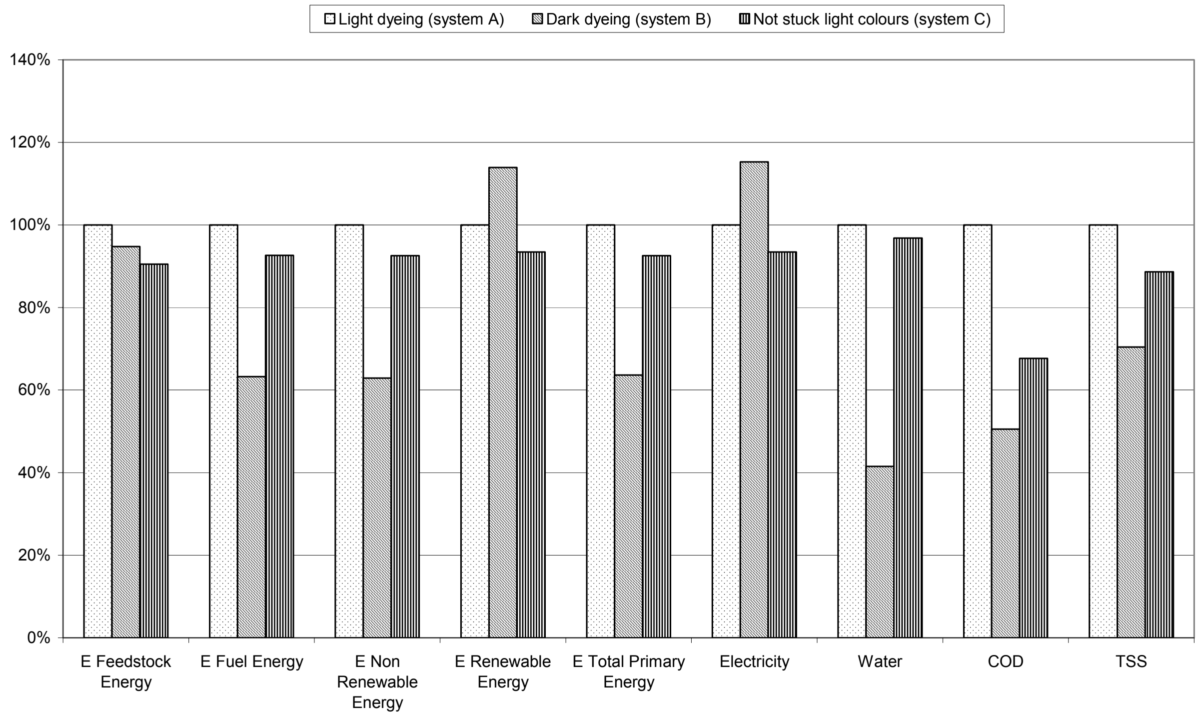

Fig. 5.14 Comparison of selected inventory data for systems A, B, C.

System B (dark colours dyeing) shows significant reduced impact compared to system A mainly because flax dyeing is done in different equipment (jigger with a bath volume of 2 m3 instead of an overflow with a bath volume of 4 m3) which has a better liquor ratio and is used more efficiently. System C differs from system A only for the pretreatment process which is performed at lower temperature (influence on total primary energy consumption) and causes lower emissions of contaminants (COD and TSS).

5.2.2 Environmental impact categories

As shown in Fig 5.15 for these environmental impact categories too, the reduced impact of system B can be explained with a more efficient use of the dyeing jigger. For system C the lower impact is due to minor energy consumption due to a lower bath temperature.

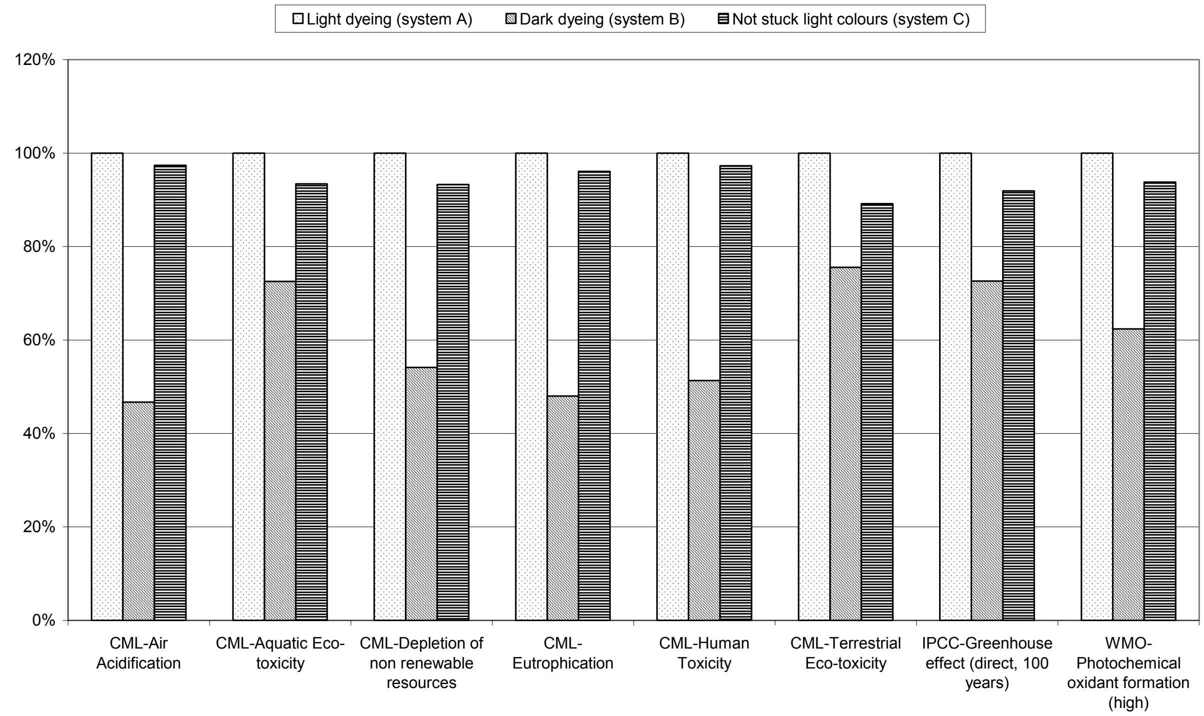

Fig. 5.15 Comparison of selected impact categories for systems A, B, C.

