NON-IRON BED LINEN

BY

BASF SE

GUP/CE
Ludwigshafen

Documentation.

Case Study undertaken within the PCF Pilot Project Germany

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Content

1 Preface

The case study “Non-iron Bed Linen” that follows was elaborated within the scope of the Product Carbon Footprint (PCF) Pilot Project Germany by BASF SE in association with BASF Eco-Efficiency group. For the PCF Pilot Project, BASF joined nine other companies to pursue, together with the project initiators – WWF Germany, Öko-Institut (Institute for Applied Ecology), the Potsdam Institute for Climate Impact Research (PIK) and THEMA1 – the following project objectives:

1. *Gaining experience*: On the basis of concrete case studies, the project initiators and the participating companies gain experience with the practical application of current methods for determining carbon footprints and examine the efficiency of these methods (ISO[1] standards for life cycle assessment, BSI[2] PAS 2050).

2. *Deriving recommendations:* Based on the findings of the case studies, recommendations are derived for the further development and harmonisation of a transparent, scientifically founded methodology for determining the carbon footprint of products. The pilot project explicitly refrains from developing its own methodology.

3. *Communicating results:* Consumers must be informed of the product carbon footprint in a scientifically sound and comprehensible manner. To this end, the project stakeholders are holding discussions on reliable communication on a sectoral, company and product level to foster climate-conscious purchase decisions and use patterns. The relevance in terms of increasing the climate consciousness of consumer decision making is crucial to these considerations. The pilot project explicitly refrains from developing its own climate-related label since the current methodological conventions are not sufficiently consistent and are still under discussion, meaning that its significance in terms of possible courses of action would therefore be low.

4. *Standardising internationally*: The findings reached and the recommendations derived contribute to a situation in which the PCF Pilot Project Germany actively helps to shape the international debate on the determination and communication of carbon footprints.

[1] International Organization for Standardization.
[2] The British Standards Institution.

The definitions and uses of the term “product carbon footprint” differ internationally. Within the scope of the PCF Pilot Project Germany, the project stakeholders agreed on the following definition:

“Product carbon footprint describes the sum of greenhouse gas emissions accumulated during the full life cycle of a product (good or service) in a specified application.”

In this context, greenhouse gas emissions are understood as all gaseous materials for which a Global Warming Potential coefficient was defined by the Intergovernmental Panel on Climate Change (IPCC). The life cycle of a product encompasses the whole value chain – from the acquisition and transportation of raw materials and primary products over production and distribution to the use, recycling and disposal of the product. The term “product” is used as a generic term for goods and services.

The project initiators and participating companies regard the international standard for life cycle assessment (ISO 14040 and 14044) as the basic methodological framework for determining a product carbon footprint. Moreover, this standard is the most important foundation of the British PAS 2050 as well as of the above-mentioned dialogue processes of the ISO and the World Business Council for Sustainable Development/World Resources Institute[3]. Therefore, within the scope of the pilot project, ISO 14040/44 constituted an essential basis for the work carried out on methodologies and thereby for the case studies themselves.

Many of the basic methodological conditions of ISO 14040/44 can be applied in the case of the PCF methodology, but several have to be adapted. Some terms of reference of the ISO 14040/44 are loosely formulated, making it necessary to examine whether it is possible to develop less ambiguous terms of reference which have a comprehensive or product group-specific foundation. This would simplify the comparability of different PCF studies. In addition, within the course of the case studies, the significance of PCF compared to other environmental impacts in the product life cycle was analysed in varying detail. From the perspective of the PCF Pilot Project, this analysis is crucial to the securing of decisions and approaches to communication, which are made and developed on the basis of PCF. Furthermore, creating clearer terms of reference constitutes one of the greater methodological challenges in this context, also in respect of international harmonisation and all applications where public communication of the PCF is intended.

Each participating company selected at least one product from its portfolio for which a PCF was determined. In this way, methodological frameworks or rules of interpretation regarding the ISO 14040/44 could be practically tested using a specific case study. In turn, specific methodological issues also emerged from the case studies. The broad spectrum of products selected for the case studies made for a comprehensive discussion. The

[3] With regard to the WBCSD/WRI process, a final decision has not yet been taken. However, it can be assumed, given the current status of the discussion, that a decision on the ISO 14040/44 will be taken in the coming weeks.

involvement of companies from very different sectors in the PCF Pilot Project was challenging but also fruitful, constituting an essential prerequisite for the development or optimisation of a methodology which could be used as broadly as possible. The case study “Non-iron Bed Linen” by BASF constituted an important component of the project, on the basis of which – together with the diverse experiences gathered in terms of carbon footprinting – the findings and recommendations were developed according to the project objectives.

The most important results of the pilot project are summarised in a paper entitled “*Product Carbon Footprinting – Ein geeigneter Weg zu klimaverträglichen Produkten und deren Konsum? – Erfahrungen, Erkenntnisse und Empfehlungen aus dem Product Carbon Footprint Pilotprojekt Deutschland* “. This paper, along with much more information on product carbon footprinting and the PCF Pilot Project, can be found at:

www.pcf-projekt.de

The work carried out within the pilot project should not be understood as the final word on the determination and communication of product carbon footprints. Therefore, the project partners are happy to receive intensive feedback from interested stakeholders, also with regard to the case study presented in the following. Based on this feedback and the project findings, the project initiators and partners wish to actively support international debates on the harmonisation of product carbon footprinting by virtue of their findings. Only in this way, with the help of an internationally accepted standard, can PCFs be determined, assessed and reliably communicated in a uniform and comparable fashion.

Ludwigshafen, 26 January 2009

2 Executive Summary (Company)

Fixapret® AP and Fixapret® ECO are non-iron and easy care finishings that can be applied in clothing and home textiles. Non-iron or easy care textiles, such as shirts or bed linens, considerably reduce time and effort in drying and ironing. As a result, energy is saved and carbon dioxide emissions reduced.

It can be shown, that the scenarios can change the range for the bed linen from 230 kg to 174 kg CO2-e at the low end to 316 to 444 kg CO2-e.

As a quintessence out of this case study, the PCF was not the most significant ecological category. Optimization in the reduction of the PCF must be considered taking other environmental factors also into consideration. Decisions should not be based only on PCF.

The ecology fingerprint shows a summary of all environmental factors of the two alternatives along the whole lifecycle. It clearly shows that the bed linen finished with Fixapret AP is the favourable alternative compared to bed linens without any non-iron finishing.

The basis for calculating the carbon footprint and other ecological numbers along the life cycle of products should be ISO 14040 and 14044 along with results and methodological recommendations from the PCF-project. To assess additional environmental factors, the Eco-efficiency Analysis is the preferred tool. There will be an ISO rule for it in the future.

PCF case studies like this one for bed linen can be used for the definition of PCR. It shows a range of CO2-e that can be obtained for these materials and where the main environmental contributions along the whole supply chain are. All the data sets together can be used for the definition of a PCR as well as showing the best available technology.

So an intelligent use of high performance chemicals can contribute very well to the reduction of the PCF of bed linen.

3 Company's Profile

- **Brief introduction to the company**

BASF is the world's leading chemical company – The Chemical Company. With over 95,000 employees, six Verbund sites and close to 400 production sites worldwide we serve customers and partners in almost all countries of the world.