5.3 Evaluation

5.3.1 Completeness check

Although in this study inventory data on 89% in weight of the total used chemicals have been collected, we decided to check the sensitivity of the results to this partial lack of data.

5.3.2 Sensitivity check

5.3.2.1 Lack of data on chemicals

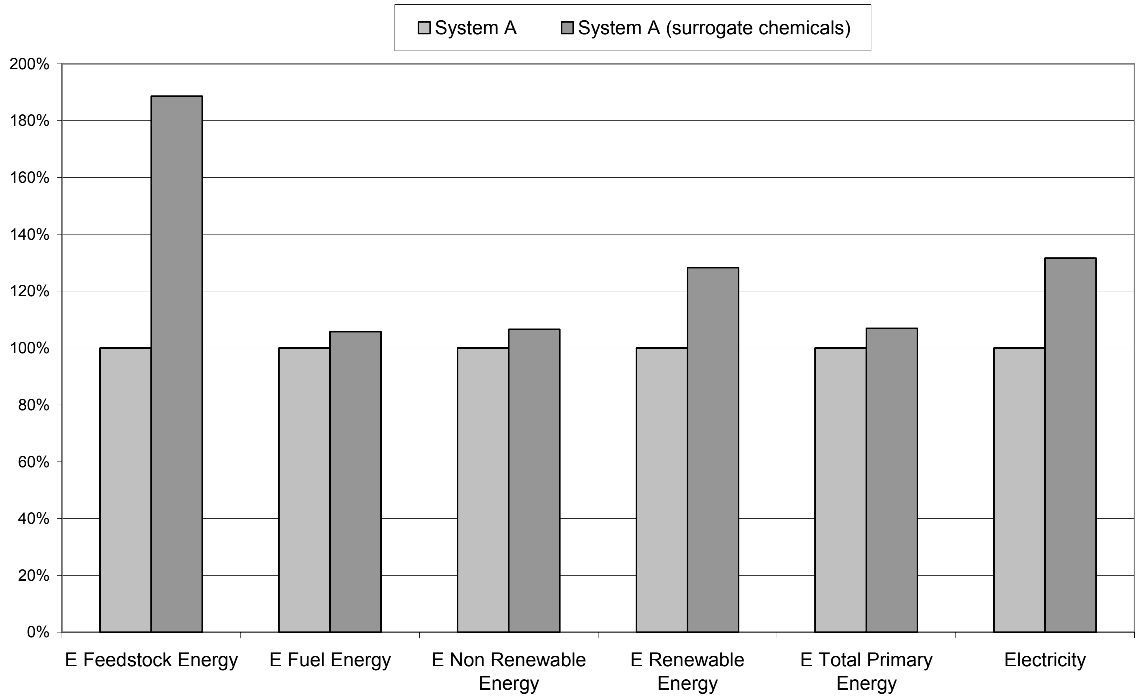

Fig. 5.16 Energy indicators for System A

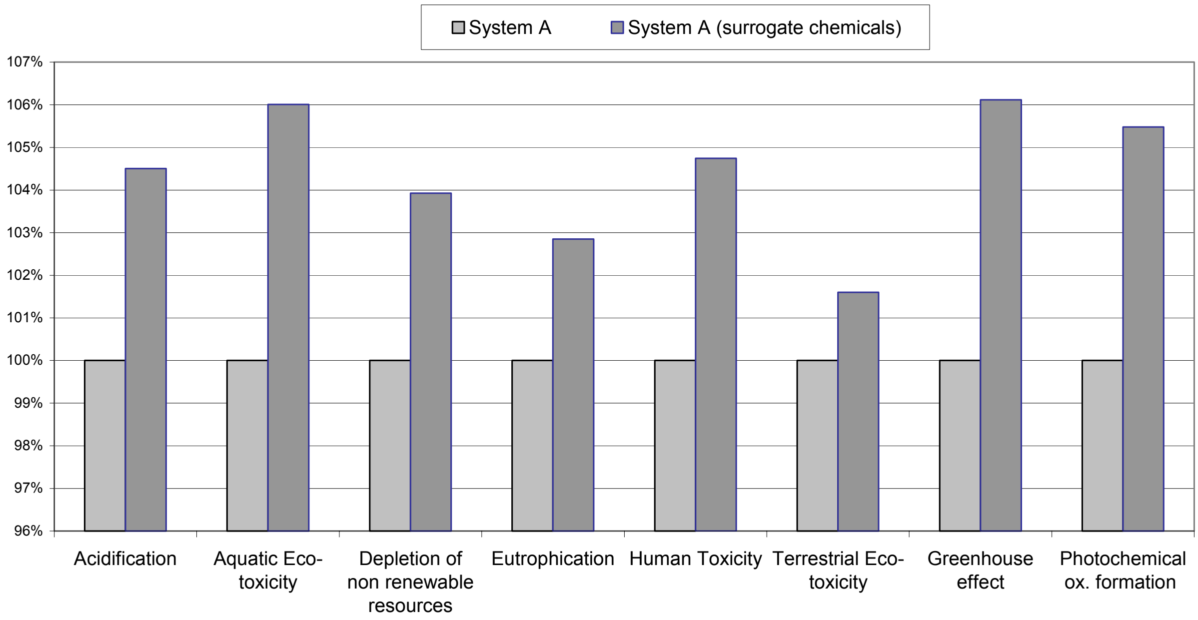

Fig. 5.17 Impact categories for System A

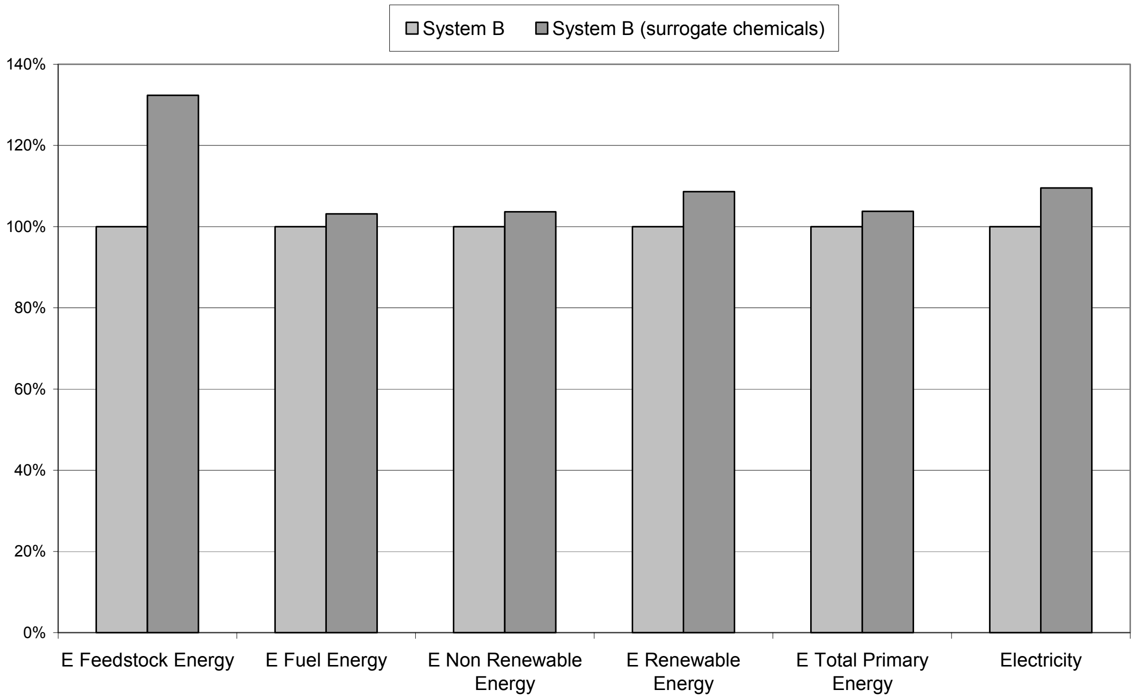

Fig. 5.18 Energy indicators for System B

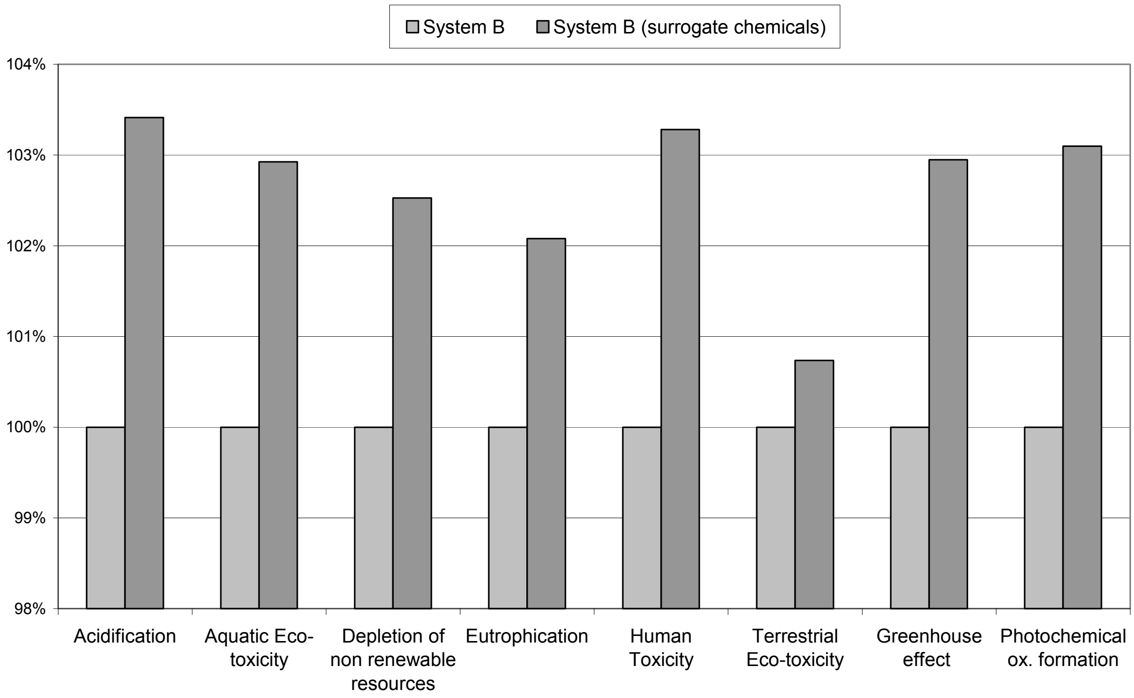

Fig. 5.19 Impact categories for system B

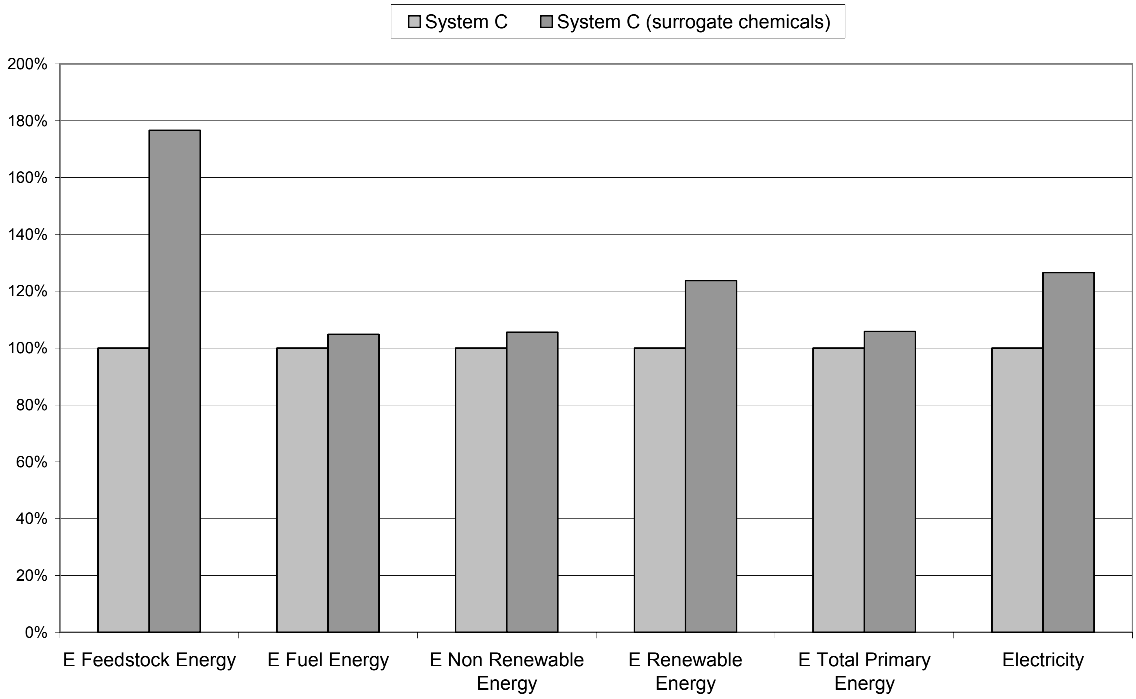

Fig. 5.20 Energy indicators for System C

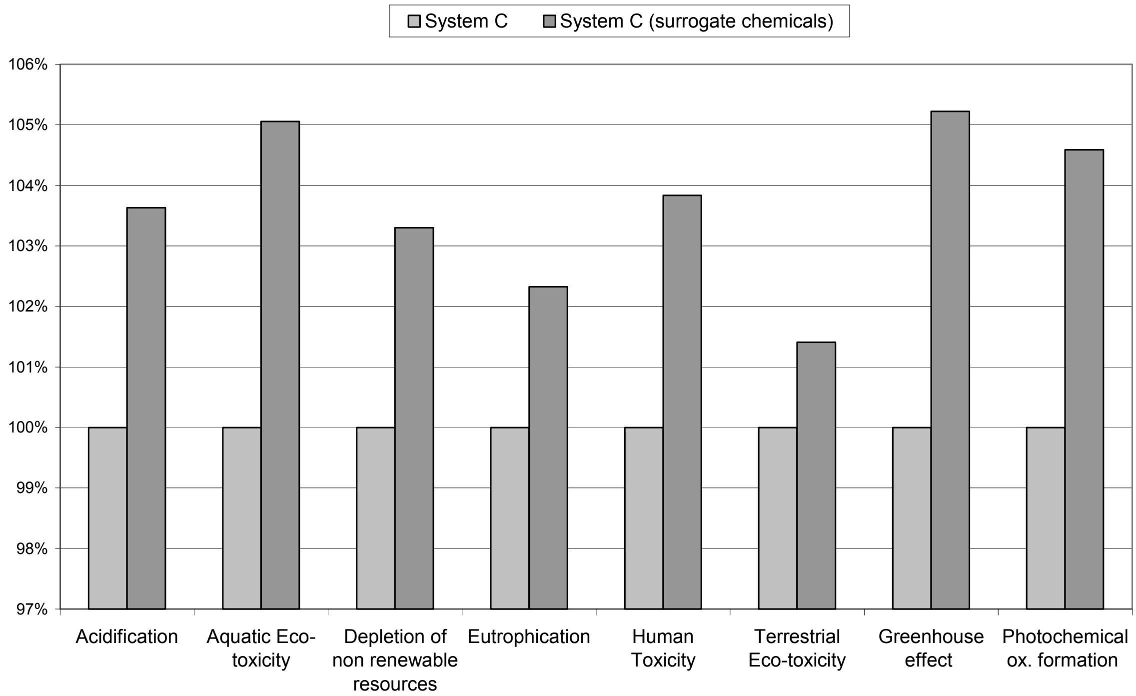

Fig. 5.21 Impact categories for System C

5.3.2.2 Allocation of thermal energy

The allocation rule applied for the definition of process specific steam and methane consumption (described in Chapter 3.2.1.3) is based on theoretic calculations and not on direct measurements. The final results of the study identified steam consumption as a significant issue for several inventory and impact categories. A sensitivity check was necessary to analyse the effect of the uncertainty of this aspect to the final results. Figures 5.14-17 show comparison of final results in the hypothesis of a steam consumption increased by 10%.