In 2007, BASF posted sales of Euro 58.0 billion and income before special items of approximately Euro 7.6 billion. We help our customers to be more successful through intelligent system solutions and high-quality products. Through new technologies we can tap into additional market opportunities. We conduct our business in accordance with the principles of sustainable development.

BASF is the world's leading chemical company - The Chemical Company. As a reliable partner, we help our customers in almost all industries to be more successful. With high-value products and intelligent solutions, with innovations and new technologies, we open up new market opportunities for ourselves and our customers.

We aim to constantly increase the value of our company by growing profitably. With our products and services, we want to participate in successfully shaping the future of our customers, business partners and employees.

We combine economic success with social responsibility and environmental protection. We make our contribution to finding the answers to global challenges, such as climate protection, energy efficiency, nutrition and mobility. This is our contribution to a better future for us and for coming generations.

	Million €	%
Chemicals	9,358	16
Plastics	9,976	17
Performance Products	8,862	15
Functional Solutions	9,491	16
Agricultural Solutions	3,137	6
Oil & Gas	10,517	18
Other	6,610	12
Total	57,951	100.0

- **Description of importance and state of product related activities on climate change within the Company**

  BASF's innovative and energy-efficient products contribute to climate protection. BASF has long been making successful use of renewable raw materials in numerous processes and constantly researches new possible usages.

  We published a carbon balance in 2008, and were the first company in industry to do so. This balance contrasts the CO2 emission-savings that are achieved with BASF products and procedures with the emissions from raw material extraction, production and product disposal. The results that have also been confirmed by the Öko-Institut in Freiburg (Germany) show that BASF products can save three times more greenhouse gas emissions than the entire amount caused by the production and disposal of all BASF products.

  The carbon balance not only shows emissions from BASF's production, but for the first time also takes into account emissions from raw materials and precursors as well as the disposal of all products. In addition, we have looked at the product lifecycle of 90 key products that reduce CO2 emissions when used in end products.

  "Climate change is one of the main challenges faced by society," said Dr. Ulrich von Deessen, Climate Protection Officer of BASF SE. "We are facing up to this challenge and offering a wide range of solutions that help to protect the climate."

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4 Organisation and Procedures (Company)

- **Organisation of case study and activities within the Company (Set Up, Participation, Procedures)**

  Together with the business unit, the case studies were prepared. The Eco-Efficiency group of BASF (GUP/CE) worked out the studies based on the data of the business unit with the eco-efficiency methodology of BASF. The data were collected often in cooperation with customers and business partners supported by the know-how of the experts of BASF. The activities were accompanied and supported by a defined project team.

- **External partners of the case study**

  No. Only in some cases customers were involved.

5 Goals and Scope

5.1 Objectives of the Case Study (Company)

- **Documentation of the basic motivation of the company as well as the specific objectives of the chosen case study**

  BASF is working now for more than ten years in the calculation of life cycle based numbers for products. The PCF is a new challenge to contribute to the actual discussion of the calculation of carbon footprints. Performance products with their invisible contribution to a visible result are helping the consumer to be more sustainable. To support this decision making process it is interesting to choose a case with a clear relevance to the daily life of consumers.

  BASF Textile Chemicals business unit is committed to “Putting *FUTURE into Textiles” with its ecological solutions that improve consumer safety, efficient use of resources and reduces carbon dioxide emissions.

  Fixapret AP is a modified dimethyloldihydroxyethylene urea crosslinker for low-formaldehyde, washfast resin finishing of woven and knitted fabrics of cellulosic fibers and their blends with synthetic fibers. It is ideal for the BASF *A*dvanced *P*erformance Finish process. High reactivity and extremely low formaldehyde values according to the LAW 112 and AATCC 112 methods.

  When used properly according to our recommendations, Fixapret AP can be used for textiles to be certified as “Tested for harmful substances” according to Öko-Tex Standard 100, Product Class II.

BASF Textile Chemicals' eco-efficient products and solutions help customers reduce carbon dioxide emissions during textile processing. In addition, consumers can contribute to climate protection by using clothing and home textiles treated with them.

Bed linen are well known for all consumers and can be therefore an example for PCF-calculations with a lot of practical information. It helps the customer for his decision-making process in the market. The results can be understood from a final customer whereas the calculation only of chemicals are more difficult to understand.

5.2 Product Selection and Definition of the Functional Unit

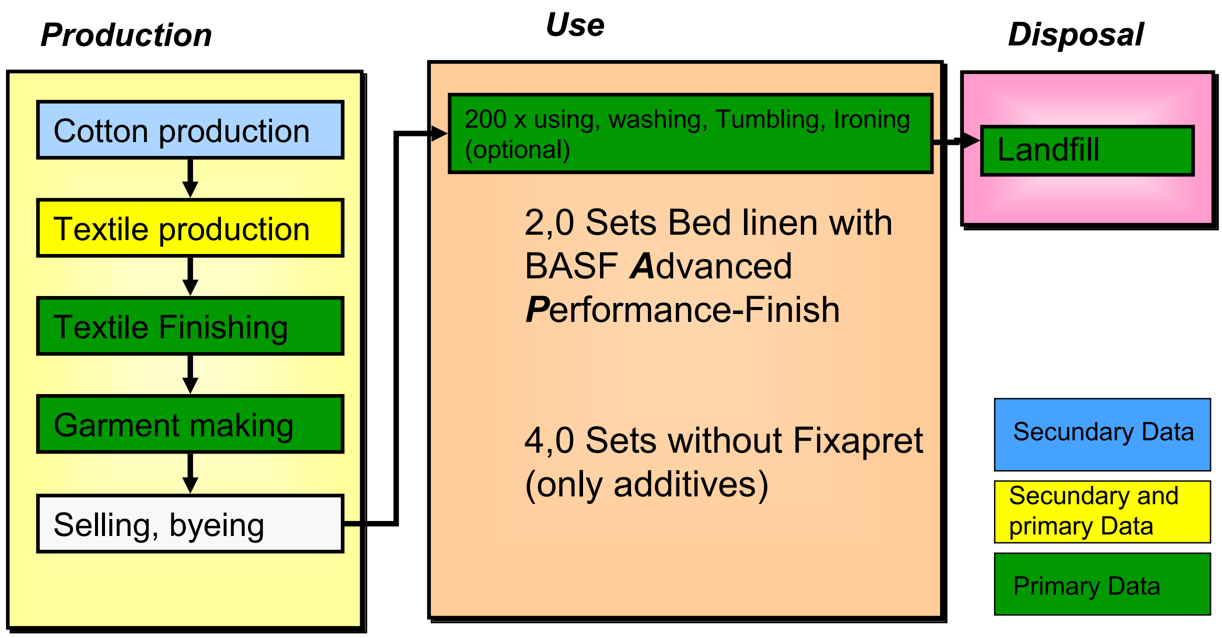
- **Explanation for product selection**

  Fixapret® AP: non-iron and easy care finishings that can be applied in clothing and home textiles. Non-iron or easy care textiles, such as shirts or bed linens, considerably reduce time and effort in drying and ironing. As a result, energy is saved and carbon dioxide emissions reduced.