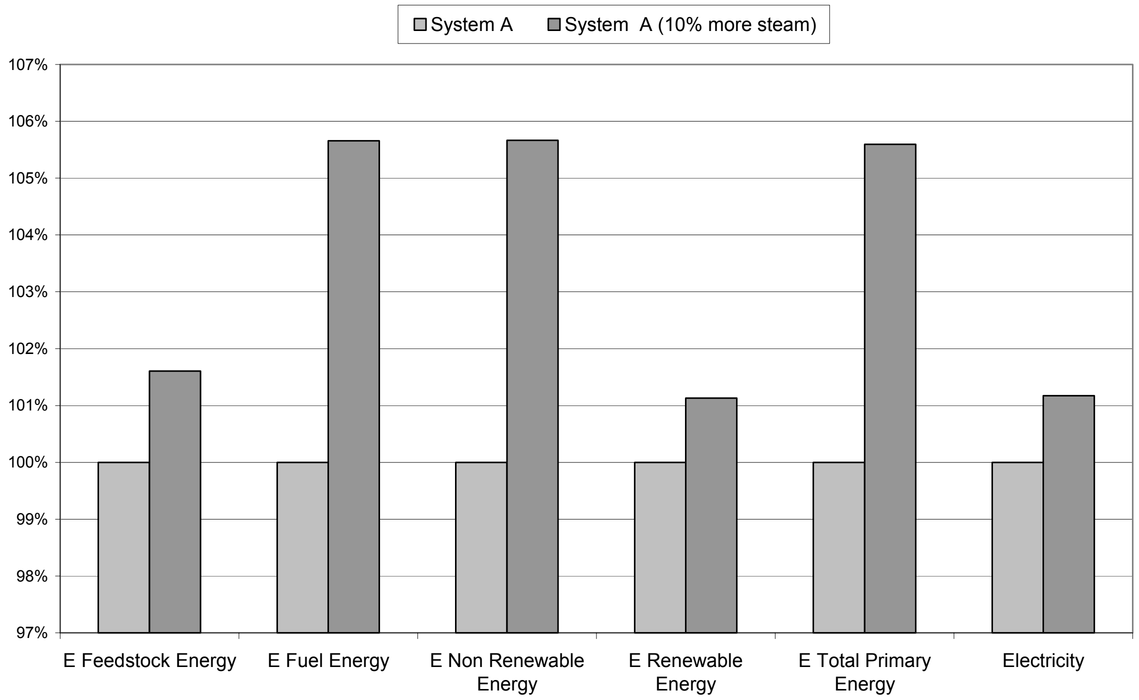

Fig. 5.22 Energy indicators for System A

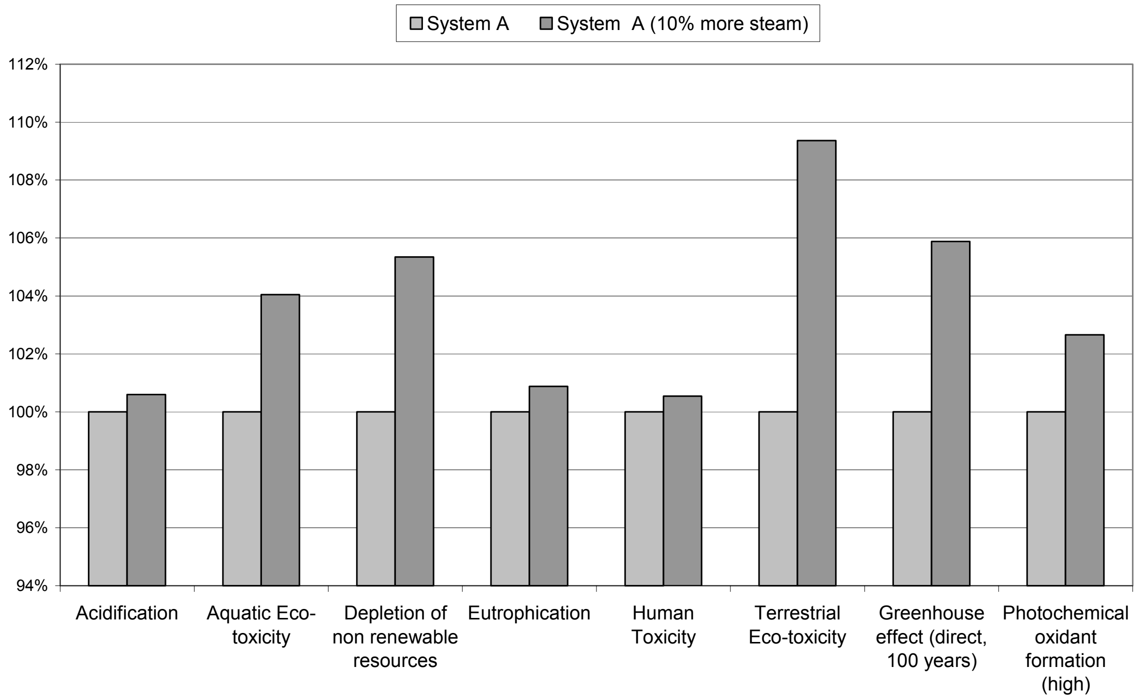

Fig. 5.23 Impact categories for System A

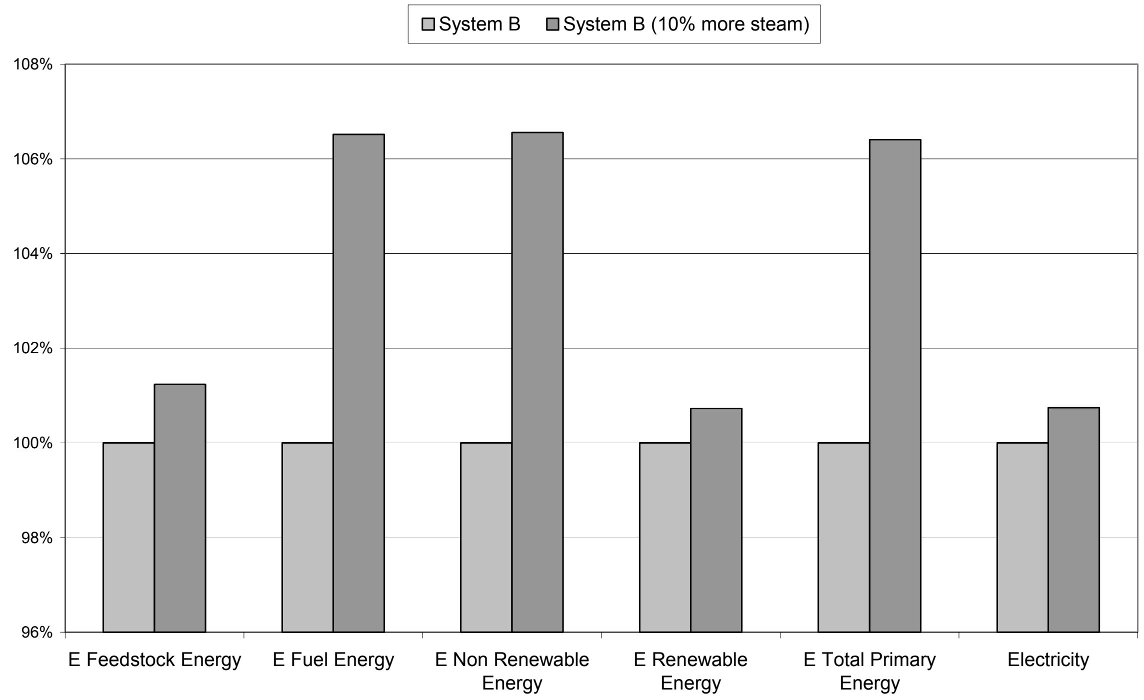

Fig. 5.24 Energy indicators for System B

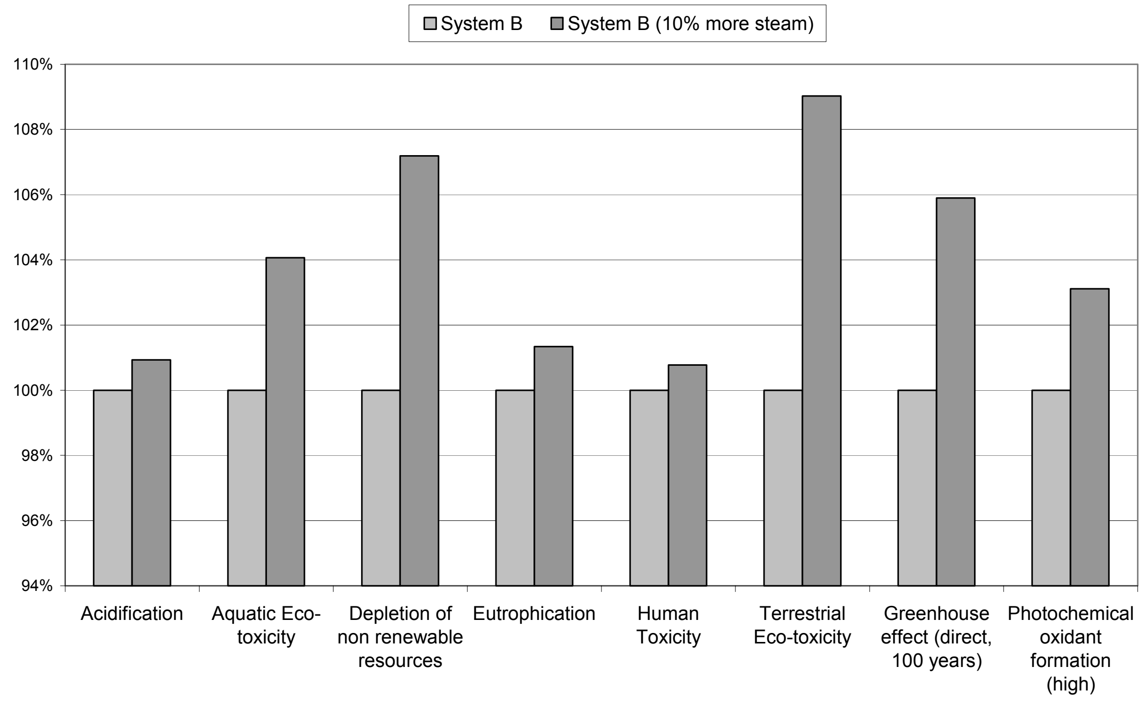

Fig. 5.25 Impact categories for System B

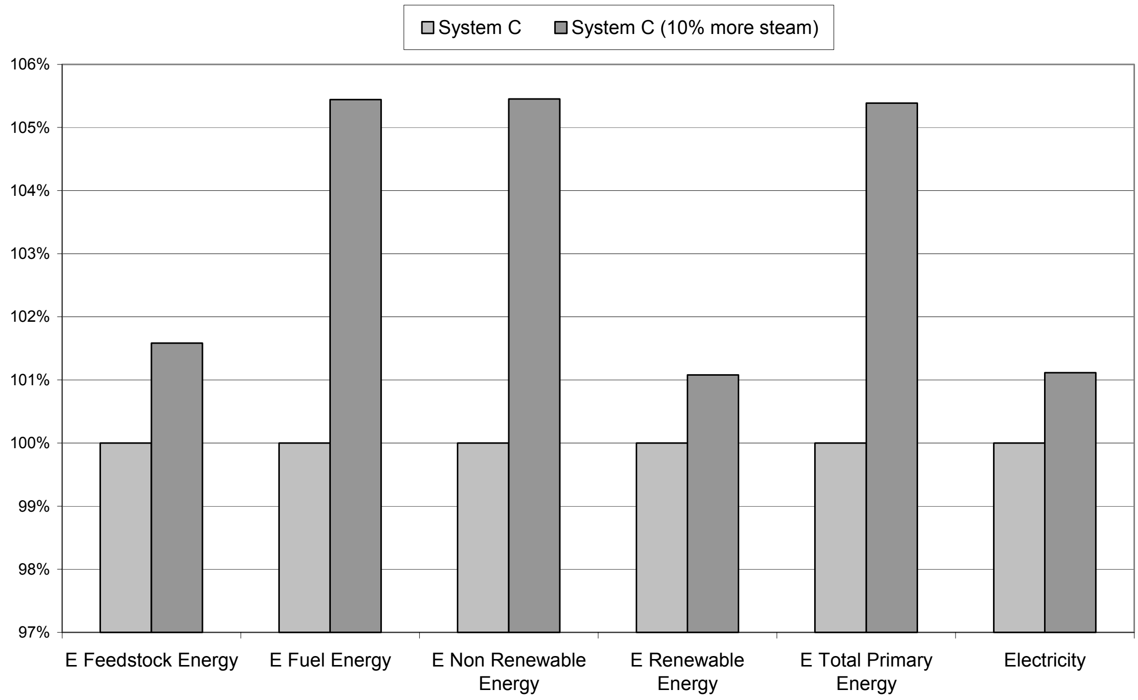

Fig. 5.26 Energy indicators for System C

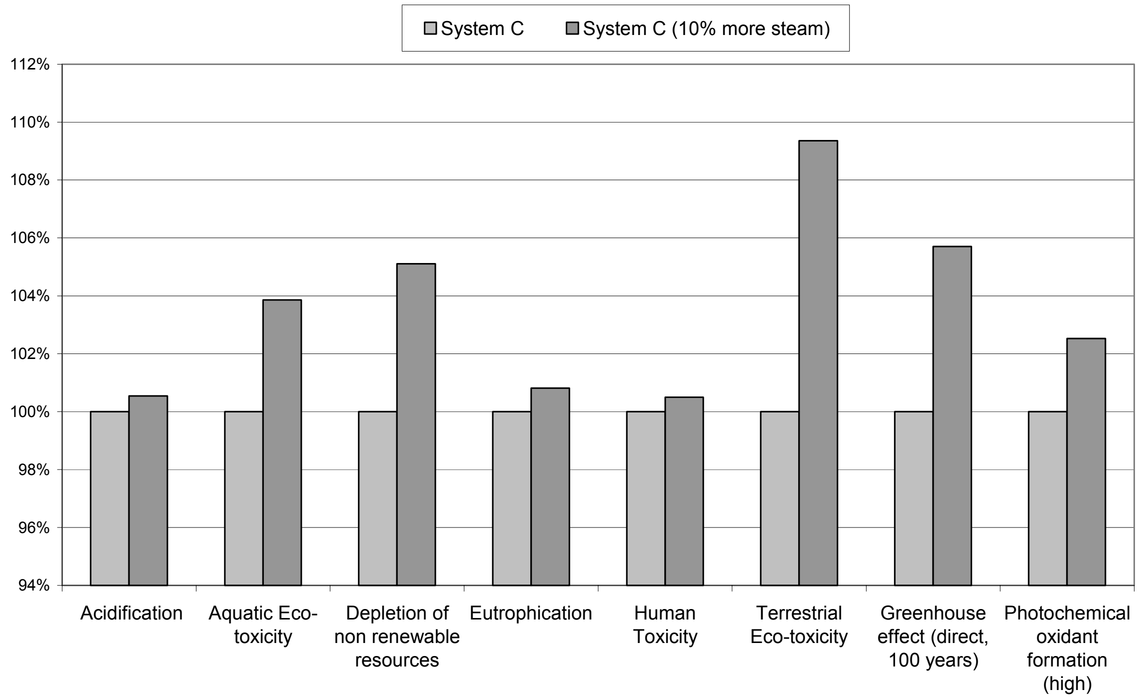

Fig. 5.27 Impact categories for System C

5.3.3 Consistency check

This LCA study can be considered consistent. Most of the data are from PIDACS or from TEAM 3.0 modules which guarantee a good general consistency. The only process having a different origin is the waste water treatment plant, which influence on the overall system is limited.

6 Conclusions

The following main conclusions can be drawn:

- In the A system life cycle the most part of water (83%) is used in the dyeing flax process and is drawn from an industrial aqueduct. The water used outside the company gates for chemicals and energy production is only a small fraction of the total water. To treat 100 kg of Flax-Pes fabric almost 60 cubic meters of water are needed.
- The dyeing flax process is the main contributor to COD and TSS emissions, because of the several washings needed for the process.
- The process G.7.2 (dyeing flax) is the main contributor to all environmental impact categories but eutrophication of system A. The main reason of this relevant impact is the high liquor ratio at which is used O192 overflow and the consequent higher consumption of steam and chemicals for dyeing 100 kg of Flax-PES fabric. The use of a more efficient process is the main reason of the better performance of system B compared to system A.
- Steam production is a “hot spot” for several impact categories (Total primary energy consumption, greenhouse effect, terrestrial and aquatic ecotoxicity, depletion of natural resources) with a contribution from 40% to 94%. Electric energy production is an important pollutant source mainly for acidification and ecotoxicity categories, because of heavy use of fossil fuels for the production of electric energy in Italy.