  In the evaluation, only bed linen without a flexible rubber, which are non-iron alternatives, is used.
- **Definition and explanation of functional unit**
- *Production and use of 5.4 m^2 of a 2 layer bed linen in a 200 times cycle.*

5.3 System Boundaries

- **Description and explanation of system boundaries**

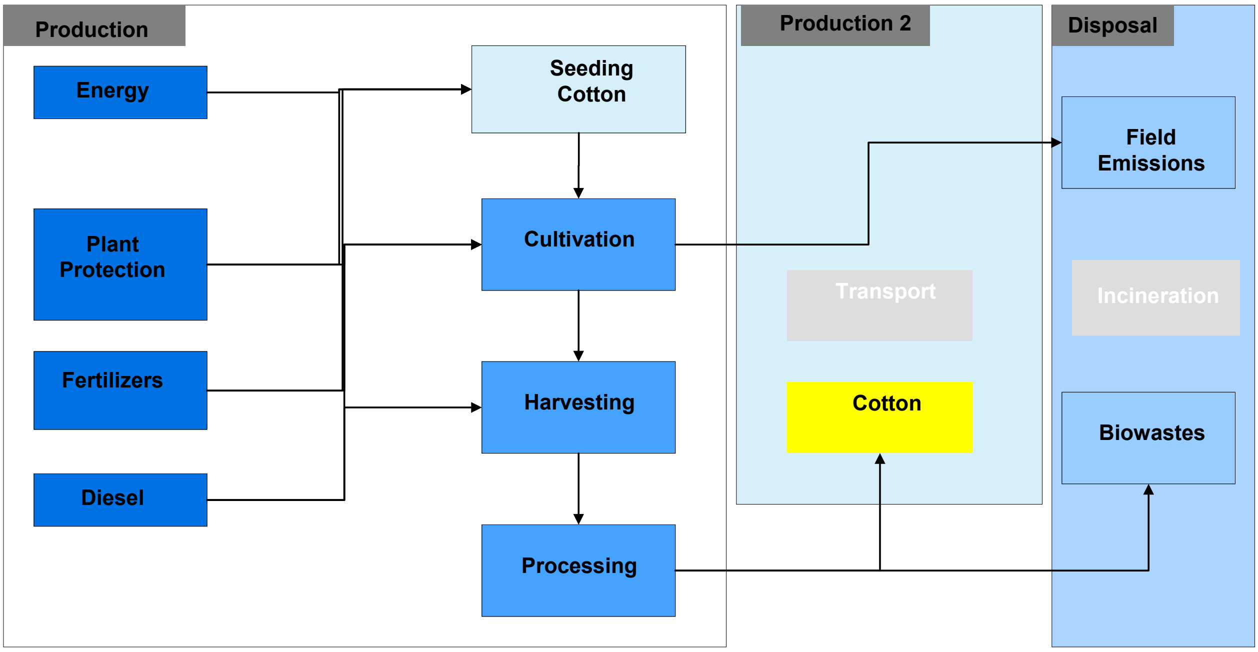


Bed linen with Fixapret AP can be used for 100 cycles of washing, tumbling, ironing etc.. So 2 sets of this bed linen are necessary for 200 cycles. Bed linen without Fixapret are lasting only for 50 cycles, so 4 sets are needed. These information were evaluated by BASF testing procedures.

Bed linen without Fixapret, still need additives to produce them. They are also considered in the alternative “Without Fixapret”.

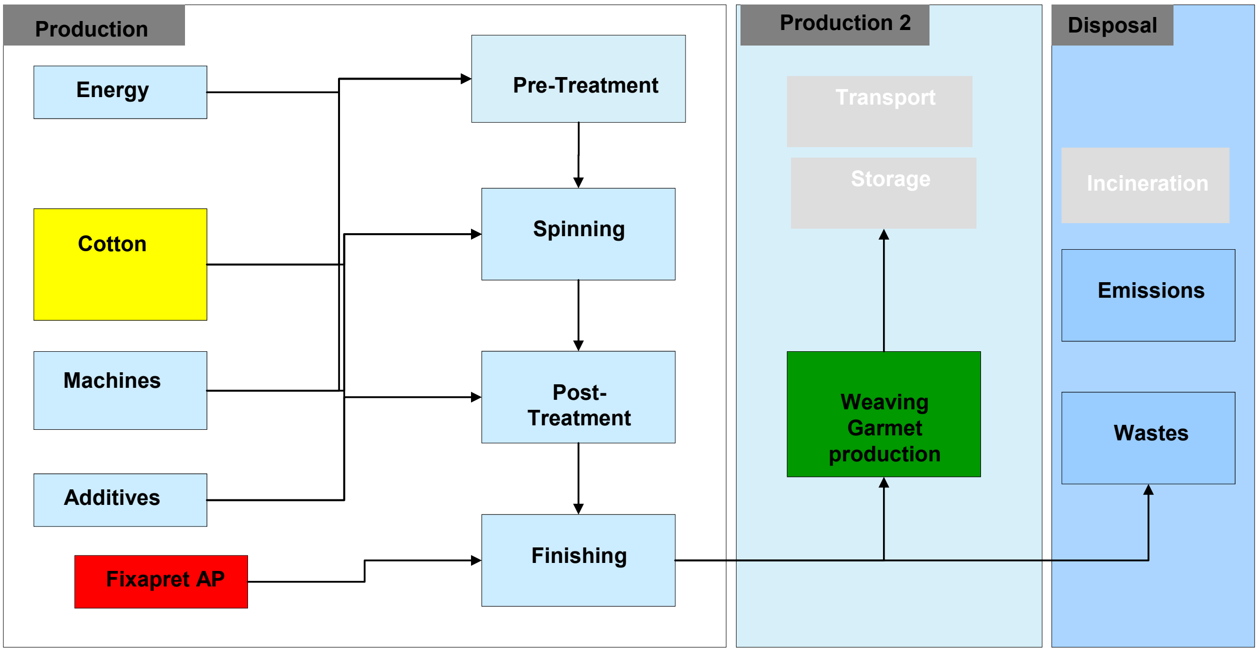
To assume a bed linen change in a household every three weeks, 200 cycles means a time period of about 8 years, in a hotel it would mean a change of every two days (estimate) and a time period of about 13 month. Bothe are reasonable time spans. Shorter periods are covered and can be evaluated just by introducing a calculation factor.

- **If applicable please describe specifically for:**
  - **Extraction of raw materials; here cotton production in China with average production numbers**