- Production of chemicals is the dominant contributor to air acidification, human toxicity and photochemical oxidant formation and significantly contributes to all other categories except terrestrial ecotoxicity. Among the used chemicals, the production of sodium sulphate used for the dyeing of flax in System A has by far the highest impact, because of the big quantities used in this process. The sensitivity check used to evaluate the importance of the missed chemicals inventories, showed a low sensitivity to surrogate chemical production data, highlighting how the study conclusions maintain their validity.
- WWTP impacts are not significant for all impact categories except eutrophication (63% of the total impact) because of emissions of treated effluent to Lambro river.
- Process specific steam consumption was calculated applying an allocation rule based on the estimation of the energy needed for heating the process water. A sensitivity check demonstrated that a 10% uncertainty of this calculation does not significantly influence inventory and impact assessment results. In contrast, there are some categories (fuel energy, non renewable energy, total primary energy, depletion of non renewable resources, terrestrial ecotoxicity and greenhouse effect) where total results can be modified by more than 5% because of this error.

7 References

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Annex 1 : Structure and content of PIDACS

1) NOTES ON DATA COLLECTION.

- Reference year:.
- Sampling and data collection period:
- Compiler name:
- Company contact people:

2) GENERAL DATA.

a) Production:

Reference year:

Fiber	*Type*	*(%)* *of total weight*	*processed* *linear meters/yr*	*kg per linear meter*	*processed* *kg/yr*
TOTAL:					

Notes:

b) Water use:

b.1) Supplied water:

Reference year:

Source	*Quantity* *[m^3/yr]*	*Specific Cost* *[€/m^3]*	*Energy consumption* *[kWh/m^3]*
TOTAL:			

Notes:

b.2) Process water and treatment for internal use:

Reference year:

Water type	*Source*	*Treatment*	*Use*	*Quantity* *[m^3/yr]*	*Treatment specific cost [€/m^3]*
W1					
W2					
W3					
…					

Notes:

b.3) Process water analytic features:

Reference year:

Type	*W1*	*W2*	*W3*	*W4*	*W5*	*W6*	*W7*
T [°C]							
pH [-]							
Conductivity [mS/cm]							
COD [mg/l]							
TSS [mg/l]							
Hardness [°F]							
Chlorides [mg/l]							
Sulphates [mg/l]							
Sulphides [mg/l]							
Total phosphorous [mg/l]							
NO2-N [mg/l]							
NO3-N [mg/l]							
NH4-N [mg/l]							
TKN [mg/l]							
Hexavalent chrome[mg/l]							
Trivalent chrome [mg/l]							
Iron [mg/l]							
Copper [mg/l]							
Zinc [mg/l]							
Lead [mg/l]							
Cadmium [mg/l]							
MBAS [mg/l]							
BiAS [mg/l]							

Notes:

b.4) Steam production:

Reference year:

Steam type	*Water type*	*Quantity [t/yr]*	*T max [°C]*	*Use*
S1				

Notes:

b.5) Discharged water:

Reference year:

Type	*D1* (1)	*D2*(2)	*D3*(2)	*D4*(2)	*D5*(2)	*D6*(2) (3)
Quantity [m^3/yr]						
Final destination						
Features:						
T [°C]						
Conductivity [mS/cm]						
Hardness [°F]						

pH [-]						
COD [mg/l]						
BOD5 [mg/l]						
TSS [mg/l]						
TKN [mg/l]						
N-NH4 [mg/l]						
N-NO2 [mg/l]						
N-NO3 [mg/l]						
Ptot [mg/l]						
Absorbance 420 nm						
Absorbance 550 nm						
Absorbance 680 nm						
Anionic surf. [mgMBAS/l]						
Non-ionic surf. [mgBiAS/l]						
Cationic surf. [mg/ l]						
Chlorides [mg/l]						
Chlorine [mg/l]						
AOX [mg/l]						
Chrome [mg/l]						
Copper [mg/l]						
Endocrine activity						
Hydrocarbons [mg/l]						
Iron [mg/l]						
Manganese [mg/l]						
Nickel [mg/l]						
Zinc [mg/l]						
Toxic Units (for algae)						
Toxic Units (for fish)						
Toxic Units (for bacteria)						
Toxic Units (for invertebrates)						