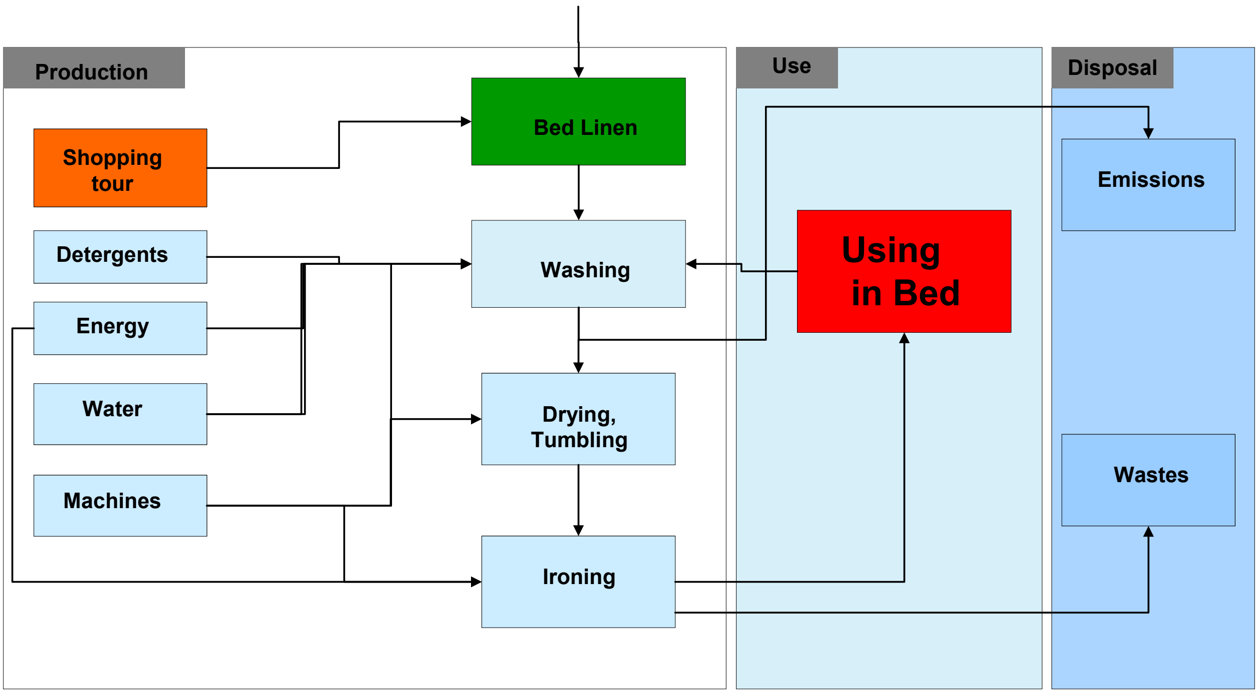


System boundaries of Cotton production

- **If applicable please describe specifically for:**
  - **Production of Cotton textiles**



  - **Production of Bed Linen, Shopping tour, use phase, disposal**



Capital goods (Washing machine, Iron) have no important impact, this was checked by additional calculations to estimate this effect.

5.4 Data Sources and Data Quality

- **Analysis and assessment of the share of primary and secondary Data**
  - **Activity data**
    - **About 70 % are primary data**
  - **Emission factors**
    - **About 70 % are primary data**
  -
- **Assessment concerning:**
  - **Specifity:**
    - **Reporting period 2008**
    - **Geography Germany**
    - **Technology Common washing technology, A-class**
  - **Accuracy > 90 % of relevant data were assessed**
  - **Preciseness 10 % uncertainty**
  -
  - **Completeness (dealing with data gaps) No Major data gaps**
  - **Consistency given**
  - **Reproducibility given**

- **Referencing the main sources for secondary data**
  - **Activity data**
  - **Emission factors**

5.5 Allocation

- **Explanation of the generally used allocation procedures**
  - **Co-production: Cotton wastes, economically allocated in the base case, scenario: by mass**
  - **Emissions from waste: not relevant**
  - **Recycling**
  - **Emissions from energy processes**
    - **Combined Heat and Power (CHP) Generation**
    - **Renewable energies**

- **Transport:** **Truck and ship transportation**

5.6 Treatment of particular emission sources

- **Renewable resources: Cotton, cotton wastes, carbon dioxide-neutral**
- **Direct and Indirect Land Use Change: no**
- **Aircraft emissions: no**

Only if relevant for the case study under consideration.

6 Inventory and Calculation

- **Specific methodological procedures for the case study (especially regarding data collection [activity data and emission factors], involvement of suppliers)**
- **Presentations of used**
  - **Tools** **Eco-Efficiency methodology, MS Excel, MS Access**
  - **Software** **Boustead, SimaPro**
  - **databases for secondary data:** **Boustead, SimaPro, BASF**

6.1 Extraction of Raw Materials

- **Brief description of the most relevant processes for the extraction of raw materials (incl. transports)**
  Extraction of phosphates, sulphur for fertilizers, phosphates for detergents, oil and gas for chemicals, energy production, transportation, iron for machines with low relevance.

- **Explanation of main activity data (indication of confidential information)**
  The most important activities are extraction of fuels and not renewable materials. The most relevant resources are oil, gas and coal, phosphorous and sulphur.

- **Important assumptions**
  Biobased materials were assumed as sustainable generated and have no resource factor. The carbon dioxide emissions of the materials were assumed as carbon neutral, the carbon dioxide assimilation was not considered due to the generation of the same amount in incineration and landfill with a factor below 100 years.

  All other raw materials were assessed with resource factors of the US Geographical survey.

Life time of different treated bed linen during 200 cycles. Fixapret treated bed linen have a higher life time.

- **Mentioning of main sources for primary and secondary data (activity data, emission factors)**

  Carbon dioxide emissions for raw materials were used from the Boustead database including extraction, transportation, milling and further treatment.
- **Depiction of data gaps**
- **Explanation of System Boundaries and potential cut-off criteria**

  All data were assessed along the whole supply chain with cradle-to-gate approaches. Cut off are materials below 5 % contribution.
- **Allocations**

6.2 Production

- **Brief description of the most relevant production processes**

  The most important activities are the production of the cotton bed linen, the treatment with the chemicals.
- **Explanation of main activity data (indication of confidential information)**

  Confidential information are the chemicals production, the treatment and finishing. Data were included from BASF as primary data.

- **Important assumptions**
-
- **Mentioning of main source for primary and secondary data (activity data, emission factors)**
- **Depiction of data gaps**
- **Explanation of System Boundaries and potential cut-off criteria**
- **Allocations**

6.3 Distribution

- **Brief Description of the most relevant processes for the distribution of the products**

  Ship transportation of cotton from China
- **Explanation of main activity data (indication of confidential information)**
- **Important assumptions**

  Ship transportation from China 20.000 km, 65 % usage, 12 g/tkm CO2, truck transport, 75 % usage, 127 g/tkm; shopping tour with default value

- **Mentioning of main source for primary and secondary data (activity data, emission factors)**

  Average numbers for transportation from Boustead source

- **Depiction of data gaps**

  Single transportation steps
- **Explanation of System Boundaries and potential cut-off criteria**
- **Allocations**

6.4 Shopping Tour

- **Brief Description of the most important scenarios for last-mile transport to the end-use location (i.e. shopping tour)**
- **Explanation of main activity data (indication of confidential information)**
- **Important assumptions**
- **Mentioning of main source for primary and secondary data (activity data, emission factors)**
- **Depiction of data gaps**
- **Explanation of System Boundaries and potential cut-off criteria**
- **Allocations**

In this life cycle step default values were considered, no important transportation steps are necessary. The importance of this step is low compared to other life cycle stages.

6.5 Product Use

- **Brief description of the most relevant processes and potential different scenarios for use phase of the product**

  The most important activities are the washing tumbling and ironing for the alternatives without Fixapret treatment. But also the replacement of non-usable bed linen which also reflects to the production phase is important.
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- **Explanation of main activity data (indication of confidential information)**
- **Important assumptions**

  Water usage during washing and per 5 kg cloth is 45 l, energy use 0.95 kWh, use of detergents is 75 ml. Washing temperature 60 °C.

  Tumbling per 5 kg cloth is 3,5 kWh, time is 20 min

Ironing with 1400 W, 0 and 15 min per bed cloth, depending on treatment with Fixapret AP or without Fixapret AP. This are data from common products of the market. They can be found in the internet.

Otto-Katalog online (www.neu.otto.de; 4.3.02): Waschvollautomat, Bosch, »WFO 244 S«

Otto-Katalog online (www.neu.otto.de; 4.3.02): Wäschetrockner »Lavatherm T520 Electronic«

Otto-Katalog online (www.neu.otto.de; 4.3.02): Bügelautomat, Tefal, »Supergliss 15«

And updated versions of 2008..

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- **Mentioning of main source for primary and secondary data (activity data, emission factors)**

  General data sources, sources for electrical machines
- **Depiction of data gaps**
- **Explanation of System Boundaries and potential cut-off criteria**

  Contributions below 5 %
- **Allocations**

6.6 Recycling/Disposal

- **Brief description of the most relevant processes for the recycling/ disposal phase**
- **Explanation of main activity data (indication of confidential information)**
- **Important assumptions**

  Wastes were incinerated with 125 g CO2 per kg waste. All cotton wastes, chemical wastes were incinerated.
- **Mentioning of main source for primary and secondary data (activity data, emission factors)**
- **Depiction of data gaps**
- **Explanation of System Boundaries and potential cut-off criteria**
- **Allocations**

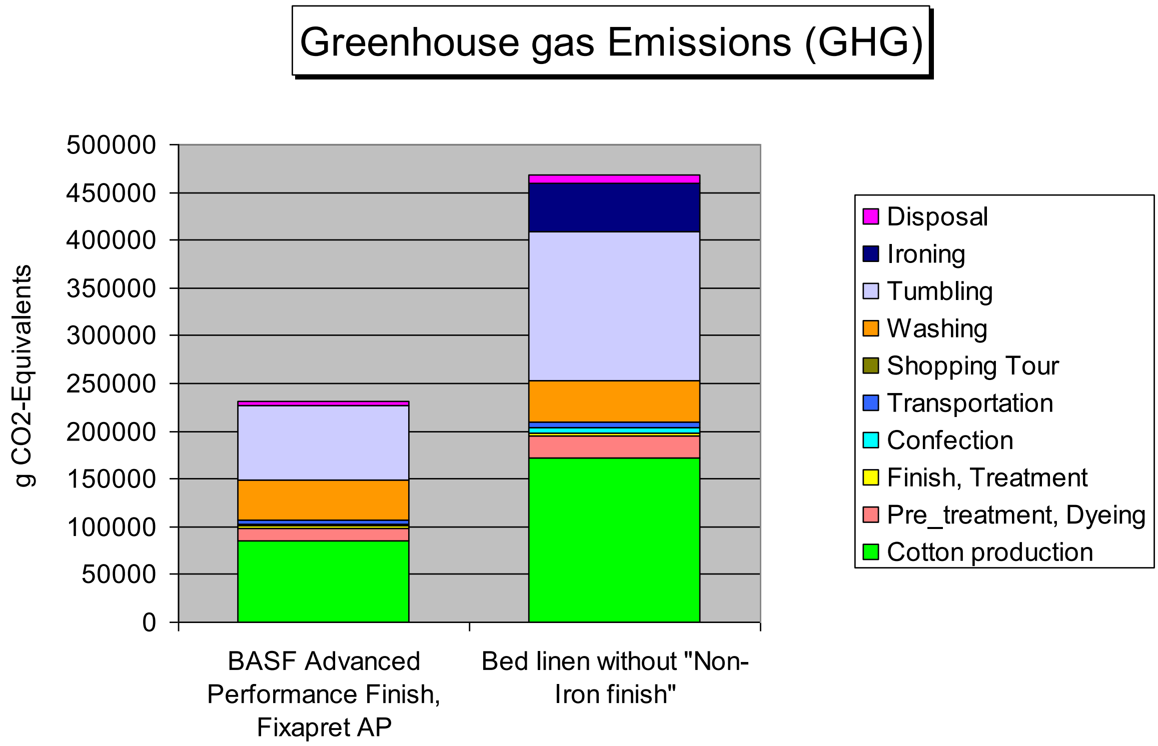
  Electricity production and replacement of electricity in Germany with 1.4 MJ per kg waste with more than 10 MJ heating value
- **Presentation and Analysis of Results**

7 Presentation of Results (best guess)

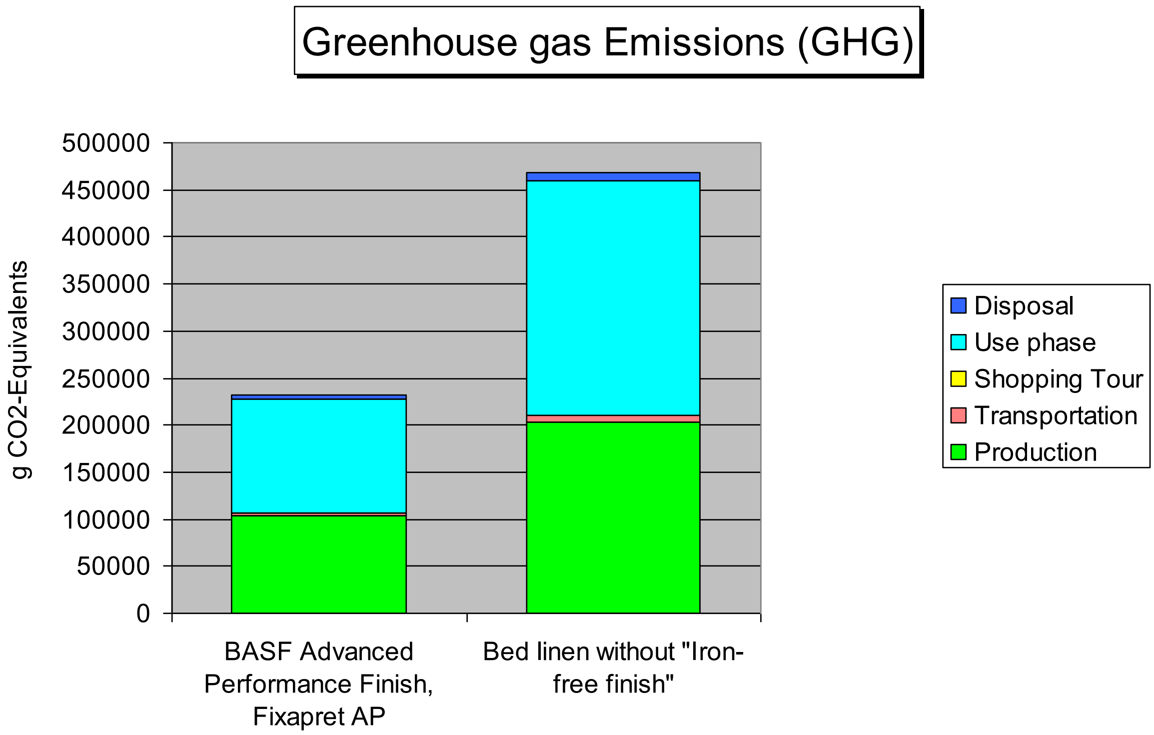
7.1 Overview

- **Overall results**
- **Share of individual life cycle stages and greenhouse gases**

  The difference between the two alternatives are around 230 kg for the whole Functional unit. The range of the bed linen which can be used as a product classification role is between 470 kg and 230 kg GHG equivalents per functional unit.



in g CO2-e_functional unit	**BASF Advanced Performance Finish, Fixapret AP**	**Bed linen without "Non-Iron finish"**
Cotton production	85.873	171.746
Pre_treatment, Dyeing	11.996	23.992
Finish, Treatment	3.023	2.780
Confection	2.266	4.532
Transportation	3.394	6.789
Shopping Tour	203	406
Washing	42.150	42.150
Tumbling	78.216	156.431
Ironing	0	50.721
Disposal	4.397	8.793
	231.517	468.339



	BASF Advanced Performance Finish, Fixapret AP	Bed linen without "Non-Iron finish"
Production	103.159	203.050
Transportation	3.394	6.789
Shopping Tour	203	406
Use phase	120.365	249.302
Disposal	4.397	8.793

- **Driver – „Hot Spots“**

  The most important lifecycle step is the use phase of the linen, followed by the production.

  The most important Hot Spots are the cotton production, followed by Tumbling, Ironing and washing. The Fixapret alternative has strong advantages because of the reduction of the greenhouse gases of the important life cycle stages.

-
- **Uncertainties**

  How often the cotton can be used until it must be replaced, time spent for ironing, washing processes.

  In the incineration it is important, which technology is used. Furthermore, often disposal is the common recycling opportunity with reduced carbon dioxide emissions.

7.2 Extraction of Raw Materials

- **Overall footprint**
- **Share of most relevant processes and greenhouse gases**
- **Driver – „Hot Spots“**

- The most important Raw material is the cotton between 85 and 171 kg CO2 per functional unit. The chemicals for Fixapret AP have a contribution of 3 kg CO2-e, the non treated materials generates 2.8 kg CO2 equivalents for other additives.
- **Uncertainties**

7.3 Production

- **Overall footprint**
- **Share of most relevant processes and greenhouse gases**
- **Driver – „Hot Spots“**
- **Uncertainties**

7.4 Distribution

- **Overall footprint**
- **Share of most relevant processes and greenhouse gases**
- **Driver – „Hot Spots“**
- **Uncertainties**

7.5 Shopping Tour

- **Overall footprint**
- **Driver – „Hot Spots“**
- **Uncertainties**

7.6 Product Use

- **Overall footprint**
- **Share of most relevant processes and greenhouse gases**
- **Driver – „Hot Spots“**
- **Uncertainties**

7.7 Disposal/Recycling

- **Share of most relevant processes and greenhouse gases**
- **Driver – „Hot Spots“**
- **Uncertainties**

8 Assessment of the Results

8.1 Sensitivity Analysis

- **Scenarios in each life-cycle stage**
- **Scenario 1: Reduced function of Fixapret, in tumbling, there is no advantage for Fixapret AP in this life cycle step.**

in g CO2-e_functional unit	**BASF Advanced Performance Finish, Fixapret AP**	**Bed linen without "Non-Iron finish"**
Cotton production	85.873	128.809
Pre_treatment, Dyeing	11.996	17.994
Finish, Treatment	3.023	4.186
Confection	2.266	3.399
Transportation	3.394	7.909
Shopping Tour	203	304
Washing	42.150	42.150
Tumbling	78.216	78.216
Ironing	0	27.051
Disposal	4.397	6.595
	231.517	316.613

Reduced Function of Fixapret compounds ends in reduced advantages because of shorter usage times of cotton and reduced advantages for ironing.

- **Scenario 2: Reduced time for ironing by 50 %. It can be, that the ironing time may be shorter because of different ironing techniques. Due to discussions, which ironing scenario is the most relevant one, it may be an option to use this scenario also as a base case scenario. Nevertheless, compared to the other numbers of the life cycle steps, the ironing step is not the most relevant one.**

in g CO2-e_functional unit	**BASF Advanced Performance Finish, Fixapret AP**	**Bed linen without "Non-Iron finish"**
Cotton producti	85.873	171.746
Pre_treatment,	11.996	23.992
Finish, Treatme	3.023	2.780
Confection	2.266	4.532
Transportation	3.394	6.789
Shopping Tour	203	406
Washing	42.150	42.150
Tumbling	78.216	156.431
Ironing	0	27.051
Disposal	4.397	8.793
	231.517	444.670

The advantage for the Fixapret AP alternative is still very high.

- **Scenario 3: Reduction of the energy consumption of a tumbler by 50 %**

in g CO2-e_functional unit	**BASF Advanced Performance Finish, Fixapret AP**	**Bed linen without "Non-Iron finish"**
Cotton production	85.873	171.746
Pre_treatment, Dyeing	11.996	23.992
Finish, Treatment	3.023	2.780
Confection	2.266	4.532
Transportation	3.394	6.789
Shopping Tour	203	406
Washing	42.150	42.150
Tumbling	78.216	74.491
Ironing	0	50.721
Disposal	4.397	8.793
	231.517	386.299

- **Scenario 4: Changing from economical allocation for cotton to a mass based allocation of biowastes and cotton**

in g CO2-e_functional unit	BASF Advanced Performance Finish, Fixapret AP	Bed linen without "Non-Iron finish"
Cotton production	28.624	57.249
Pre_treatment, Dyeing	11.996	23.992
Finish, Treatment	3.023	2.780
Confection	2.266	4.532
Transportation	3.394	6.789
Shopping Tour	203	406
Washing	42.150	42.150
Tumbling	78.216	156.431
Ironing	0	50.721
Disposal	4.397	8.793
	174.269	353.842

It can be shown, that the scenarios can change the range for the bed linen from 230 kg to 174 kg CO2-e at the low end to 316 to 444 kg CO2-e. The scenarios 1-3 are depending on technical issues and numbers, scenario 4 shows that a physical allocation normally generates lower numbers for the Carbon Footprint than an economical allocation. In industry the main processes should get the main burden because the process is used for getting these materials. So the economic allocation should be the preferred alternative.

8.2 Uncertainty and Error Analysis (optional)

8.3 Handling of other Environmental Impact Categories

8.3.1 Analysis of other Environmental Impact Categories

8.3.2 Multicriterial Assessment (if relevant)

The Eco-Efficiency Analysis of BASF is seen as a life-cycle management tool. It can be used in assessing the entire product life-cycle, from concept development, to design and implementation, further to marketing, and finally, end-of-life issues. The analysis method incorporates both economic and environmental aspects and lead to a comprehensive evaluation of products and processes over their entire life-cycle.

The results of the Eco-Efficiency Analysis are presented as aggregated information on costs and environmental impact and show the strengths and weaknesses of a particular product or process. The ecological calculations of the single results in each category are following the ISO-rules 14040 and 14044.

For the calculation and comparison of the environmental position of each alternative, data from the different production methods are assimilated and analysed to provide a value for

energy consumption,

raw-material consumption,

emissions, (greenhouse gases are a part of this category)

use of area,

risk potential and

toxicity potential.

All raw-materials required in the process and how these are derived, are factored into the study, as are the steps required to bring the product to the end-user.

In the same manner economical data from the life-cycle chain of a product application or process evaluation, may also be calculated and summarized. At the end, this analysis can lead to better decisions with regard to product design, material utilization, and capital investment. The rationale behind this assessment tool has been described by Saling et al. (2002) and by Landsiedel and Saling (2002).

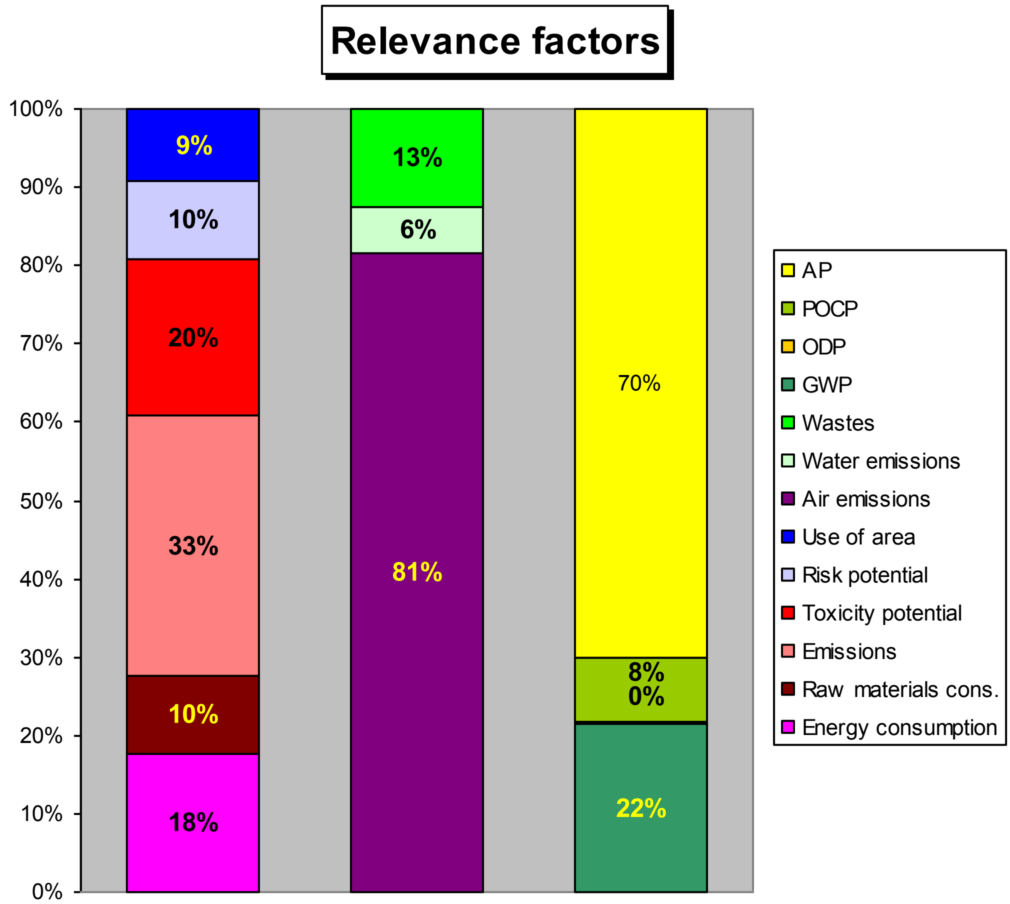
The values obtained in the material balance and impact estimate (greenhouse potential, ozone depletion potential, photochemical ozone formation potential, acidification potential, water emissions, solid waste, energy consumption, raw material consumption and area requirement) are aggregated with weighting factors to yield an overall environmental impact value. The weighting factors consist of the following:

- a *societal factor:*
  What value does society attach to the reduction of the individual potentials?
- a r*elevance factor*:
  What is the fractional contribution of the specific emission (or consumption) to the overall countrywide emissions?

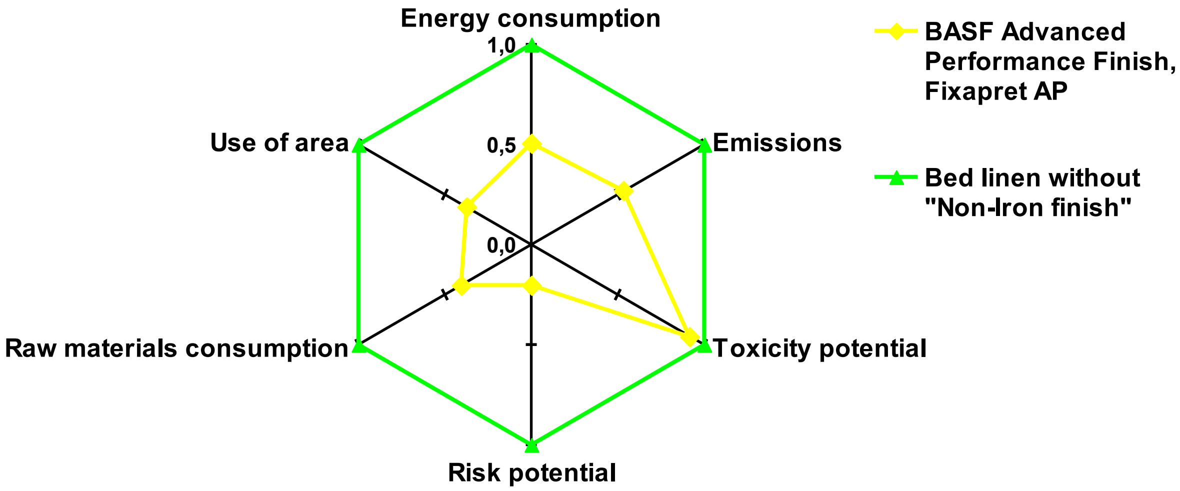
In this case study, the Eco-efficiency Analysis was also used to evaluate the relevance of different environmental criteria compared to that of greenhouse gas emissions.

In this specific case study, the most important environmental relevance factors based on the statistics are the emissions. Within emissions, air emissions are the most relevant category and herein the acidification potential is the most important environmental factor. This is due to the air emissions linked with the energy use during the cotton production in China. In China, source of electricity is mainly coal, which is the reason for this high figure.

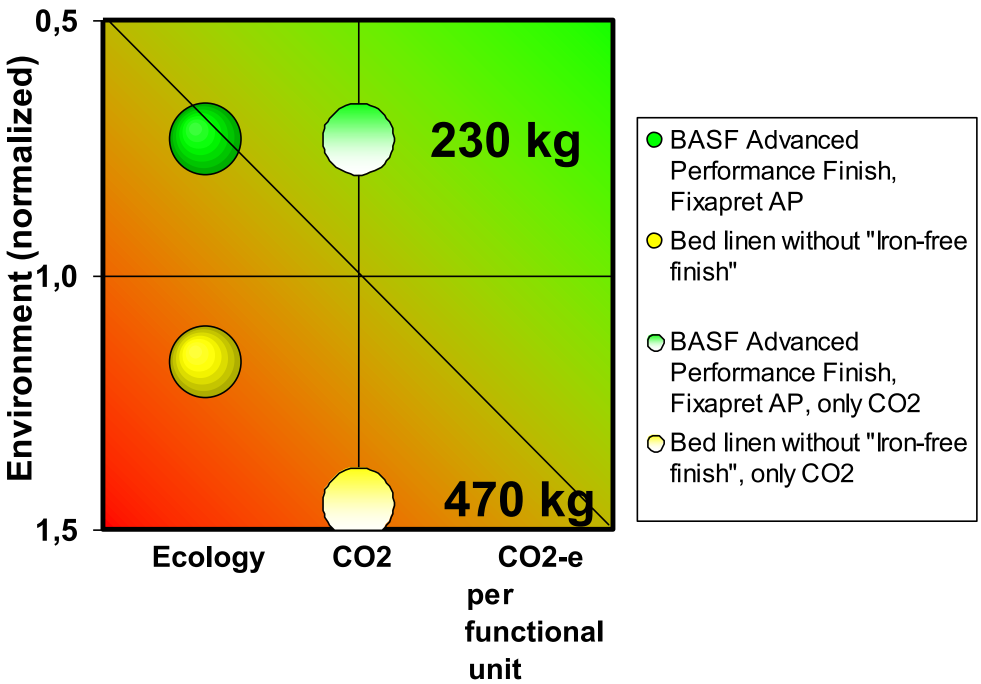
As a quintessence out of this case study, the PCF was not the most significant ecological category. Optimization in the reduction of the PCF must be considered taking other environmental factors also into consideration. Decisions should not be based only on PCF.



The ecology fingerprint below shows a summary of all environmental factors of the two alternatives along the whole life cycle. It clearly shows that the bed linen finished with Fixapret AP is the favorable alternative compared to bed linens without any non-iron finishing.



The ecology factors can also be aggregated by the eco-efficiency methodology to a single number which can be shown in a special diagram. It also can be shown, that the differences between the alternative are much higher if only GHG-emissions are considered.



9 Interpretation and Perspectives (Company)

9.1 Challenges of the Case Study

The calculation of the wide range of numbers, assessing different situations in using bed linen and assessing the main impacts of the study.

9.2 Identification and Assessment for Further Reduction Options of the PCF

9.3 Measures under Consideration to Further Reduce the PCF

The use phase is very important. By the implementation of more bed linen equipped with Fixapret AP together with very efficient washing processes, drying and ironing machines, the PCF can be reduced very effectively.

Secondly, optimized processes for cotton production, linked with an energy generation with a higher efficiency, the PCF can be reduced.

Thirdly, it was shown, that the effects of chemicals are much higher than the emissions for their production. So an intelligent use of high performance chemicals can contribute very well to the reduction of the PCF of Bed linen.

9.4 Product Carbon Footprinting at [Name of the Company] in the Future (optional)

- **Put PCF in the wider company sustainability strategy (with a special focus on climate change)**

BASF will stick to the Eco-efficiency Analysis, which presents more detailed and comprehensive information. The sustainability of the products as a whole is evaluated it can be used in making business decisions. Nevertheless, Carbon Footprint is part of this analysis and can be utilized to understand the carbon dioxide emissions along the value chain. In addition, it can be used to identify reduction opportunities taking other ecological criteria also into consideration.

10 Recommendations (Company + Service)

10.1 International Methods for Calculation and Assessment of Product Carbon Footprints

Basis: ISO 14040 and 14044, results and methodological recommendations from the PCF-project. To assess additional environmental factors, the eco-efficiency analysis is a preferred tool. There will be an ISO rule for it in the future.

10.2 Proposals for Product Specific Definitions and Rules (EPD, PCR)

PCF case studies like this one for bed linen can be used for the definition of PCR. It was shown a range of CO2-e that can be obtained for these materials and where the main environmental contributions along the whole supply chain are. All the data sets together can be used for the definition of a PCR as well as showing the best available technology.

10.3 Reporting, Communication and Claims of Reductions to Customers and Consumers

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12 Annex

12.1 Documentation of the Data

12.1.1 Extraction of Raw Materials

					Data index			
Data Module (Output)	**Processes covered**	**Time related coverage**	**Geographical specificity**	**Technological specificity**	**Place of reference: in-house (I), literature (L), other (O and specify)**	**Single value (S); aggregated value (A) and specify the percentage or absolute amount of each part**	**Measured (M); calculated (C); estimated (E)**	**Data source**
Examples								
Cotton	Cotton farm, including irrigation, fertiliser, pesticides	2005	China	Average cotton farm in China	I, L	S	C	BASF, literature 2005
Electric energy	Resource depletion, power plants, distribution	2005	China	Electricity mix	L	A	C	Literature 2005
Chemicals	Resource depletion,	2008	Europe	Single chemicals	I	S	M	BASF 2008

	power plants, distribution							
Electric energy, steam	Resource depletion, power plants, distribution	2007	BASF	Electricity and steam of BASF	I	A	M, C	BASF 2007

12.1.2 Production

					Data index			
Data Module (Output)	Processes covered	Time related coverage	Geographical specificity	Technological specificity	Place of reference: in-house (I), literature (L), other (O and specify)	Single value (S); aggregated value (A) and specify the percentage or absolute amount of each part	Measured (M); calculated (C); estimated (E)	Data source
Examples								
Green coffee beans	Coffee farm, including irrigation, fertiliser, pesticides	2007	Tansania	Average coffee farm in Africa	I	S	C	Tchibo 2008

Electric energy	**Resource depletion, power plants, distribution**	**2005**	**Germany**	**Electricity mix**	**L**	**A**	**C**	**EcoInvent 2008**

12.1.3 Distribution

					Data index			
Data Module (Output)	**Processes covered**	**Time related coverage**	**Geographical specificity**	**Technological specificity**	**Place of reference: in-house (I), literature (L), other (O and specify)**	**Single value (S); aggregated value (A) and specify the percentage or absolute amount of each part**	**Measured (M); calculated (C); estimated (E)**	**Data source**
Examples								
Materials	**Fuels, emissions**	**2005**	**Germany**	**Average**	**L**	**S**	**C**	**Boustead**
Shopping Tour	**Fuels, emissions**	**2005/2008**	**Germany**	**Average**	**L**	**S**	**C**	**PCF-Project, Boustead**

12.1.4 Product Use

					Data index			
Data Module (Output)	**Processes covered**	**Time related coverage**	**Geographical specificity**	**Technological specificity**	**Place of reference: in-house (I), literature (L), other (O and specify)**	**Single value (S); aggregated value (A) and specify the percentage or absolute amount of each part**	**Measured (M); calculated (C); estimated (E)**	**Data source**
Examples								
Tumbling, Ironing	**Cotton treatment**	**2006**	**Germany**	**Averages of machines**	**L**	**S**	**C**	**Internet, UBA**
Electric energy	**Resource depletion, power plants, distribution**	**2005**	**Germany**	**Electricity mix**	**L**	**A**	**C**	**EcoInvent 2008**
Washing	**Water heating**	**2002**	**Germany**	**Electricity mix**	**L**	**A**	**C**	**BASF, Eco-Institute**

	detergents							

12.1.5 Disposal/Recycling

					Data index			
Data Module (Output)	**Processes covered**	**Time related coverage**	**Geographical specificity**	**Technological specificity**	**Place of reference: in-house (I), literature (L), other (O and specify)**	**Single value (S); aggregated value (A) and specify the percentage or absolute amount of each part**	**Measured (M); calculated (C); estimated (E)**	**Data source**
Examples								
Incineration		**2003**	**Germany**	**Specified plant**	**I**	**S**	**C**	**BASF, Martin**
Landfil		**2005**	**Germany**	**Average**	**I**	**A**	**C**	**BASF**