Notes:

c) *ENERGY CONSUMPTIONS:*

Reference year:

Source	*Unit*	*Use*	*Quantity*	*Specific cost [€/]*
Methane Gas				
Electricity				

Notes:

d) *SOLID WASTES*:

Reference year:

Type	*SW1*	*SW2*	*SW3*	*SW4*		
Description						
Waste class						
Production [kg/yr]						

Disposal						
Disposal cost[€/kg]						

Notes:

e) *OFF-GAS EMISSIONS:*

e1) Identification

Reference year:

Type	*Emission source*	*Flow rate [Nm^3/h]*	*Fumes temperature [°C]*	*Abatement*	*Abatement system*
G1					
G2					
G3					
G4					
G5					
G6					
G7					
G8					
G9					

Notes:

e2) Analytical features

Reference year:

Type	*G1*	*G2*	*G3*	*G4*	*G5*	*G6*	*G7*	*G8*	*G9*
NOx [mg/Nm^3]									
CO [mg/Nm^3]									
Aldehydes [mg/Nm^3]									
VOC [mg/Nm^3]									
Acetic acid [mg/Nm^3]									
Formic acid [mg/Nm^3]									
Ammonia [mg/Nm^3]									
Particles [mg/l]									

Notes:

f) DEPARTMENTS AND WORKING TIME:

Reference year:

Department	*Operating days*	*Daily operating period*	*Weekly operating period*	*N° of shifts per days*
General facilities				
Preparation				
Dyeing				
Finishing				

Notes:

g) EQUIPMENT:

Reference year:

Department	*Equipment*	*Item*	*Quantity*	*Operating mode*	*Bath Volume [m^3]**	*Installed power [kW]*	*Absorbed power [kW]*	*Operating years*

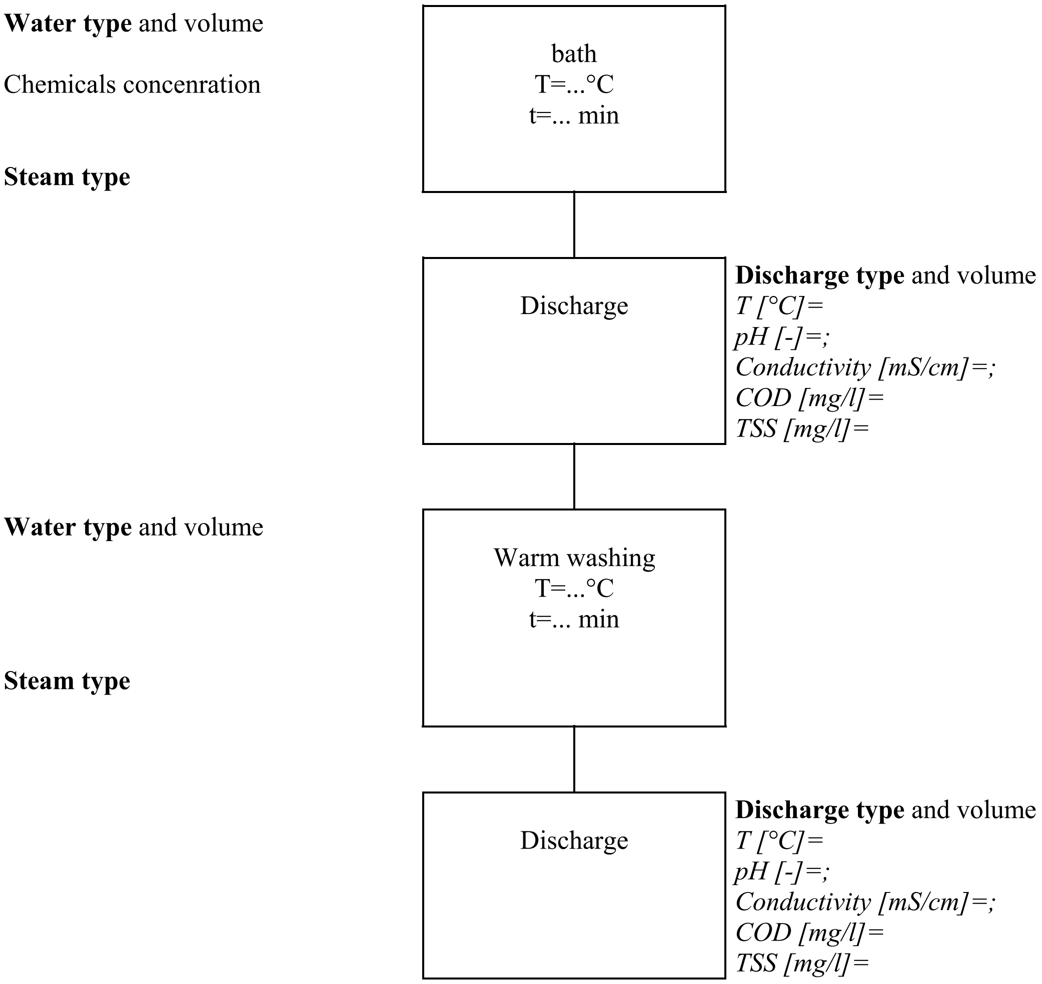
Notes:

3) ANNEXES (***<u>all sheets have to be considered as relevant part of the whole document</u>***):

- **An.A:** ***Material flow chart***;
- **An.B:** ***Energetic flow chart***;
- **An.C:** ***Water flow chart;***
- **An.D:** ***Production model;***
- **An.E**: ***General Facilities - Process scheme;***
- **An**.**F**: ***Preparation - Process scheme;***
- **An**.**G** : ***Dyeing - Process scheme;***
- **An**.**H** : ***Finishing - Process scheme;***
- **An.I:** ***Water consumptions;***
- **An**.**L**: ***Water discharges;***
- **An.M**: ***Discharged water analytic data;***
- **An**.**N**: ***Chemicals safety data sheets.***

Example of a Process scheme (An.E-F-G-H)

Department	
Yarn	
Process	
Equipment	
Item	
Run time (h)	
Number of run/yr	
Processed yarn (kg/yr)	
Processed yarn per run (kg)	



Notes: