The true price of diaper systems

Final report | October 2022

External report | Commissioned by: Future Diaper Project

trueprice.org

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Overview

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Management summary

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SUMMARY MANAGEMENT SUMMARY

The true price gap of conventional disposable diapers is ~ €0,06 per change and ~ €0,045 per change for a washable diapers.

Scope of analysis

This true price research compares the true price gaps of 3 diaper types:

1. Conventional disposable plastic diapers (>80% oil-based plastics);
2. 'Ecological' disposable plastic diapers (±40% bio-based plastics) that are widely available on the market and that are not (far) apart in terms of functionality;
3. Washable (cloth) diapers.

The analysis covers the production, use and waste phase (end-of-life), for children in the Dutch context from birth to toilet trained. Moreover, it analyses multiple use and waste scenarios (see chapter 3, approach). The analysis focuses on 6 material impacts: contribution to climate change, scarce water use, land use, water pollution, underpayment in the value chain and fossil fuel depletion. The results are based on secondary data. For a complete overview of data sources used, please see annex. The results are communicated in EUR 2021 prices.

Insights

- The true price gap* for conventional disposable diapers is ~ €0,06 per change and ~ €0,045 per change for a washable diaper for one child from birth to toilet trained at 3,5 years old (see Results Impact Diaper Change, p.30).
- Timely toilet training (at 2 – 2.5 years**, 1 year earlier than the current average) reduces the impact of diaper use by more than 20% (see Scenario 2, p.35).

Average true price gap per change per diaper type

Single use conventional diapers

€0,064 / change

Single use biopolymer diapers

€0,061 / change

Reusable cloth diapers

€0,043 / change

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SUMMARY MANAGEMENT SUMMARY

The choices parents make during the use phase of the diapers, have substantial effect on the true price gaps of the diaper systems.

- With a difference of 30%, the washable diaper seems the more sustainable choice for a comparable period of use (also with just one child).
- The differences become much greater if the washable diaper (1) is used for a second child and (2) if the electricity for washing is purchased sustainably: about 60% of the impact of washable diapers comes from washing in the use phase, of which 80% due to electricity use (see Results Impact per Life Cycle Phase, p.32).
- Remarkably, the use of so-called 'newborn' washable diapers (a separate small size washable diaper for the first period of 2-3 months) is not more sustainable than disposable diapers in the same period. The production of (cotton) washable diapers for a such a short period has more negative impact than the use of disposable diapers (see Scenario 1, p.33).
- The drying method (dryer or line drying) has a major impact on the environmental results. Drying with the dryer increases the environmental impact to a comparable level to disposable diapers. The calculation is based on the average Dutch energy mix (green/grey) (see Scenario 4, p.36).
- The differences between the conventional 80% oil-based disposable plastic diapers and the 40% bio-based*** plastic disposable diapers are small (bio-based has a ~5% lower true price gap). The conversion of plant-based materials (such as maize and sugar beet) into (bio)plastics (also) has a high impact (see Results Impact per Toilet Trained Child, p.29).
- When the 'diaper recycling' capacity is scaled up to 50% of the waste stream in the Netherlands, the true price gap will be ~6% lower for both types of disposable diapers and ~4% lower for washable diapers (see Waste Management Scenario, p.38).

Interpretation

- The results provide a solid indication for a material part of the true price gap of the diaper systems. However, caution is advised as this assessment has a limited scope (see chapter 3, Approach).

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SUMMARY FOOTNOTES

* The True Price gap gives a financial value to the (hidden, not incurred) costs that a product has in the production, use and waste phase by calculating the environmental and social impacts and translating these into costs for remediation of those impacts (see p. 47).

** Children are - on average - toilet trained 1.5 years later then 40 years ago. Most children are mentally and physically able to start toilet training between 18 and 24 months. – Vermandel (2022) A sample of 400 children at daycare centers in Leiden confirmed the average toilet-training age of 3.5+ (research by Future Diaper Project commissioned by the Municipality of Leiden, the Netherlands).

*** In theory, a diaper can already be made from bio-based plastics to a greater extent (60-80%), but the costs are at a price point (> €1 per disposable diaper) that this is not included as a viable option in this research. Bio-based plastics are not the same as biodegradable plastics. Bio-degradable plastics have no significance in the current Dutch waste chain outside of organic waste: diapers (human excrement) are not allowed in the compost bin and many bio-degradable plastics are only factory-degradable (under special conditions).

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Introduction & background

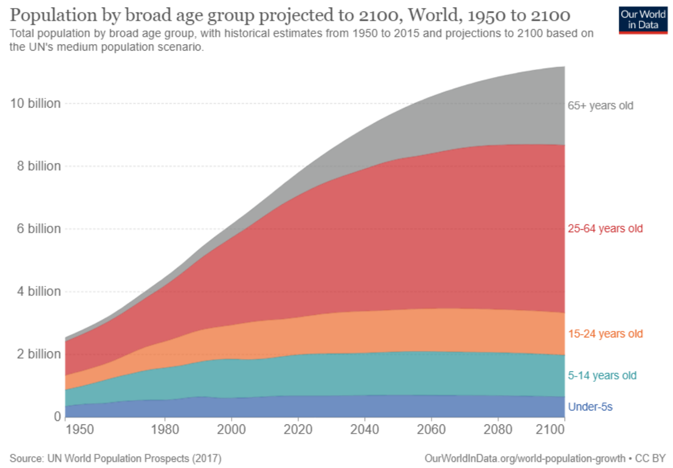
02

INTRODUCTION THE TRUE PRICE OF DIAPERS

The Future Diaper Project (FDP) is on a mission to make the global diaper industry more sustainable, for which it embraced true pricing.

- There have never been so many children in the world as there are now. In the next decades this number will increase slightly (see visual).
- Simultaneously, due to the growth of global welfare, the demand for diapers will continue to grow. Good diapers are necessary for health in the first years of babies.
- However, the production, use and waste of diapers cause damage to people and the environment. Without changes, children who are currently wearing diapers will pay that price.
- Future Diaper Project (FDP) is on a mission to reduce the negative impact of the diaper industry. There are different types of diapers, but it's unclear which one is the most sustainable option. And what consumers, retailers, and other stakeholders can do to minimize the negative impact of diaper use.
- FDP wants to gain these insights to be able to develop sustainable diaper services, help consumers make more sustainable decisions and inspire industry stakeholders to change.
- They embraced true pricing as an instrument to realize their mission and embarked on their true price journey in 2021 with a workshop. Now, they have asked True Price to do a true price assessment of 3 types of diaper systems and investigate different consumption and waste management scenarios.
- This report describes the results of the analysis, its approach, scope, data and limitations. Furthermore, it describes at a high-level how the industry could transition towards a more sustainable one.

Estimation of the growth of the world population up to 2100 (source: Our World in Data)



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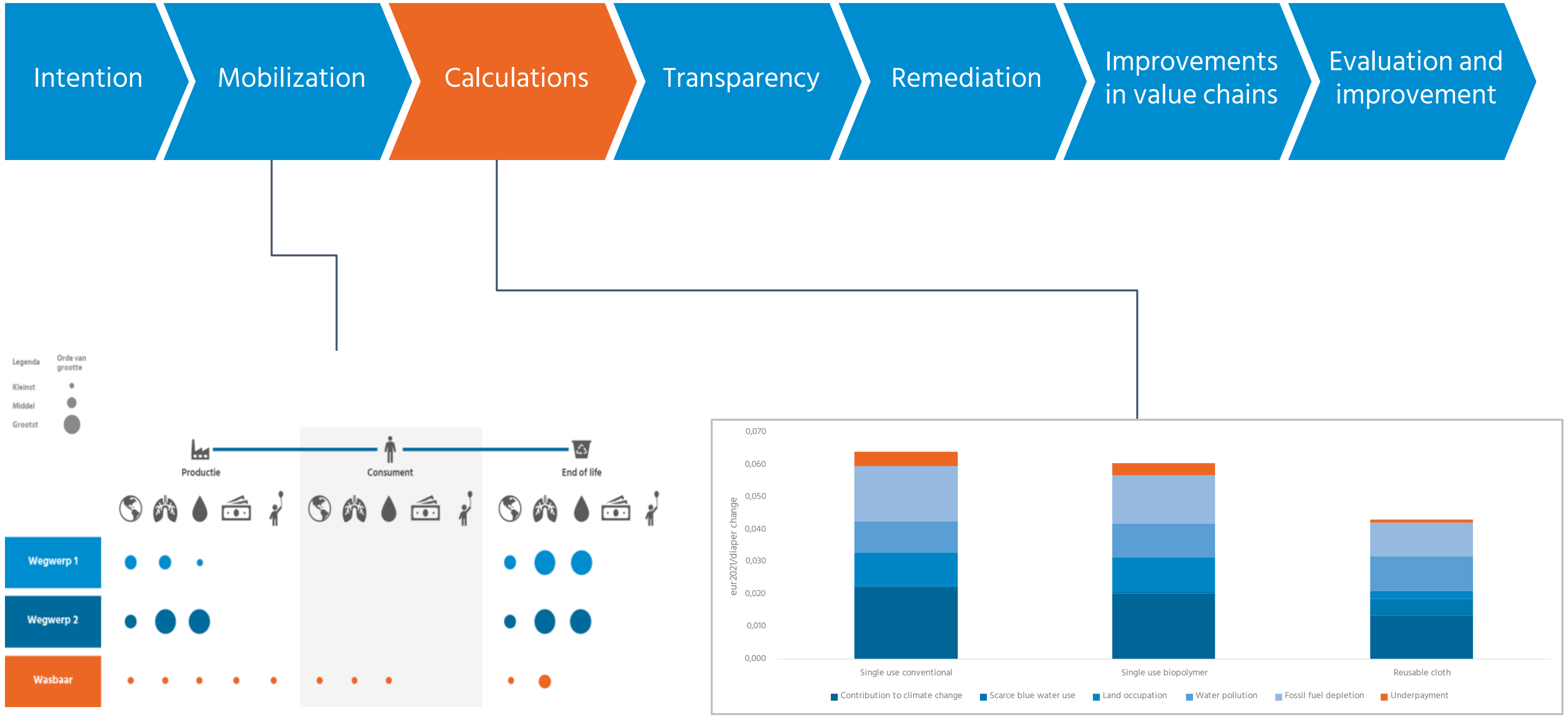
INTRODUCTION FDP EMBARKED ON ITS TRUE PRICE JOURNEY IN 2021

The analysis build on the qualitative true price workshop

- A true price journey is a step-by-step approach for companies to use true pricing in their business.
- In January 2021, FDP and True Price did a workshop to gain initial qualitative insights into the place and extent of five external costs of washable and disposable diapers. In addition, work has been done on developing a strategy and communication to reduce external costs.
- The workshop provided a foundation to build on for this analysis, in terms of scope and focus, which can be considered the third step in its true price journey: calculations (in orange).

Illustration of a true price journey of a company. Including some results of the workshop (a qualitative estimate of 5 external costs of 3 types of diapers), the current analysis, and how these fit into the journey of FDP.



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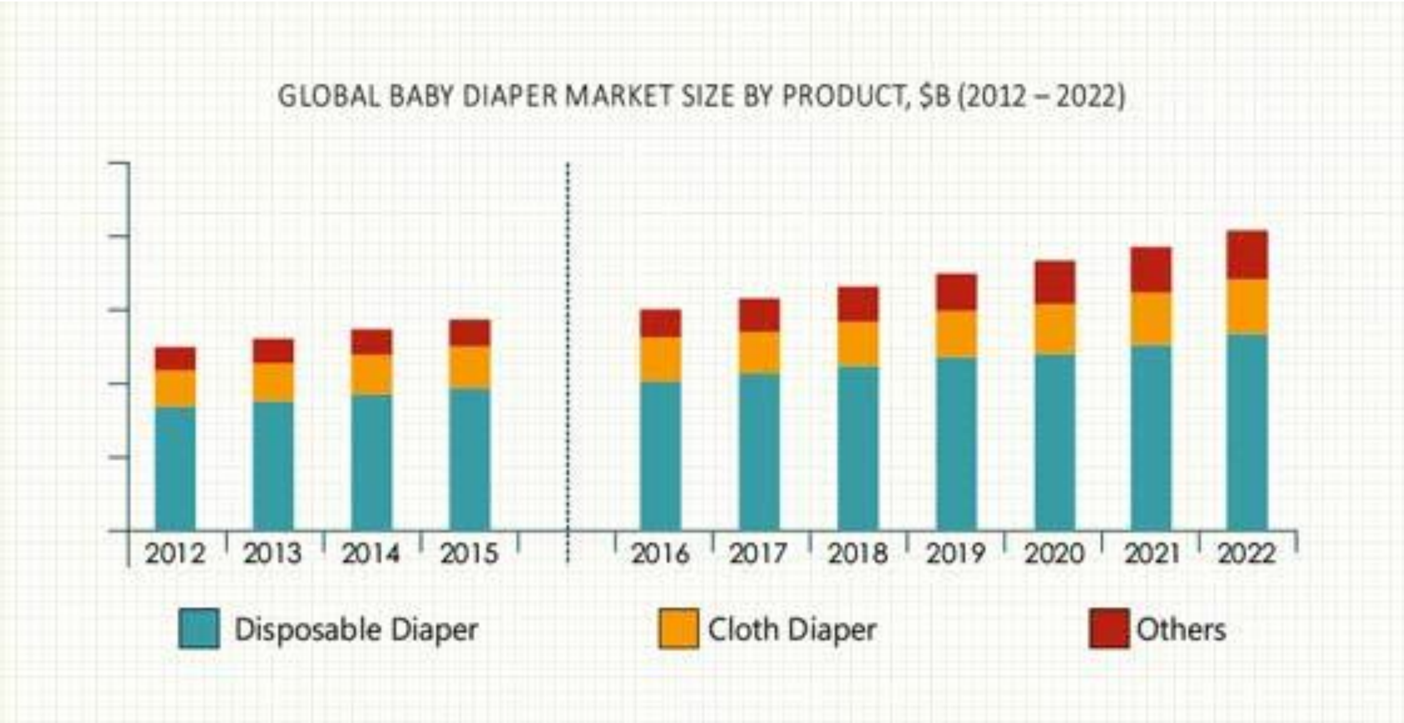
INTRODUCTION THE GLOBAL DIAPER MARKET AT A GLANCE

The global diaper market has been growing the past decade and will continue growing the coming decade.

- The global diaper market has been growing substantively in recent decades. According to a market study report published by Facts and Factors, the demand analysis of Global Diaper Market size and share revenue was worth approximately USD 68.46 billion in 2020 and is expected to grow to around USD 100 billion by 2028*.
- Key drivers of this growth: the increase in the number of working women provides a chance for countries to expand their workforce and achieve greater economic growth, as a result the disposable income will increase, thereby propelling the diaper market growth. Further, the market has been expanding during the past few years, owing to factors such as, aging population, increase in urban population, high birth rate in emerging countries and delayed toilet training of children in developed countries**.

Illustration of the development of the global diaper market (in $bn, 2012-2022), for different types of diapers (source: P&S Intelligence)



* Source: Global News Wire
** Source: Global News Wire

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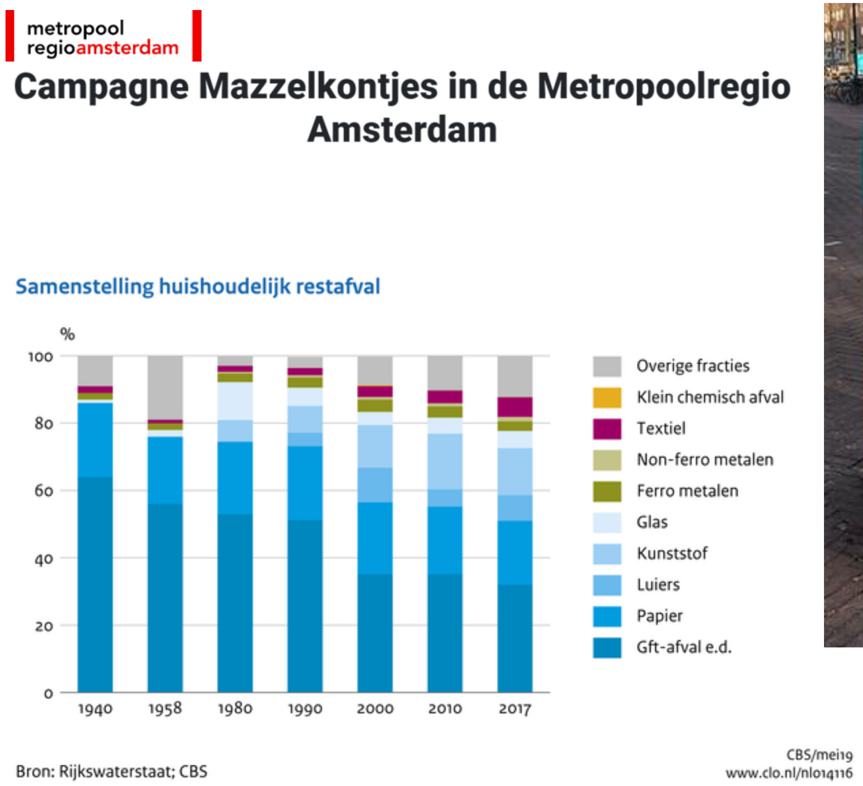
INTRODUCTION DIAPER WASTE IS A GROWING PROBLEM

The attention for the environmental impact of diaper waste is growing, new initiatives are popping up to tackle the problem.

- Diapers make up a substantial amount of the total waste produced by households in the Netherlands. In 2020, diaper use resulted in around 200.000 tons of waste* - which is around 5% of all household waste in the Netherlands (CBS).
- Currently, most of the diapers are incinerated. In other countries, diapers also end up in landfills. There are some initiatives in The Netherlands that aim to recycle diapers, which potentially reduce the environmental impact of diaper waste.
- The Dutch government supports and initiated several projects and actions to make the diaper industry more circular. They are looking, for example, into the possibilities of expanding the producer's responsibility to ensure or enable the sustainable collection and processing of diaper waste.
- Besides that, they seem to focus on promoting reusable diapers. A number of municipalities and Milieucentraal started a campaign 'Mazzelkontjes' to promote reusable diapers by informing parents about their benefits and allowing them to use cloth diapers for two months for free.

Illustration of the development of the proportion of diapers in the total household waste in the Netherlands (source: CBS). And illustrations of new initiatives to improve the diaper industry.



* https://www.rvo.nl/praktijkverhalen/luiers-zitten-waardevolle-grondstoffen

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Approach

03

APPROACH TRUE PRICE METHOD PROCESS

This chapter describes the approach, scope and method used to execute the analysis. The analysis is based on the true price method, which follows a clear and structured process.*

Stage	A FRAME	B SCOPE			C MEASURE AND VALUE			D REPORT	
Steps	01 Define goal and audience	02 Define the product	03 Define product lifecycle	04 Determine impacts in scope	05 Measure the impacts	06 Value the impacts	07 Integrate the impacts	08 Interpret and test the results	09 Report
Key elements to consider	The intended use and target audience Stand-alone or comparative	The specification of the product Possible reference scenarios The functional unit Currency and year of results	Mapping the product lifecycle Selection of relevant lifecycle steps	Impacts to consider Materiality assessment Impacts and parts of the lifecycle in scope	List footprint indicators Collect data Evaluate the data quality Quantify impacts and scale to functional unit	Monetize the impacts	Combine the monetized values of the impacts in scope into the total true price	Interpret the results to form conclusions Test reliability Identify impacts and lifecycle steps that require more research	Report the results of the assessment and disclose to the intended audience

* The method is part of the true price standard, which is currently being developed in collaboration with Wageningen University and will be published on the True Price website in 2022.

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APPROACH FRAME

The goal and audience of the analysis were defined with FDP and preliminary research on impacts of the diaper sector.

- The analysis is a **comparative study** between single-use (conventional & biobased) and reusable diapers consumed in the Netherlands. The results will be communicated externally to inform the public on True Price results, based on average production, usage and waste management practices.

- 2 additional targets are determined based on relevant audiences for these products:
- Target 1: Estimate how True Prices of the products can vary based on consumer behaviour.
- Target 2: Estimate how True Prices of the products change based on waste management practices

- The relevance of these 2 targets is further supported by the main conclusions of a UNEP meta-analysis on disposable diapers and their alternatives.

- Based on these targets, several **scenarios** are formulated to provide further insights on the sustainability of diaper use in the Netherlands and the reduction of the negative externalities* connected to this use.

Single-use nappies and their alternatives, Recommendations from Life Cycle Assessments (UNEP, 2021)**

*"This report serves to highlight important aspects that policy makers should consider when evaluating environmental information (often in the form of LCA studies) to inform policy development that is context specific and locally relevant… **For single-use nappies, particularly important aspects to consider are available and future waste management technologies and infrastructure. For reusable nappies,the most critical aspects are consumer behaviour and perceptions,** both in recognising the need for convenience and cost effectiveness that single-use nappies bring, and in the washing habits that strongly affect the environmental impacts of reusable nappies."*

* Externality is a societal cost or benefit that affects a party who did not choose to incur this cost or benefit. A societal cost is a negative externality and a societal benefit is a positive externality.
** https://www.lifecycleinitiative.org/wp-content/uploads/2021/03/UNEP-D003-Nappies-Report_lowres.pdf

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APPROACH SCOPE - OVERVIEW

The scoping stage consists of three steps: 1. Define the product, 2. Define the product lifecycle, 3. Determine material impacts. Four relevant dimensions emerge from these steps.

- The true price assessment is scoped based on 4 dimensions: 1) items & system boundaries, 2) value chain, 3) impacts and 4) data.

1. **Items & system boundaries**. The analysis covers 3 types of diapers: 1. single use conventional diapers, 2. single use biobased diapers, 3. reusable all-in-one cloth diapers. Single use and reusable cloth diapers are manufactured in Europe and Asia respectively. The diapers are used and wasted in the Netherlands. Raw materials for diapers are mainly sourced in Europe. The **functional unit** is €/One toilet trained child*. Other relevant units are: €/diaper, €/changes.

2. **Value chain**. The analysis covers 3 stages in the lifecycle of diapers: A) raw material production & manufacturing of the diapers, B) use phase in households, and C) waste treatment.

3. **Impacts**. The analysis focuses on 6 material impacts: contribution to climate change, scarce water use, land use, water pollution, underpayment in the value chain and fossil fuel depletion.

4. **Data**. The results are based on secondary data. For a complete overview of data sources used, please see annex.

- Results are communicated in EUR 2021 prices.

- The scope is determined in cooperation with FDP. Various impacts and value chain steps are not included due to assessed materiality and limited resources. The analysis is executed in line with the True Price Method, which provides a scientific, well-developed and widely supported method to calculate true prices.

Why diaper systems?

By taking a **systems perspective** the life cycle of the product is considered. This life cycle perspective is especially important for diaper systems, where the highest impacts of reusable diapers occur not in manufacturing but in the use phase, while for single-use diapers, the design of the diaper (the weight and its materials) along with its management at end-of-life are the important life cycle stages.

* This functional unit allows us to make equivalent comparisons between the different diaper systems. While the impact of producing 1 diaper, or the impact of washing the diapers after a certain number of changes are building elements of the diaper system, the overall impact of all diapers produced, consumed and disposed up until the child gets toilet trained and out of diapers can better represent the overall life cycle of diaper systems.

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APPROACH SCOPE - DEFINE THE PRODUCT

The analysis covers 3 diaper systems, including their raw materials.*

Single use conventional diapers

• Virgin cellulose fluff	27,7%
• Polypropylene	11,6%
• Sodium Polyacrylate	35,5%
• Polyester	2,8%
• Polyethylene	13,9%

Single use biopolymer diapers

• Virgin cellulose fluff	27,7%
• Polypropylene	11,6%
• Sodium Polyacrylate	35,5%
• Polyester	2,8%
• Polylactic Acid (PLA)	13,9%

Reusable cloth diapers

• Viscose (inlay)	1%
• Cotton	29%
• Bamboo	37%
• Polyester	33%

Single use conventional diaper sizes

- Single use diapers come in different sizes, depending on the age of the child. Each diaper size has a different weight.

Product	Size	Weight (g)
New-born	1	19,1
Mini	2	22,7
Midi	3	27,4
Maxi	4	32,3
Junior	5	35

Reusable diaper sizes

- For reusable diapers one size fits all, except for the new-born phase (first 3 months). Cloth diapers are consumed together with inlays.

Product	Weight (g)
New-born	162,6
Regular	232,3

Reusable diaper systems in this analysis

- Reusable cloth diapers can be consumed **in combination with single use diapers**. This can be the case for new-borns up to 3 months old, where the high number of diaper changes per day might prevent parents to use cloth diapers. Combining cloth and single use diapers, allows for a transition towards full time use of cloth diapers as well.
- **FDP** has created an **approach for sustainable diaper use.** FDP's approach includes a combination of bio-based disposable diapers and washable diapers. And when the child is ready, they help with pedagogically responsible toilet training. The present analysis approaches reusable diaper systems by accounting single use bio based diaper consumption in the majority of the scenarios.

*The materials under scope cover 92% of singe use diapers. Adhesives and elastic cuff materials are left out of scope. Raw materials are sourced from Europe. Exceptions: Virgin cellulose fluff for single-use diapers (N. America), Bamboo & cotton for reusable diapers (Asia). All relevant data were provided by FDP.

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APPROACH SCOPE - PRODUCT LIFECYCLE

The analysis covers 3 value chain phases. The total lifecycle of the diapers under scope is briefly described in this section.

Raw materials production & diaper manufacturing	Use (at home)	Waste treatment

Lifecycle of single use diapers

- The value chain commences with the procurement of **raw materials** of the different diaper types (conventional and bio based). The raw materials are transported within or to Europe where the diapers are **manufactured.** The diapers are then transported to the Netherlands.
- Since diapers are generally a private consumer good, they are typically sold by (online) retailers, supermarkets and drugstores to households.
- Once the diapers have been used by the child, they are disposed of in the residual garbage bin. A waste collection company is responsible for collecting the garbage from the streets. 99% of the diaper waste is transported to the Waste Incineration Plant where **incineration** occurs. The rest of the diaper waste is collected separately and transported to the ARN plant, where the **recycling** process of *Thermal Pressure Hydrolysis* takes place. By-products of the 2 waste treatment options include electricity, heat and recycled plastic material.

Lifecycle of reusable diapers

- The value chain commences with the procurement of **raw materials** of the cloth diaper. The raw materials are transported within Asia where the diapers are **manufactured.** The diapers are then transported to the Netherlands.
- Since diapers are generally a private consumer good, they are typically sold by (online) retailers, supermarkets and drugstores to households.
- Once the diapers, together with the inlays, have been used by the child, they are collected in a diaper basket. Diapers are typically **washed** every 2 -3 days to avoid piling of diapers in the diaper basket & stains. The water from the washing machine gets treated in a **wastewater treatment** plant. Inlays are washed together with diapers for "urine" changes, and they get discarded in residual garbage bin for "feces" changes. Inlays can be washed up to four times until they are discarded. Discarded inlays are collected and transported to the Waste Incineration Plant where **incineration** occurs. The cloth diapers can be re-used by other children after toilet training*.

* The disposal of the cloth diapers is left out of scope. This follows other LCA reports on diapers such as: *An updated lifecycle assessment study for disposable and reusable nappies* (Environmental Agency, 2008

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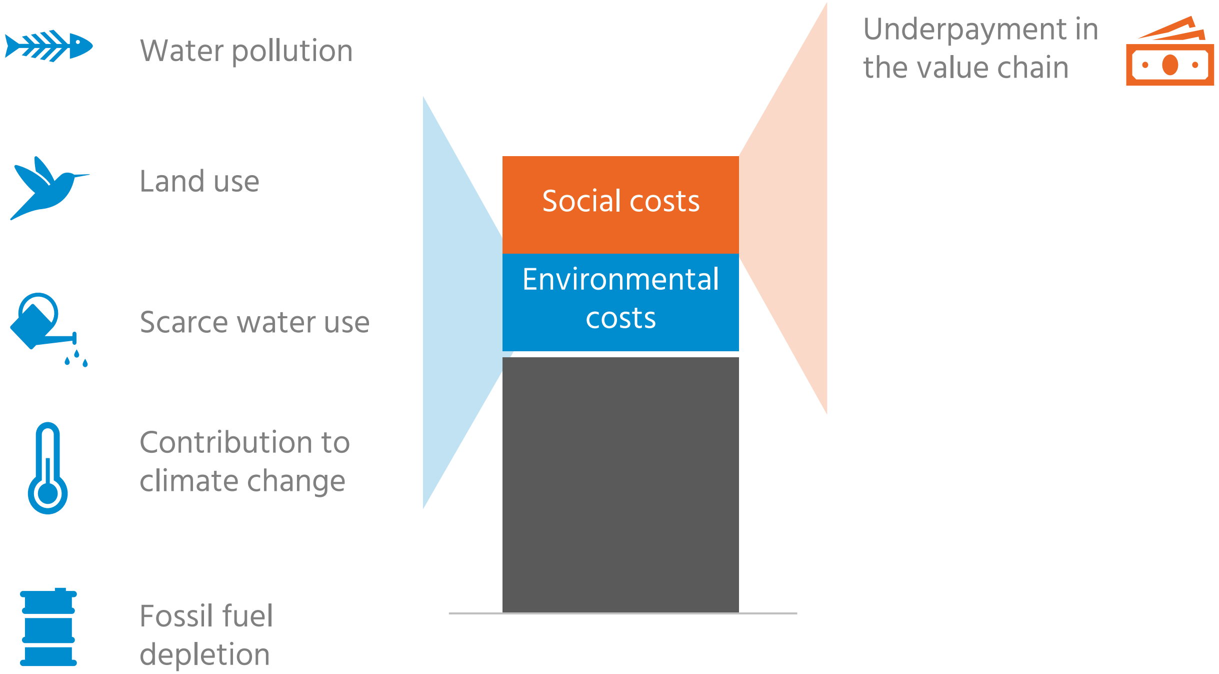
APPROACH SCOPE - DETERMINE IMPACTS

The True Price method covers a variety of environmental and social impacts connected to a consumer product. This analysis takes into account 6 material impacts.



Selection of impacts

- A materiality assessment was performed to help determine the impacts in scope for the current true price study.
- A materiality assessment is an evaluation of which impacts are relevant per phase of a product's lifecycle. Any activity in any lifecycle phase that causes, contributes to, or is directly linked to one of the true price impacts is a reason to consider an impact material for the specific lifecycle phase*.
- Secondary data sources** on sustainability of different diaper types were used to identify the most material impacts that cover all three diaper systems. In addition to secondary sources, impacts that are relevant to specific raw materials of the cloth diapers were evaluated and selected. Underpayment in the value chain in relation to cotton production is such an impact. Underpayment is estimated only at the raw materials phase.
- Please see the annex for the definitions of the impacts and the results, sources and process of the materiality assessments.

* https://www.globalreporting.org/how-to-use-the-gri-standards/resource-center

**Sources include: 1. *An updated lifecycle assessment study for disposable and reusable nappies* (Environmental Agency, 2008). 2. *Single-use nappies and their alternatives: Recommendations from Life Cycle Assessments* (UNEP, 2021), 3. *Life Cycle Assessment: Reusable and disposable nappies in Australia* (O'Brien et al. 2009)

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APPROACH MEASURE AND VALUE

The true price gaps of the diaper systems are calculated by quantifying and monetizing the impacts.

- A true price gap is calculated by quantifying and monetizing the size of the impacts. Quantification of the impact means that the footprint per impact* per functional unit is estimated.
- As a next step, these footprints are monetized. Monetization means that the value of the impacts is expressed in a monetary unit (euro) by determining the cost of remediation. Remediation consists of repairing and compensating damage to people and the environment, preventing future damage and (possibly) giving a fine for violations of laws and regulations.**
- The true price gaps calculations of the diaper systems are divided into 3 parts:
- **First**: the true price gap for the production of raw materials & manufacturing of the diaper is calculated (€/kg raw material, €/kg diaper, €/diaper***).
- **Second**: the true price gap for the use phase of the diapers is calculated based on the first part (€/toilet trained child).
- **Third**: the true price gap for the waste management phase is calculated and added (€/toilet trained child). Benefits connected to the different management options (incineration and recycling) are not subtracted from the total TP gap (see results for further explanation).
- Together, these true price gaps, expressed in €/toilet trained child, make up the true price gap per diaper system.
- This method is used for the different scenarios that are developed to analyze how the diaper industry can work towards minimization of their external cost.

Impact

↓

Quantification

↓

Monetization

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* Footprint indicators are used to quantify each impact. See annex for an overview of all indicators covered in this assessment.
** More information can be found at: https://trueprice.org/monetisation-factors-for-true-pricing/.
*** True price gaps vary per diaper size. These differences are captured by converting €/kg diaper to €/diaper.

APPROACH INTRODUCTION TO SCENARIOS UNDER SCOPE

The analysis investigates different scenarios to identify opportunities to minimize the external costs of diapers.

- There are 3 main types of scenarios included in this analysis.

i. A baseline scenario
ii. User scenarios
iii. Waste management scenarios

- The elements that determine these scenarios are

1. The total period that diapers are used until toilet training
2. The number, type and sizes of disposable diapers consumed
3. The number and size of reusable diapers consumed
4. The way that cloth diapers are washed and dried
5. The way that disposable diapers are treated after they are discarded.

- Each scenario answers different questions regarding the sustainability of diaper systems. In the baseline scenario the main research question is answered: *Which diaper system has the lowest True Price gap?*

- Consumer use scenarios give insights to questions such as: *What is the impact of only using reusable diapers? What is the impact of timely toilet training per child? What is the impact of the FDP approach for sustainable diaper use? What is the impact of different washing and drying methods?*

- Waste management scenarios investigate the question: *What is the impact of increased recycling?*

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APPROACH BASELINE SCENARIO

FDP & True Price have developed a baseline to gain grip on the impact of the use and end of life phases of the diaper systems.

Baseline scenario

- **Total period of diaper use – until toilet trained**: first 3,5 years of kids. Different sizes of diapers (including increase in weights) are taken into account.
- **Single use diaper systems**:
- Single use diapers are used for 3,5 years (for biobased and conventional).
- **Reusable diaper systems:**
- Biobased single use diapers are used for the first 3 months, 24 regular cloth diapers are used until 3,5 years old.
- Washing: 60º C degrees (+ pre-wash), line drying.
- **Waste management**: 99% of single use diapers are incinerated, 1% are recycled. Inlays for cloth diapers are washed with diapers and incinerated when discarded.

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APPROACH SCENARIOS FOR DIAPER SYSTEMS

FDP & True Price have developed several (user) scenarios to gain insights into potential improvements.

User scenario 1: full-time cloth diapers

- **Single use diaper systems**:
- Same as baseline.
- **Reusable diaper systems:**
- 24 newborn cloth diapers are used for first 3 months, 24 regular cloth diapers are used until 3,5 years old.

User scenario 2: timely toilet training

- **Single use diaper systems**:
- Diapers are used for 2,5 years.
- **Reusable diaper systems:**
- Biobased single use diapers are used for the first 3 months, 24 regular cloth diapers are used until 2,5 years old.

User scenario 3: FDP approach for sustainable diaper use

- **Single use diaper systems**:
- Same as baseline.
- **Reusable diaper systems:**
- Biobased single use diapers are used for first 3 months, 6 regular cloth diapers are used parttime (2 days per week) until 2,5 years old.

User scenario 4: washing & drying

- **Single use diaper systems**:
- Same as baseline.
- **Reusable diaper systems:**
- Same as baseline (for number, types & size of diapers)
- Washing in 40 & 90 degrees (including pre-wash) with line drying.
- Washing in 60 degrees, with tumble drying for half of the washes.

Waste management scenario

- **Single use diaper systems**:
- Incineration of single use diapers decreases while recycling increases (up to 50%).
- **Reusable diaper systems:**
- Same as baseline
- Incineration of single use diapers (and inlay) decreases while recycling increases (up to 50%)

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APPROACH LIFE CYCLE ASSESSMENT

The analysis is based on Life Cycle Assessment (LCA) of the different value chain steps that are under scope.

- **Life Cycle Assessment (LCA)** is an established scientific field that deals with the quantification of impacts at the product level, mainly for environmental impacts, but to some extent also for social ones.

- A true price assessment builds on LCA to quantify (a part of) the impacts included in the true price, following an established approach. Data from **Life Cycle Inventory (LCI)** Analysis serve as a valuable source of secondary data for a true price assessment.

- This is the case for the present study as well. LCA secondary data are used to quantify the different footprints of each environmental impact. The footprints per impact are:

i. **Contribution to climate change**: Greenhouse gas emissions

ii. **Scarce water use**: Scarce blue water use

iii. **Land use**: Land occupation

iv. **Water pollution**: Freshwater ecotoxicity, Marine ecotoxicity, Freshwater eutrophication, Marine eutrophication

v. **Fossil fuel depletion**: Fossil fuel depletion

- The impacts in scope are based on **life cycle impact assessment (LCIA),** a method to translate a variety of environmental indicators to impact scores across the life cycle of a product or process. All impacts in scope are based on the **ReCiPe 2016 LCIA** method.

- However, there are some changes that are made to the ReCiPe impact list to facilitate monetization of these impacts.

- For the footprint indicator *land occupation*, further process data are collected and applied to the LCIA results. Namely, the share of biome cover in the area where diapers (and their raw materials) are produced, consumed and wasted, is approximated by using OECD land cover data. Additionally, the biodiversity loss coefficient (1-MSA) (loss of Mean Species Abundance) is taken from the University of Cambridge Institute for Sustainability Leadership*.

- For the footprint indicator *scarce blue water use*, the LCIA results are adjusted for local water scarcity, by using WWF scarcity factors.

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* https://www.cisl.cam.ac.uk/resources/natural-resource-security-publications/measuring-business-impacts-on-nature

APPROACH KEY INPUT DATA (1)

Input data for the manufacturing, use and waste treatment of the different diaper systems are listed below, with relevant sources.

- **Energy use for diaper manufacturing**

The quantity of electricity and natural gas required to manufacture single use and reusable diapers is based on a LCA report on disposable and reusable diapers in the UK*.

- **Number of diaper changes**

The number of diapers changes per day for the different age phases until toilet training is provided by FDP, using ABENA as a source.

Starting age (month)	0	1	3	6	13	35
Singe –use size	Newborn	Mini	Midi	Maxi	Maxi+	Junior
Reusable size	Newborn	Newborn	Regular	Regular	Regular	Regular
Changes per day	10	8	7	6	4	3
Diapers used	300	480	630	1278	2680	600

- **Number of washes for cloth diapers**

It's recommended to wash the diapers every 2-3 days to avoid piling of diapers in the diaper basket & stains. Therefore, the frequency of washing diapers is every 2 days. An average of 10 diapers per wash throughout the time period that reusable diapers are used is taken.

- **Washing machine performance & associated electricity & water use**

A base case of household washing machines that reflects an average EU product is selected for this analysis. This base case represents washing machines with a rated nominal rated capacity of 7 kg and an A energy label*.

- **Excreta:**

When single use diapers are disposed the organic material (excreta) follows the waste stream of the diaper. 67,5% of the used diaper is organic waste**. For disposal of inlays, 10% of the organic material follows the waste stream of the inlay itself, while the rest follows the water disposal from the washing machine.

*Energy label according to 2021 scale. In the original source from 2017 the energy label corresponds to A++ or A+++ (https://op.europa.eu/en/publication-detail/-/publication/533fa096-d971-11e7-a506-01aa75ed71a1/language-en)
**https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/291130/scho0808boir-e-e.pdf

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APPROACH KEY INPUT DATA (2)

Input data for the manufacturing, use and waste treatment of the different diaper systems are listed below, with relevant sources.

- **Electricity:**

For electricity consumption in manufacturing, washing or any other relevant processes related to the diaper systems, secondary data on the average mix of countries are used. For household electricity consumption in the Netherlands this corresponds to 37% natural gas, 25% coal, 12% wind, 6% PV, 6% nuclear, 14% other*.

- **Incineration & recycling:**

For the processes of incineration and recycling for single use diapers, input data are adapted from an LCA report* that investigates these activities for the Dutch context. The recycling process of ARN is modelled. Avoided primary energy and material production resulting from these waste treatment processes follow this study as well.

- **Biogenic carbon in PLA**

Accounting for the effect of biogenic carbon in the biobased polymer –PLA used for single use diapers is not straightforward. Biogenic carbon lowers the impact of contribution to climate change. Carbon is sequestered when maize (input material for PLA production) is cultivated. This carbon is fixed*** in the PLA product until it reaches it's end of life. When the product is incinerated the fixed carbon gets released back to the environment. However, this carbon has a much lower impact than fossil-based products, because the carbon released as CO2 is biogenic. When recycling is implemented, the fixed carbon is assumed to remain in the product after it's primary life cycle. The carbon sequestered & fixed in the product reduces the total CO2 emissions released. This is a simplification of reality, since the material will not be recycled forever, and the sequestered carbon will be released to the environment later on.

*Electricity supply mix provided to Dutch households is based on EcoInvent data.
** https://www.vanluiernaargrondstof.nl/publicaties/2021-02-24-vergelijkende-mlca-luier-afvalverwerking-herzien.pdf
***The carbon fixed in the PLA product corresponds to 1.833 kg CO2 / kg PLA; calculated from the theoretical C content in the polymer.
https://www.ifeu.de/fileadmin/uploads/oekobilanzen/pdf/LCA%20zu%20PLA%20erstellt%20fuer%20NatureWorks%20(Okt%202006).pdf

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APPROACH MAIN DATA SOURCES

EcoInvent is used as the main LCA data source for all environmental impacts. The Global Impact Database is used to estimate the impact of underpayment in the production phase.

EcoInvent database

For the quantification of the footprint indicators of environmental impacts, secondary data from the EcoInvent database (version 3.7.1) are used for the majority of the processes. The EcoInvent LCI database is considered to be the most comprehensive and reliable LCI database in Europe and includes a comprehensive accounting of emissions emitted and resources consumed in the entire life cycle of many products and processes. Footprints calculated based on EcoInvent relate to the production of most raw materials, the energy consumption for manufacturing of the diapers, the electricity and water consumption and wastewater treatment for washing the diapers, the incineration of all materials and excreta of discarded diapers, the energy and material inputs of the different recycling steps, as well as the avoided energy and materials connected to these waste treatment processes.

Idemat Database

For the quantification of the footprint of bamboo cultivation the Idemat database (2022 version) is utilized. Idemat is a compilation of LCI data of the Sustainable Impact Metrics Foundation (SIMF), a non-profit spin-off of the Delft University of Technology.

Global Impact Database

The data source used for the impact of Underpayment in the value chain, related to the production of all raw materials of diapers, is the Global Impact Database, developed by Impact Institute. It contains country-sector combination monetized values, per euro of production of the sector. This impact covers both the impact of the sector and the impact of the entire value chain before it. In order to convert the impact per euro of production into impact per kilogram, the impacts per euro of production are multiplied by the average prices of each sector in the relevant country or region.

True Price Monetization Factors

Monetization factors are the monetary values that are used to price the social damage caused by CO2 emissions, water use, land use and underpayment, among other things. They include the costs of remedying the damage, which consists of repairing, compensating, preventing and/or retributing. The monetization factors form the backbone of the True Price Method and are the driving force behind studies such as the UN Food Systems Summit's The True Cost and True Price of Food report and the Rockefeller Foundation's True Cost of Food report.

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APPROACH LIMITATIONS

We advice all readers to take into account the following limitations while reading and using the results in the report.

- Due to limitations in resources and data, choices and assumptions had to be made. These have been discussed with and signed-off by the client.
- To have clear and consistent communication and prevent misunderstandings and/or wrong expectations among stakeholders, it is advised to communicate the results (externally) with caution and restraint. This implies that it clearly states that the results reflect true price gaps with a limited scope. The following limitations should be considered:

Scope

- **Impacts**: not all True Price impacts are included. The addition of more impacts, like air pollution, could provide further insights.
- **Lifecycle steps**: several lifecycle steps, such as retail, waste collection and separation and transport, are not included in the analysis.
- **Materials**: several materials (which make up a small proportion in the diapers), such as adhesives and elastic cuff materials in single use diapers, are left out of scope.
- **Other**: the impact of detergent use for washing of the diapers is left out of scope.

Data

- Due to data limitations, sector data are used for the impact of underpayment in the value chain. This data represents the sector averages for the different raw materials per country of origin (i.e. cotton from India). Also see the previous page for more information on the data used.

How to interpret the results?

- The true price gap of diaper systems is complex and contains a substantial amount of variables. This required to make choices and assumptions, based on best available data and insights. These have been discussed with and signed-off by FDP.
- The results provide a solid indication for a material part of the true price gap of the diaper systems. They provide valuable insights for multiple stakeholders and a starting point to start decreasing the environmental and social damage of the global diaper industry.
- We advice caution and restraint in communicating and using the results to prevent confusion, miscommunication and misinterpretation. They provide substantial, but not complete proof for claims regarding the sustainability of diapers systems, as this assessment has a limited scope and that – in the end – is dependent on a substantial set of indicators and variables.

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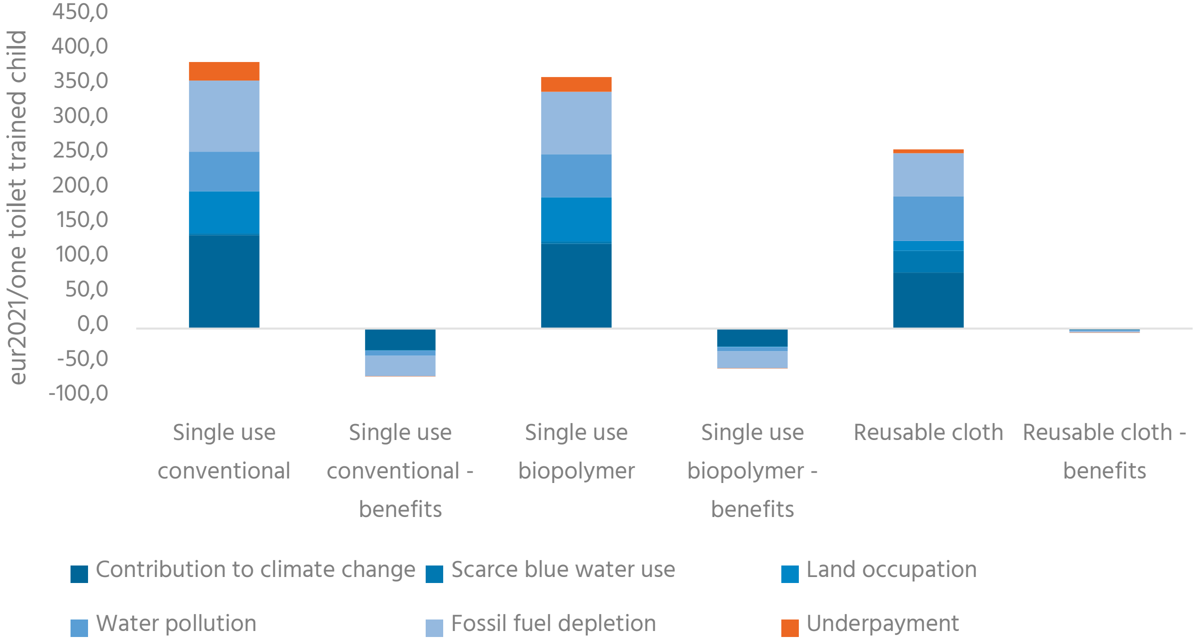
Results

04

RESULTS THE IMPACT PER TOILET TRAINED CHILD

Baseline scenario: Which diaper system has the lowest the true price gap?

- In the baseline scenario, we assess the true price gap of the three diaper systems. We also consider the benefits for society at large relating to the incineration and/or recycling of the diapers.
- The results indicate clear differences between the diaper systems. The true price gaps per toilet trained child per diaper system are (rounded):
  - Single use conventional: ~€380,-
  - Single use biopolymer: ~€360,-
  - Reusable cloth: ~€260,-
- The results indicate that reusable cloth diapers have the lowest true price gap, almost ~**32%** lower than single use conventional and ~**28%** lower than single use biopolymer diapers. The difference between single use conventional and biopolymer is **~5%**.
- The incineration of the waste is used for energy and heat production, which has benefits for society at large* (rounded):
  - Single use conventional: ~€70,-
  - Single use biopolymer: ~€60,-
  - Reusable cloth: ~€6,-



Baseline scenario
Single use diaper systems - Diapers are used for 3.5 years. Reusable diaper systems- Bio based single use diapers are used for the first 3 months, 24 regular cloth diapers are used until 3.5 years old. Washing: 60º C degrees (+ pre-wash), line drying. Waste management- 99% incineration, 1% recycling

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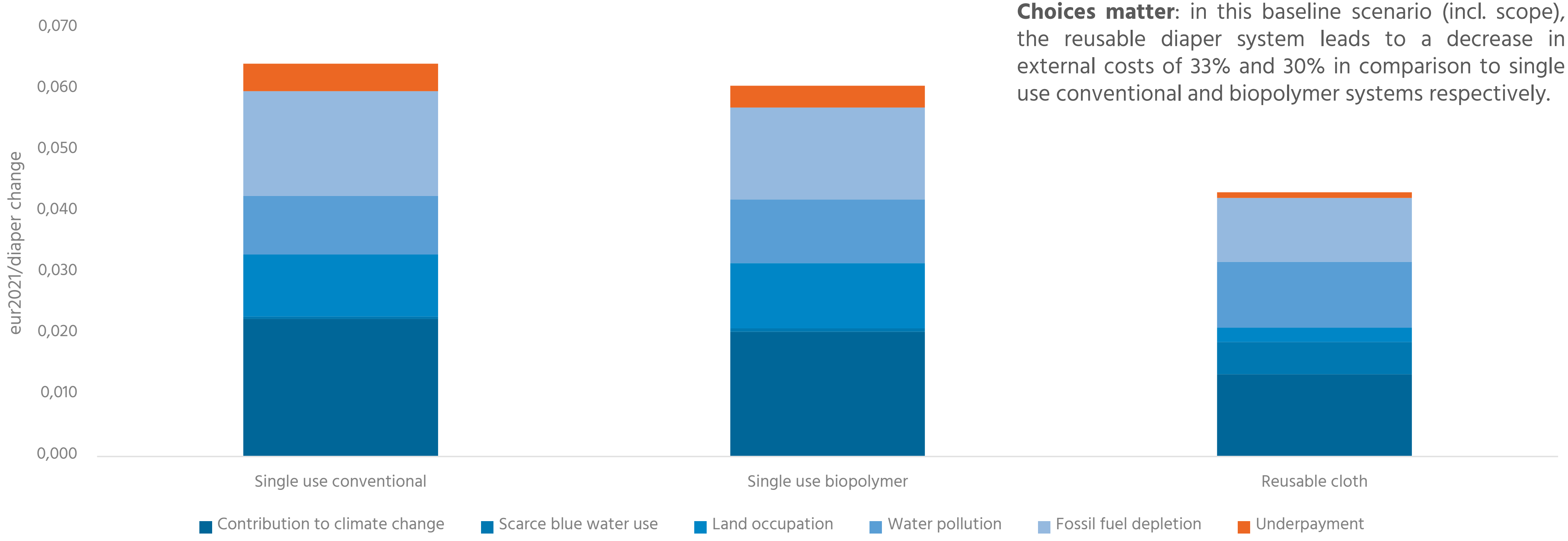
* The true price only takes into account negative impacts, which are directly related to the product. The positive benefits in this case are related to another stakeholder: society at large. For both reasons, they should not be included into (and netted against) the true price gap of the diaper systems.

RESULTS IMPACT PER DIAPER CHANGE

The true price gap per diaper change (EUR2021/diaper change).

Per diaper change, €0,043 - €0,064 of costs are externalized to society and future generations.

Choices matter: in this baseline scenario (incl. scope), the reusable diaper system leads to a decrease in external costs of 33% and 30% in comparison to single use conventional and biopolymer systems respectively.



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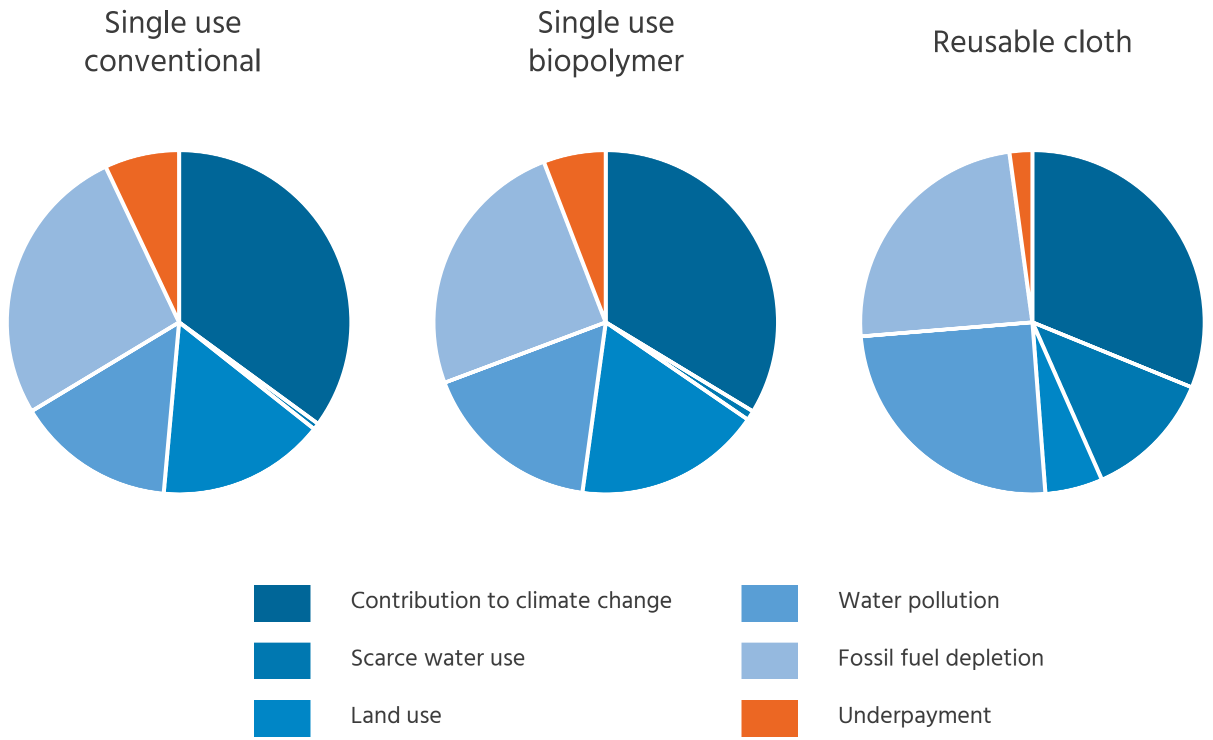
RESULTS BREAKDOWN OF TRUE PRICE GAP PER IMPACT

Baseline scenario: the true price gap per diaper system (EUR2021/toilet trained child).

- If we dive into the impacts, we find that for all diaper systems '**contribution to climate change**' is the biggest impact:
  - Single use conventional: 34%
  - Single use biopolymer: 33%
  - Reusable cloth: 31%
- For all diaper systems, the second biggest impact, responsible for about a quarter of the true price gap, is '**fossil fuel depletion**'.
- The impact **scarce water use** is relatively high for reusable cloth diapers (12%) compared to its alternatives (both 1%). This is related to the water needed to produce the diapers and the washing during the use phase.
- The results indicate that the social impact '**underpayment**' is relatively low for all diaper systems (7% for single use conventional, 6% for single use biopolymer, and 2% for reusable cloth).



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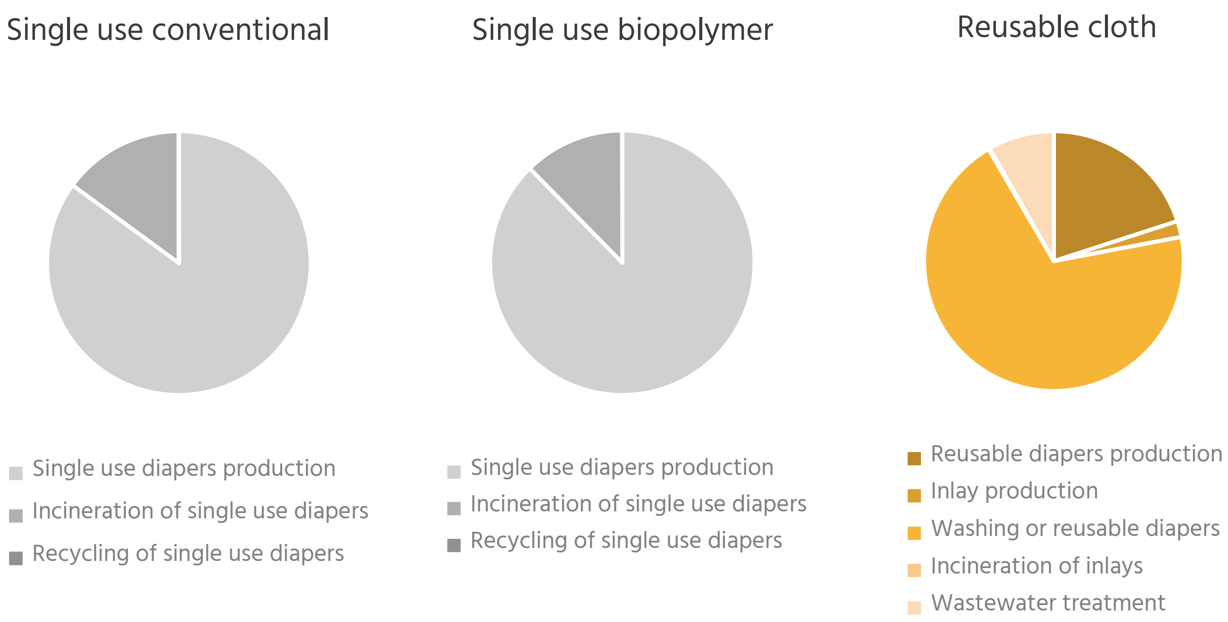
RESULTS IMPACT PER LIFE CYCLE PHASE

Baseline scenario: the true price gap per diaper system (EUR2021/toilet trained child).

- For single use diaper systems, most of the impact is linked to the production and consumption (85% for conventional and 88% for bio-based). The rest relates to the end-of-life phase.
- Fossil fuel depletion is the largest impact in this step, as the diapers contain plastics. For bio-based diapers this impact is 3% less than conventional diapers, due to the substitution of fossil fuels as raw material for PE (13.9% of the total diaper weight) with PLA produced from maize. The substitution of PE with PLA decreases the contribution to climate change during the waste treatment step by 7%. This is due to the fact that during incineration the carbon released into the atmosphere is biogenic.
- For reusable diaper systems, 61% of the total TP gap comes from the washing of the diapers, because of the consumption of water and electricity (from the grid) – 80% is related to electricity). Electricity consumption contributes mainly to climate change, fossil fuel depletion and water pollution (water used in electricity facilities often is discarded in high temperatures to aquatic environments disturbing the local biodiversity).

Breakdown of total true price gap per diaper system per life-cycle phase



- Half of the scarce water use is connected to the water consumption from the washing machine. The other 50% comes from the production of the reusable diapers (related to cotton cultivation).

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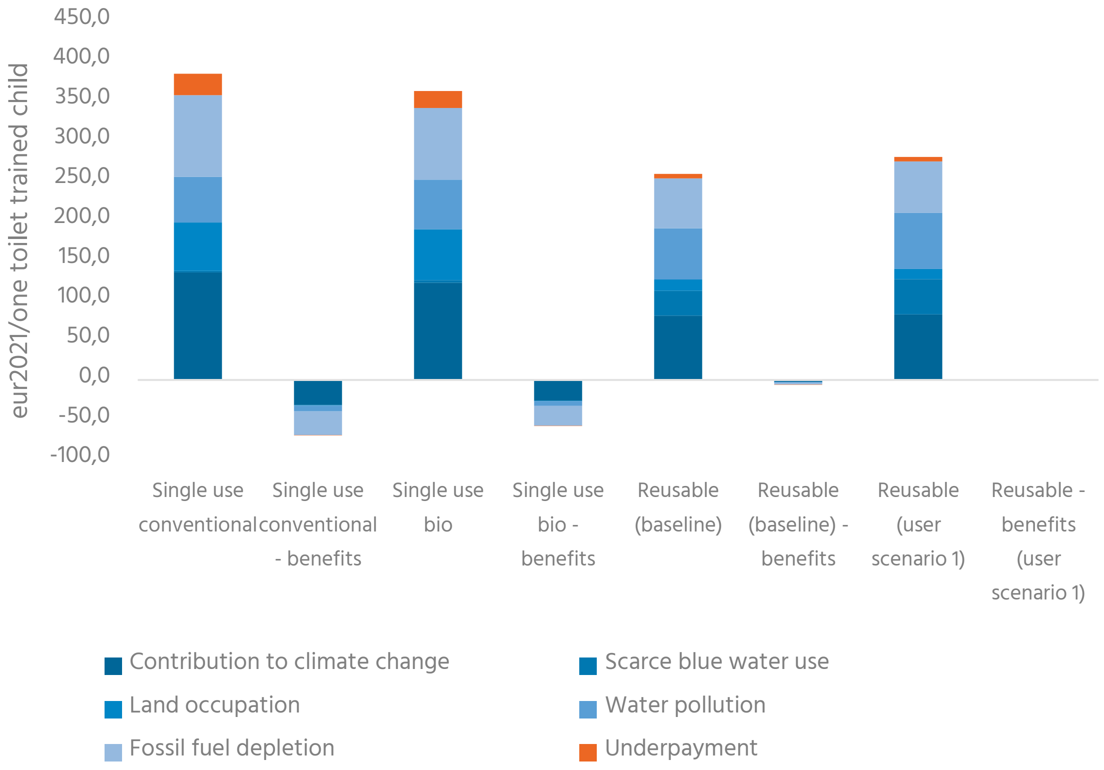
RESULTS THE IMPACT OF FULLTIME REUSABLE DIAPERS

Use scenario 1: what is the impact of only using reusable diapers?

- This scenario compares the baseline scenario to a situation in which only reusable diapers are used, including new-born diapers. The results indicate that this leads to more external costs.
- The true price gap of the reusable diaper system increases by 8%. However, it remains lower than both single use diaper systems. The impact of producing the cloth diapers for the first 3 months of diaper use is ~4% more than the impact of producing the necessary single use diapers for the same time period. However, the overall increase is mostly driven by the increase of washing and wastewater management by ~13%.
- This scenario decreases the share of contribution to climate change and fossil fuel depletion, due to the substitution of single use diapers production with cloth diapers. The overall contribution to climate change and fossil fuel depletion for producing diapers decrease ~15% and ~28%.
- On the other hand, the scarce water use share increases. This is mainly driven by the production of the cloth diapers (70%) (related to cotton production), rather than the washing phase (13%).



User scenario 1
Single use diaper systems - same as baseline. Reusable diaper systems -24 newborn cloth diapers are used for first 3 months, 24 regular cloth diapers are used until 3.5 years old Washing: 60º C degrees (+ pre-wash), line drying. Waste management- same as baseline

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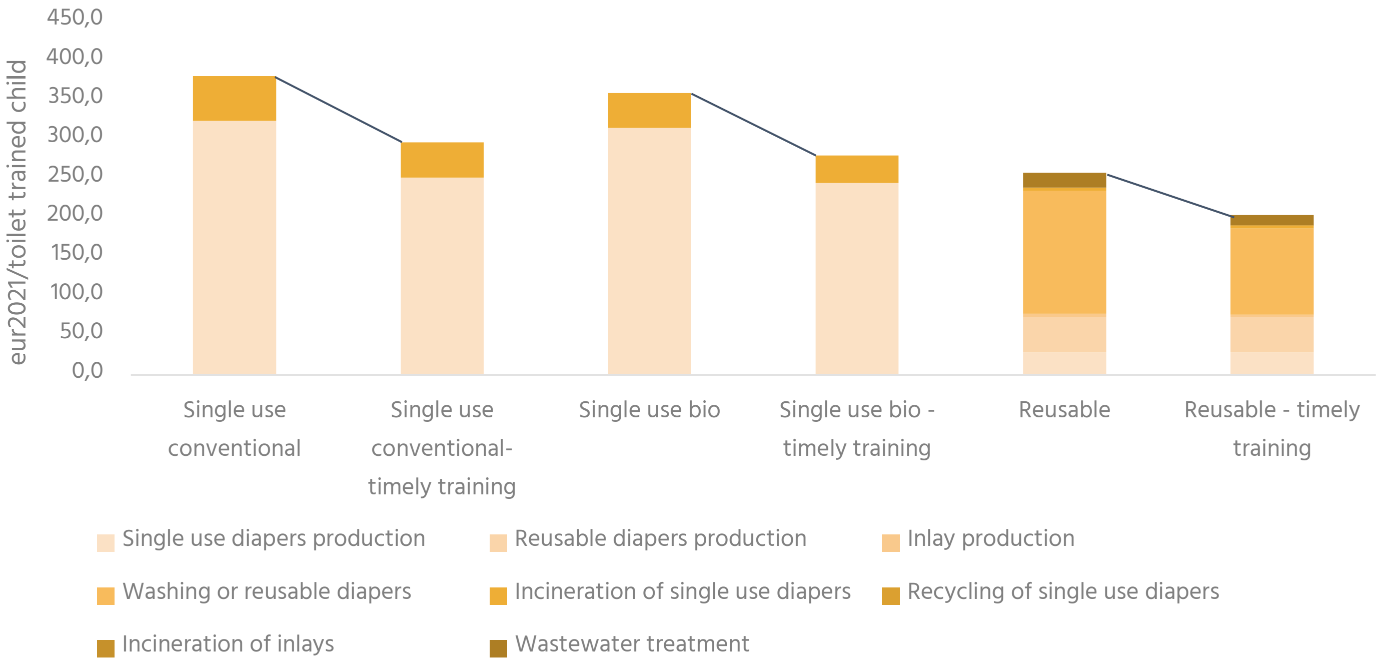
RESULTS THE IMPACT OF TIMELY TOILET TRAINING

Use scenario 2: what is the impact of timely toilet training per child?

- Toilet training has been identified as one of the most effective and tangible instruments to limit the negative impact of diapers by decreasing the number of diapers needed per child.
- In this scenario, we analyzed the effects of decreasing the time until a child is toilet trained per diaper system. Based on data from FDP, the analysis indicates that timely toilet training could lead to 2,5 years of diaper use (a decrease of 1 year, 1208 less diaper changes).
- This can lead to an overall ~22% reduction of the true price gap for single use diaper systems. For reusable diaper systems, the overall reduction is estimated to be ~21%, while the impact of washing the diapers and wastewater treatment can be reduced up to ~30%.
- It indicates that toilet training is an effective instrument to reduce the negative impact of diaper systems.



User scenario 2
Single use diaper systems - Diapers are used for 2,5 years. Reusable diaper systems- Bio based single use diapers are used for the first 3 months, 24 regular cloth diapers are used until 2,5 years old. Washing: 60º C degrees (+ pre-wash), line drying. Waste management- 99% incineration, 1% recycling

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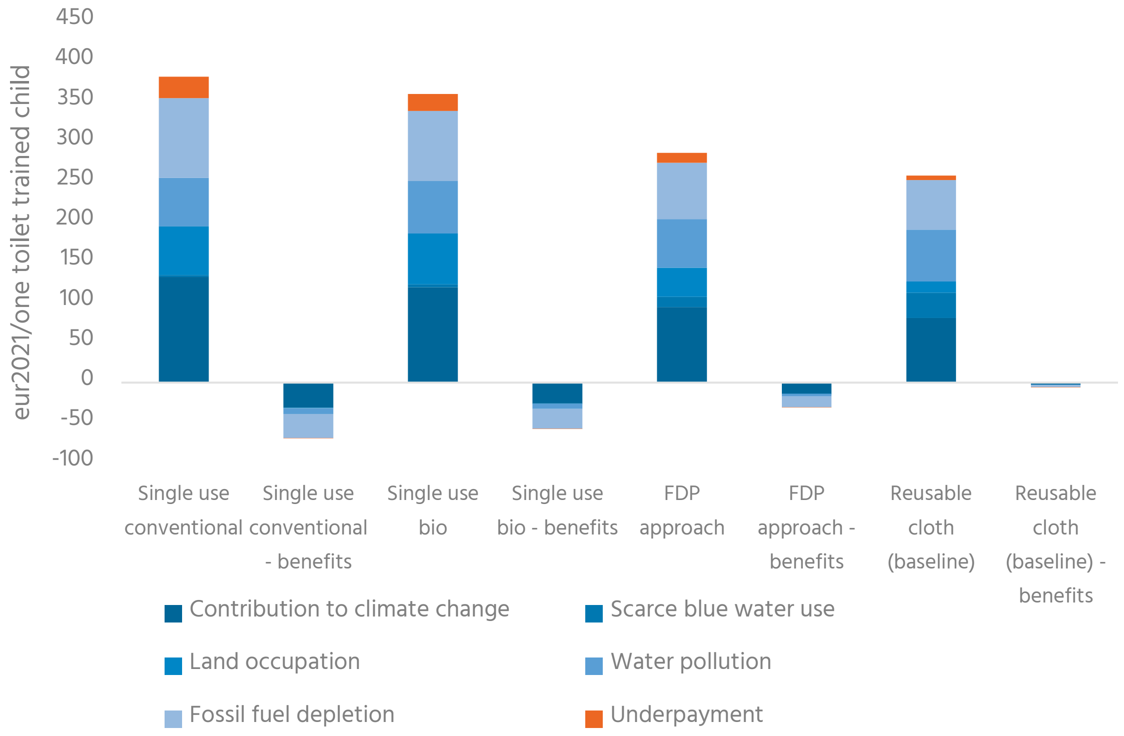
RESULTS THE IMPACT OF FDP'S APPROACH ON SUSTAINABLE DIAPER USE

Use scenario 3: what is the impact of the FDP approach for sustainable diaper use?



User scenario 3
Single use diaper systems - Diapers are used for 3,5 years. Reusable diaper systems- Bio based single use diapers are used first 3 months, 24 regular cloth diapers are used until 3,5 years old. FDP approach- Bio single use diapers are used first 3 months; 6 regular cloth diapers are used parttime (2 days per week) until 2,5 years old. Washing: 60º C degrees (+ pre-wash), line drying. Waste management- 99% incineration, 1% recycling.

- In this scenario, we analyse the differences between the baseline scenario and the FDP approach for sustainable diaper use, in which biopolymer single use diapers are used for first 3 months and 6 regular cloth diapers are used parttime (2 days per week) until 2,5 years old.
- The overall true price gap increases by 11% in relation to reusable diaper systems in the baseline scenario, but it remains lower than both single use diaper systems (~33% for conventional and ~26% for biobased).
- However, this includes the timely potty training. If we don't take into account the timely potty training for the FDP system, the true price gap increases by ~21%. The analysis finds that, then, the difference between the FDP service and single use diapers systems is smaller. Compared to conventional single use, the true price gap of the FDP service is ~5% lower. Compared to the biobased single use system, the true price gap is more or less similar (0,5% higher).
- In this (sub-)scenario, the true price gap of the reusable cloth diaper system is ~29% lower than the FDP service system.

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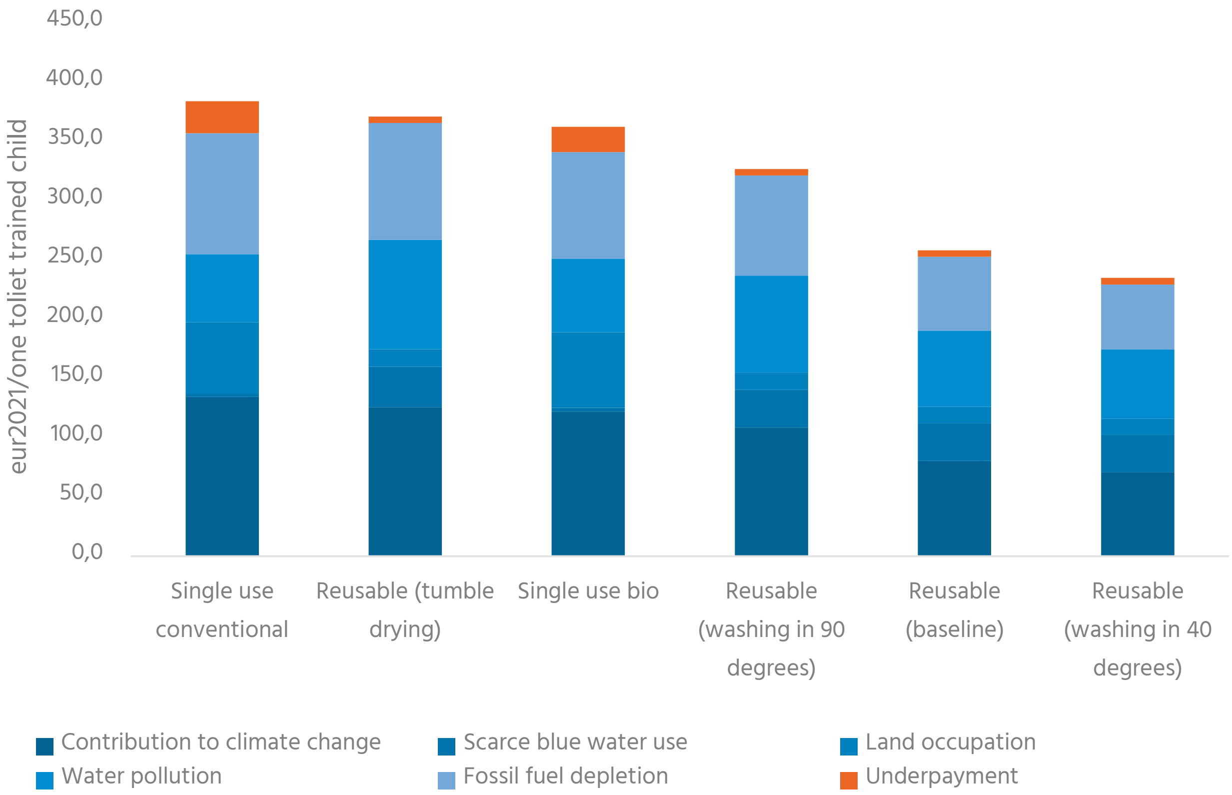
RESULTS THE IMPACT OF WASHING

Use scenario 4: what is the impact of different washing and drying methods?

- The way consumers wash and dry the reusable cloth diapers has a substantial effect on the true price gap of the system. In this scenario, we compare the true price gaps of the single use diapers in the baseline scenario, with 3 alternative washing & drying options:
- 1: tumble drying the reusable diapers
- 2: washing the reusable diapers on 90º C instead of 60º C
- 3: washing the reusable diapers on 40º C instead of 60º C
- Increasing the temperature or using tumble drying increases the true price gap of the reusable diaper system. But even if people wash the reusable diapers on a high temperature (90º C), the total gap stays lower than the single use diaper systems. If they decide to tumble dry the diapers, however, the true price gaps of the 3 diaper systems becomes almost equal.
- From an external cost perspective, it is better to wash the cloth diapers on 40 degrees and don't use tumble drying. This leads to a decrease in the true price gap by almost 10%.



User scenario 4
Single use diaper systems - same as baseline. Reusable diaper systems -24 newborn cloth diapers are used for first 3 months, 24 regular cloth diapers are used until 3.5 years old. 1. Washing in 40, 60 (baseline), 90º C degrees (including pre-wash) with line drying. 2. Washing in 60º C degrees, with tumble drying for half of the washes. Waste management- same as baseline

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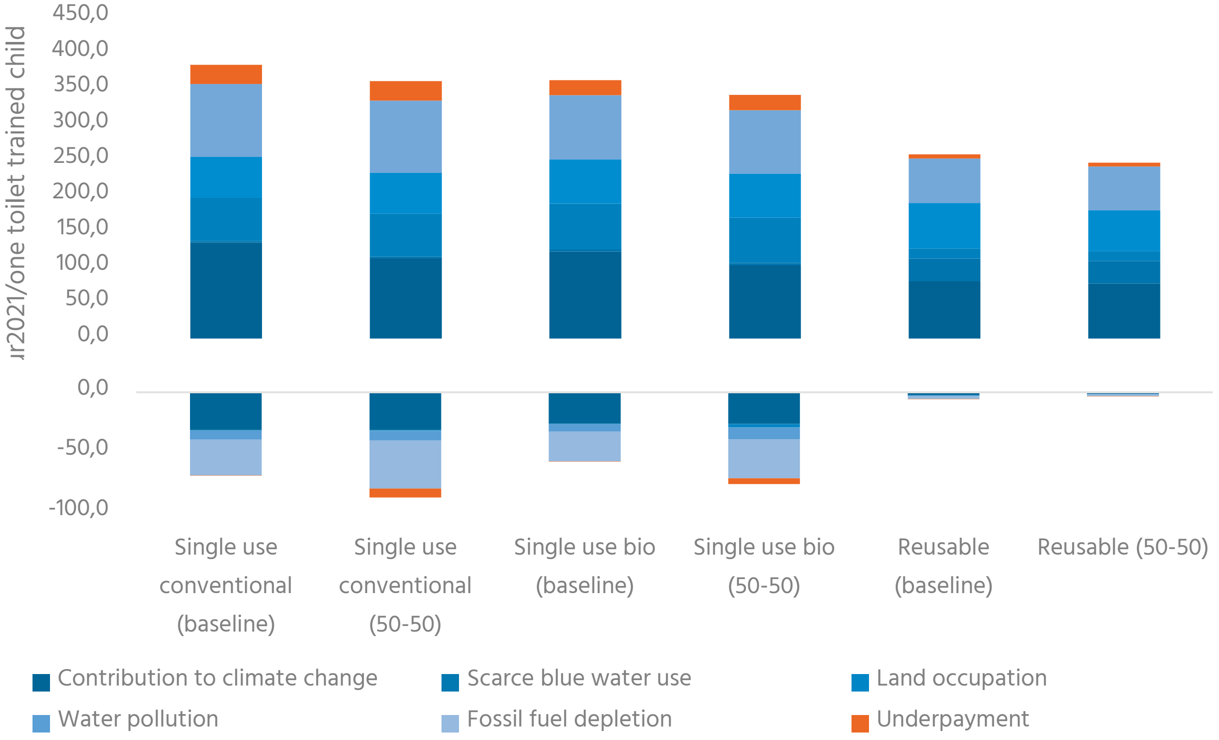
RESULTS THE IMPACT OF RECYCLING

Waste management scenario: what is the impact of increased recycling?

- Currently, almost all diapers (98%) in the Netherlands end in incineration plants. This leads to negative impacts, such as air pollution and climate change. However, the society at large simultaneously experiences some benefits, as the incineration is used to produce energy and heat. There are also several (promising) initiatives to recycle diapers.
- In this scenario, we assume that the recycling of diapers can be scaled up to 50%. We assess the effects on the true price gap of the diapers and the benefits of society at large.
- The analysis indicates that the true price gap decreases by ~6% in both conventional and bio single use diaper systems. For reusable diaper systems, the true price gap decreases by ~4%. This is mainly due to a decrease in CO_2-eq emissions, leading to a lower contribution to climate change.
- On the other hand, the benefits at the economy at large increase by ~26% for conventional and ~33% for biobased. This is mainly due to a decrease in the overall necessity for fossil fuels, as the recycled diapers can be used in new products.



Waste management scenario
Single use diaper systems - Diapers are used for 3.5 years. Reusable diaper systems- Bio based single use diapers are used for the first 3 months, 24 regular cloth diapers are used until 3.5 years old. Washing: 60º C degrees (+ pre-wash), line drying. Waste management- 50% incineration, 50% recycling (Baseline: 99% incineration, 1% recycling)

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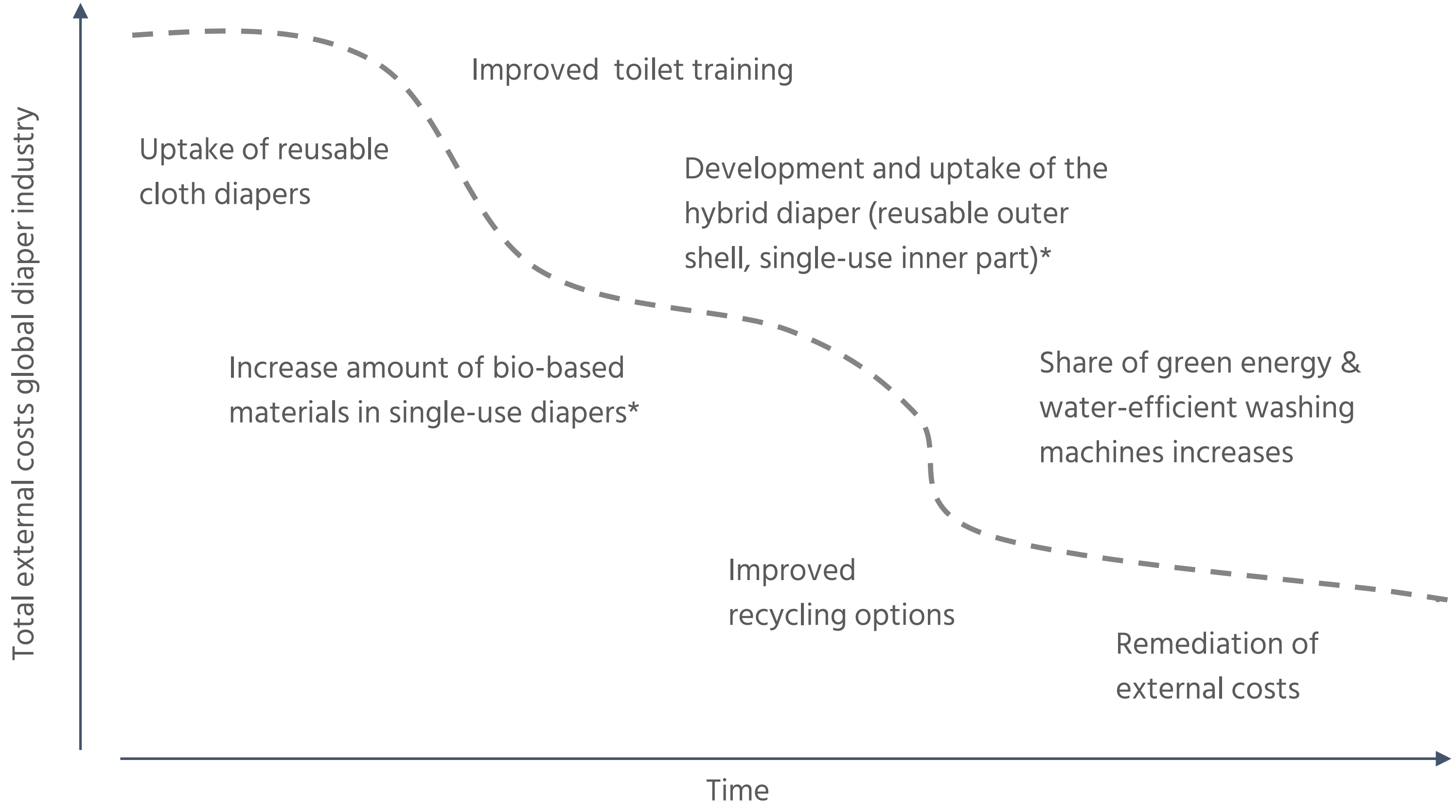
Next steps

05

NEXT STEPS TOWARDS A MORE SUSTAINABLE INDUSTRY

There are a number of interventions, innovations and products that are under development that could contribute to a more sustainable diaper industry, in which the strategic objectives of FDP fit.

Illustration of the roadmap for the diaper industry to lower their external costs through interventions, innovations, and actions.



Since the demand for diapers is expected to rise (due to increase in welfare in emerging economies), the challenge is to minimize the external costs per diaper and per toilet trained child. There are a number of interventions, innovations and new products which could contribute to lowering the external costs of the industry – showcased on the right. FDP has identified 3 strategic objectives that contribute to this end:

- Improve toilet training, ensuring that we need less diapers per child
- Increase use of reusable diapers, as they seem to have the lowest external costs
- Engage with brands and governments, to lower the external costs of production, use, and waste of diapers

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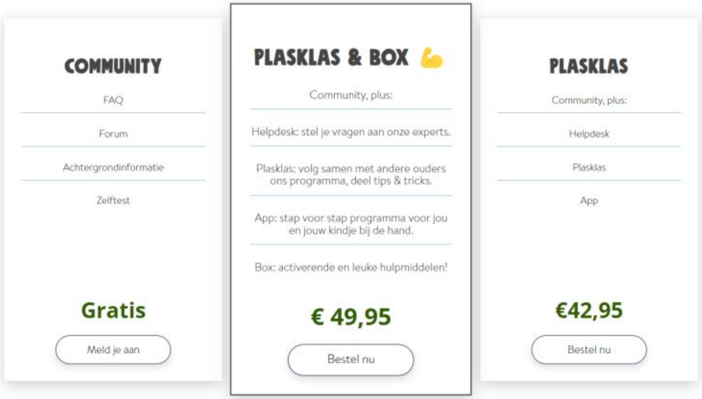
* The impact of these interventions and/or new products can be subject for future true price analyses.

NEXT STEPS **INSPIRE CONSUMERS**

Consumers can already make decisions to decrease the external costs of the diaper industry in at least 3 ways.

Timely toilet training

- Provide more guidance on the toilet training of children can decrease the time children need diapers substantially.
- The analysis indicates that a decrease of 1 year (from 3,5 to 2,5 years), can lead to a reduction of 11,5% in external costs.

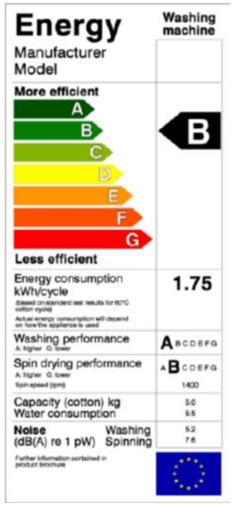


Inform about external costs

- The analysis indicates that reusable diaper systems have a 28% lower external costs than single use diaper systems.
- Informing parents about the impact they can have through their purchases (for example, on social media), incentivizes them to start make more sustainable choices.

Decrease energy use at home

- The way people wash reusable diapers has impact on its true price gap, as it accounts for over 60% of the total external costs. 80% of that is through the energy use of the washing machine. This is even more with tumble drying.
- Decreasing the amount of energy used (not tumble drying, lower temperatures, or washing machines with better energy labels, and using green energy) contributes to lower external costs.



- However, the impact can not be minimized to zero, since some energy will be needed and also ‘green’ energy has external costs.

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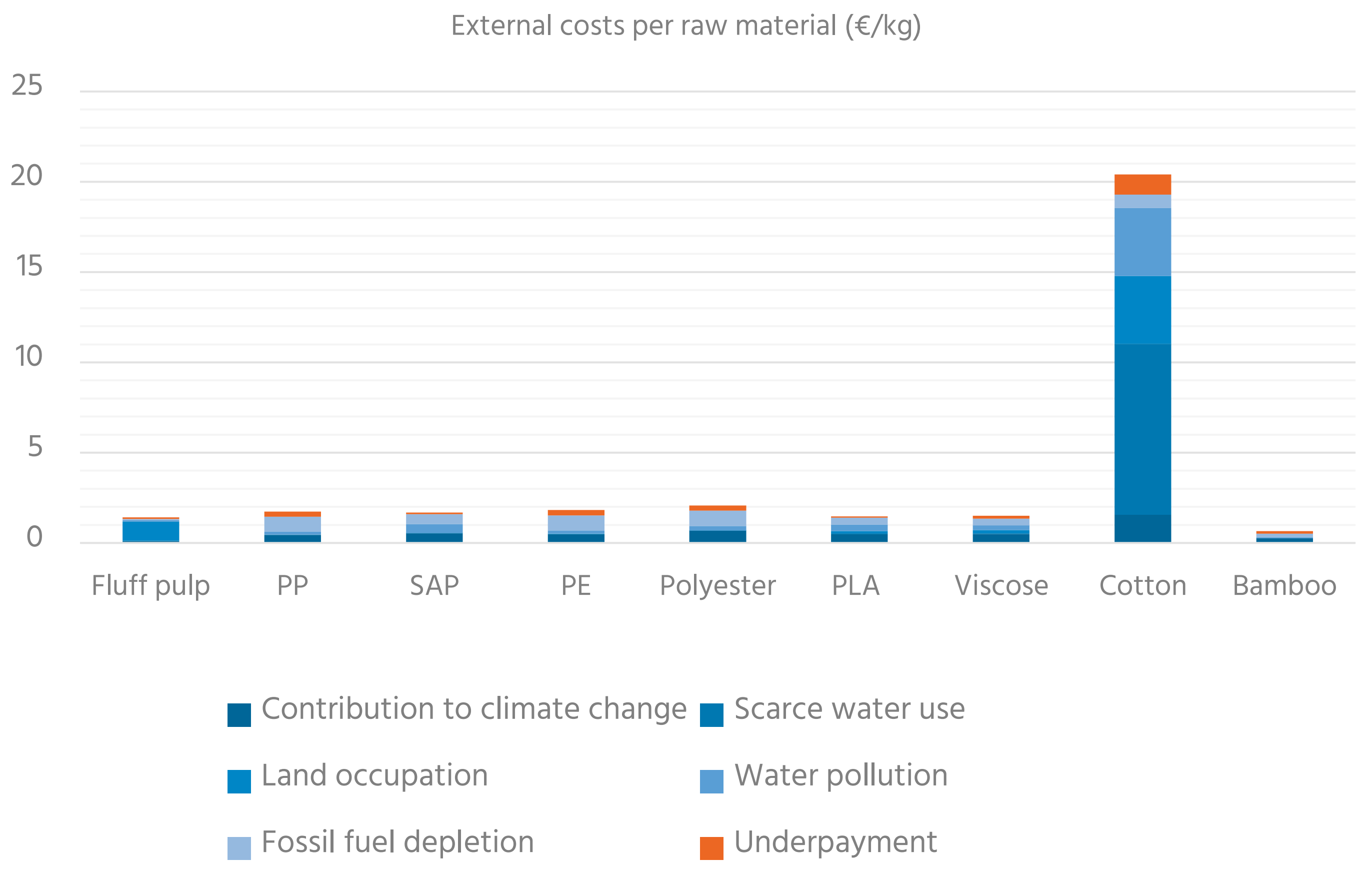
NEXT STEPS ENGAGE WITH PRODUCERS AND SUPPLIERS

Since the production of raw materials for diapers accounts for a substantial part of the external costs, it potentially is an effective place to decrease the external costs of the diaper industry.



- As discussed before, the production of the diapers takes a substantial share of the external costs of diaper systems. Producers and manufacturers have some control over their production facilities and the raw materials they use, for example through procurement and sourcing. Engaging with producers can help to decrease these external costs, through innovation, interventions, or more sustainable procurement.
- The remediation principles of true pricing can be taken into account in the strategy. For example, by starting to decrease the true price gap per kilogram of raw material, through preventing damage to nature (e.g. reduce water use) and society (e.g. start paying living wages and income). And identify options to restore or compensate damage that is unfeasible or economically inefficient to prevent (completely), such as certified reforestation projects to compensate CO2-emissions.

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NEXT STEPS ACCELERATE ACTION FROM POLICY MAKERS

Diaper waste imposes financial costs to society. Decreasing the amount of waste and better waste treatment could help lowering the external and community costs of the diaper industry.

Waste management

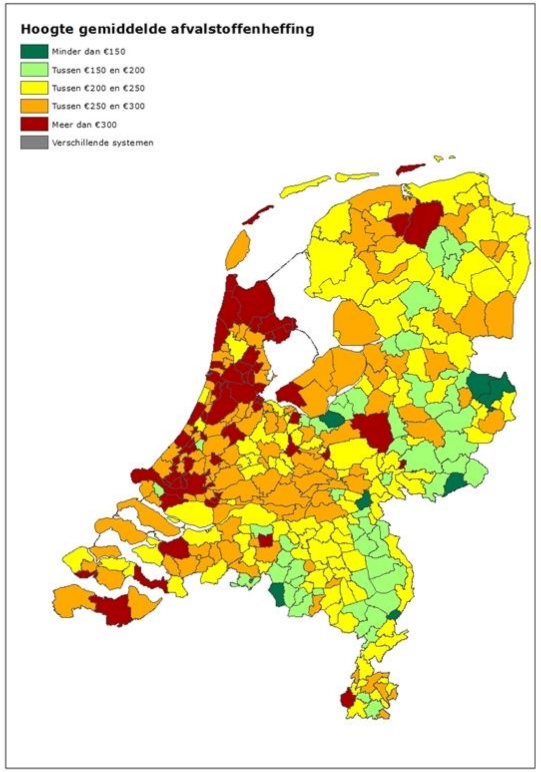
- The analysis indicates that recycling could have positive effects on the external costs of diaper systems. Transitioning from the current situation (98% incineration, 2% recycling) to more recycling (50%), leads to less external costs (4 – 6% for different systems) and higher external benefits for single use diapers (26% for conventional and 33% for biobased).
- Policy makers, among other stakeholders, have a key role in scaling up recycling of diapers, making it more efficient and effective, and lowering the barriers for consumers. There are several ways in which they can promote this:

1. By enabling more efficient and feasible diaper waste collection and distribution (for example, through diaper collection points in central spots in cities and towns).
2. By providing subsidies and other support to new and existing initiatives, projects, and companies working on recycling methods.

Community costs

- Currently, citizens pay substantial amounts per month to their municipality for waste management. Since diapers make up a substantial share of the total waste, it seems fair to assume that the community costs for diaper waste are substantial.
- Improved toilet training and an increased share of reusable diapers, would lead to less waste – and potentially lower community costs. Moreover, as a next step, FDP could look into the financial costs and benefits of scaling up the recycling of diapers. Potentially, decreasing the external costs of the diaper industry could go hand in hand with decreasing community costs for waste management.

Overview of the community costs per family per municipality in the Netherlands (in 2020).



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Annex

ANNEX - OVERVIEW

The annex contains the following items.

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About

A1

ANNEX ABOUT TRUE PRICE

True Price is a social enterprise from Amsterdam. Our mission is to realize sustainable products that are affordable for everyone by enabling consumers to see the true price of products they buy and pay voluntarily.

- True Price developed the first method worldwide to measure social and environmental costs in the value chain.
- The method includes external social and environmental impacts, such as underpayment, health and safety, greenhouse gas emissions, scarce water use and biodiversity.
- The method is based on international conventions (e.g. UN UVRM, UNGP's, ILO Fundamental Principles, OECD guidelines for MNE) as a normative basis.
- True Price has done more than 60 true pricing projects ranging from SMEs to multinationals and a variety of important products.
- True Price is based on the work of Impact Institute (spin-off of True Price), which is a member of the Circular Economy 100 program of the Ellen MacArthur Foundation.

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ANNEX ABOUT TRUE PRICING

The goal of true pricing is not to make products more expensive, but more sustainable

True Pricing is the calculation and improvement of the true price of products. The true price of a product is the conventional price including the external social and environmental costs.

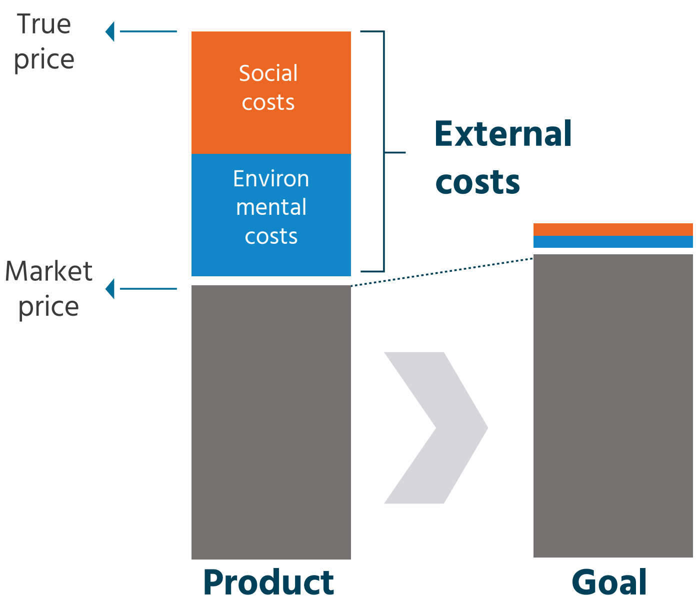
Calculating a true price consists of three phases:

1. Assessing the entire value chain of a product;
2. Mapping the violations of human, sustainability and labour rights in the value chain;
3. Calculating the cost to remedy these violations. The remediation costs are the sum of repairing, compensating, preventing and possibly fining the violations.

True price information can be used to improve (decrease) the true price of products, by:

1. Provide market players with insight into the place in the value chain and the extent of the costs. Based on this, parties can reduce external costs through innovation.
2. To offer more transparency to market players so that they choose the more sustainable alternative and that share grows.
3. To make consumers or other market parties pay the true price. The additional contribution will make it possible to repair the damage and reduce future external costs.

Visualization of the true price of a product and the purpose of true pricing.



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Data & limitations

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ANNEX DEFINITIONS OF IMPACTS IN SCOPE

Please visit https://trueprice.org/true-price-resources/ for more information.

Underpayment	Underpayment occurs when the actual wages of employees over standard working hours, including financial wages and some forms of in-kind compensation, lie below the legal minimum wage or a decent living wage. Underpayment in the value chain can also include underpayment of child labourers and forced labourers. It excludes underpaid overtime, which is included under ‘Excessive and underpaid overtime’.
Water pollution	Emissions to water contributing to ecotoxicity and human toxicity, as well as eutrophication of marine- and freshwater. Eutrophication occurs due to the runoff and discharge of nutrients, for example from leaching of plant nutrients into soil, marine and freshwater bodies and the subsequent rise in nutrient levels, i.e., of phosphorus (P) and nitrogen (N).
Fossil fuel depletion	The consequence of the primary extraction of fossil fuels linked to fuel use, energy use and to produce other inputs, such as mineral fertilizer. Extraction of crude oil, hard coal and natural gas bears external societal costs because the stock of these materials is reduced for present and future generations. (Huijbregts et al., 2016). In this method, fossil fuel depletion is considered separately from the depletion of other non-renewable materials in line with LCA methodologies.
Land use	The decreased availability of land for purposes other than the current one, through land occupancy. Land occupation by agriculture displaces habitats and ecosystems and therefore leads to biodiversity loss and loss of ecosystem services (Milà i Canals et al., 2007; Alkemade et al., 2009; De Groot et al., 2012).
Scarce water use	Concerns the use of blue water in such a way that the water is evaporated, incorporated into products, transferred to other watersheds or disposed into the sea, in areas where water is scarce (Falkenmark and Rockstrom, 2004). Water that is used as such is not available anymore in the watershed of origin for humans nor for ecosystems (Huijbregts et al., 2016). Scarcity of water depends on the watershed of origin and the geographical context (WWF, 2020)
Contribution to climate change	Contribution to climate change from emissions of greenhouse gases (carbon dioxide, methane, nitrous oxide and others). Emissions of greenhouse gases increase their atmospheric concentration (ppb), which increases the radiative forcing capacity and consequently increases the global mean temperature. Ultimately, extreme weather patterns, reduced agricultural yields and increased frequency of natural disasters can result in damage to the economy, human health – e.g., increased risk of diseases, natural disasters - and ecosystems (Huijbregts et al. 2016).

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ANNEX DATA SOURCES

An overview of the main data sources used in the analysis is given below.

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ANNEX LIST OF MONETIZATION FACTOR

The monetization factors used to calculate the different TP gaps are presented.

Impact	Footprint indicator	Sub-footprint indicator	Unit	Global Value	Value NL
Contribution to climate change	Greenhouse gas (GHG) emissions		EUR 2021/ kg CO2 eq	0,157	0,157
Fossil fuel depletion	Fossil fuel depletion		EUR 2021/ kg oil eq	0,448	0,448
Water pollution	Toxic emissions to water	Freshwater ecotoxicity	EUR 2021/ kg 1,4-DCB	0,0406	0,0406
Water pollution	Freshwater eutrophication		EUR 2021/ kg P eq	203	203
Land use	Land occupation	Tropical forest	EUR 2021/MSA*ha*yr	2,130	2,130
		Other forest	EUR 2021/MSA*ha*yr	1,020	1,020
		Woodland/shrubland	EUR 2021/MSA*ha*yr	1,370	1,370
		Grassland/savannah	EUR 2021/MSA*ha*yr	2,440	2,440
		Inland wetland	EUR 2021/MSA*ha*yr	14,900	14,900
		Coastal wetland	EUR 2021/MSA*ha*yr	11,000	11,000
Water pollution	Toxic emissions to water	Marine ecotoxicity	EUR 2021/ kg 1,4-DCB	0,0019	0,0019
Water pollution	Marine eutrophication		EUR 2021/ kg N eq	14,10	14,10
Scarce water use	Scarce blue water use		EUR 2021/ m3	1,29	1,29

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ANNEX LIST OF FOOTPRINTS INDICATORS - RAW MATERIALS

The footprint results (for environmental impacts only) for the raw materials of diapers are presented.

Footprint indicator	Footprint unit	Virgin cellulose fluff	Polypropylene	Sodium Polyacrylate	Polyester	Polyethylene	Polylactic Acid (PLA)	Viscose	Cotton	Bamboo
Greenhouse gas (GHG) emissions	kg CO2 eq/kg raw material	0,7308	2,8398	3,4162	4,2863	3,0261	3,0769	3,2108	9,9372	1,6864
Fossil fuel depletion	kg oil eq/kg material	0,1887	1,8424	1,2376	1,9046	1,8561	0,8730	0,8227	1,6773	0,4493
Freshwater ecotoxicity	kg 1,4-DCB/kg material	0,0317	0,0910	0,1231	0,1466	0,0808	0,1716	0,1441	0,6801	0,0150
Freshwater eutrophication	kg P eq/kg material	0,0003	0,0007	0,0024	0,0011	0,0009	0,0016	0,0012	0,0091	0,0003
Land occupation	ha yr /kg material	0,0003	0,0000	0,0000	0,0000	0,0000	0,0001	0,0001	0,0011	0,0000
Marine ecotoxicity	kg 1,4-DCB/kg material	0,0424	0,1173	0,1625	0,1930	0,1065	0,2119	0,1937	0,8468	0,0215
Marine eutrophication	kg N eq/kg material	0,0002	0,0001	0,0002	0,0003	0,0001	0,0014	0,0001	0,1320	0,0000
Scarce blue water use	m3/kg material	0,0178	0,0285	0,0336	0,0538	0,0558	0,1566	0,0853	15,2175	0,0035

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ANNEX LIST OF FOOTPRINTS INDICATORS - MANUFACTURING

The footprint results (for environmental impacts only) for the manufacturing of the diapers are presented.

Footprint indicator	Footrpint unit	Manufacturing of single use diapers	Manufacturing of reusable cloth diapers
Greenhouse gas (GHG) emissions	kg CO2 eq/kg diaper	0,2697	3,2579
Fossil fuel depletion	kg oil eq/kg diaper	0,0738	0,9816
Freshwater ecotoxicity	kg 1,4-DCB/kg diaper	0,0080	0,0274
Freshwater eutrophication	kg P eq/kg diaper	0,0003	0,0006
Land occupation	ha yr /kg diaper	0,0000	0,0000
Marine ecotoxicity	kg 1,4-DCB/kg diaper	0,0111	0,0376
Marine eutrophication	kg N eq/kg diaper	0,0000	0,0000
Scarce blue water use	m3/kg diaper	0,0044	0,0074

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ANNEX LIST OF FOOTPRINTS INDICATORS - WASHING

The footprint results (for environmental impacts only) for washing the diapers are presented, per wash cycle.*

Footprint indicator	Footprint unit	Electricity	Water	Total
Greenhouse gas (GHG) emissions	kg CO2 eq/wash	0,6014	0,0003	0,7295
Fossil fuel depletion	kg oil eq/wash	0,1673	0,0001	0,2025
Freshwater ecotoxicity	kg 1,4-DCB/wash	0,0408	0,0000	0,0490
Freshwater eutrophication	kg P eq/wash	0,0003	0,0000	0,0003
Land occupation	ha yr /wash	6,71E-07	6,31E-10	8,37E-07
Marine ecotoxicity	kg 1,4-DCB/wash	0,0511	0,0000	0,0615
Marine eutrophication	kg N eq/wash	0,0000	0,0000	0,0000
Scarce blue water use	m3/wash	0,005164	0,001006	0,099719

*washing conditions correspond to baseline scenario.

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ANNEX LIST OF FOOTPRINTS INDICATORS - INCINERATION

The footprint results (for environmental impacts only) for incinerating the (used) single use diaper and inlay materials are presented

Footprint indicator	Footprint Unit	Virgin cellulose fluff	Polypropylene	Sodium Polyacrylate	Polyester	Polyethylene	Polylactic Acid (PLA)	Viscose	Organic material
Greenhouse gas (GHG) emissions	kg CO2 eq/kg material	0,0231	2,5321	2,3463	2,0289	2,9931	0,0463	0,1299	0,0113
Fossil fuel depletion	kg oil eq/kg material	0,0048	0,0027	0,0094	0,0029	0,0029	0,0094	0,0116	0,0019
Freshwater ecotoxicity	kg 1,4-DCB/kg material	0,0065	0,0652	0,0596	0,0699	0,0772	0,0596	0,0073	0,0023
Freshwater eutrophication	kg P eq/kg material	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Land occupation	ha yr /kg material	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Marine ecotoxicity	kg 1,4-DCB/kg material	0,0080	0,0912	0,0749	0,0969	0,1080	0,0749	0,0089	0,0028
Marine eutrophication	kg N eq/kg material	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0002	0,0002
Scarce blue water use	m3/kg material	0,0007	0,0005	0,0011	0,0005	0,0005	0,0011	0,0010	0,0002

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ANNEX LIST OF FOOTPRINTS INDICATORS - RECYCLING

The footprint results (for environmental impacts only) for recycling the (wasted) single use diaper are presented, per recycling step.

Impact category	Reference unit	TPH PROCESS	Digester & CHP	Dewatering & wastewater treatment
Greenhouse gas (GHG) emissions	kg CO2 eq/ kg waste diaper	0,06875	0,00689	0,00449
Fossil resource scarcity	kg oil eq/ kg wasted diaper	0,00323	0,00043	0,00124
Freshwater ecotoxicity	kg 1,4-DCB/ kg wasted diaper	0,00207	0,00027	0,00031
Freshwater eutrophication	kg P eq/ kg wasted diaper	0,00001	0,00000	0,00000
Land occupation	ha yr/ kg wasted diaper	0,00000	0,00000	0,00000
Marine ecotoxicity	kg 1,4-DCB/ kg wasted diaper	0,00261	0,00035	0,00039
Marine eutrophication	kg N eq/ kg wasted diaper	0,00000	0,00000	0,00000
Scarce blue water use	m3/ kg wasted diaper	0,00012	0,00002	-0,00026

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ANNEX LIST OF FOOTPRINTS INDICATORS - WASTEWATER TREATMENT

The footprint results (for environmental impacts only) for treatment of wastewater from washing are presented, per m3 of water.

Footrpint indicator	Footprint Unit	Wastewater
Greenhouse gas (GHG) emissions	kg CO2 eq/m3	0,4111
Fossil fuel depletion	kg oil eq/m3	0,069773
Freshwater ecotoxicity	kg 1,4-DCB/m3	0,038694
Freshwater eutrophication	kg P eq/m3	0,001047
Land occupation	ha yr /m3	8,15E-07
Marine ecotoxicity	kg 1,4-DCB/m3	0,051485
Marine eutrophication	kg N eq/m3	0,005994
Scarce blue water use	m3/m3	0

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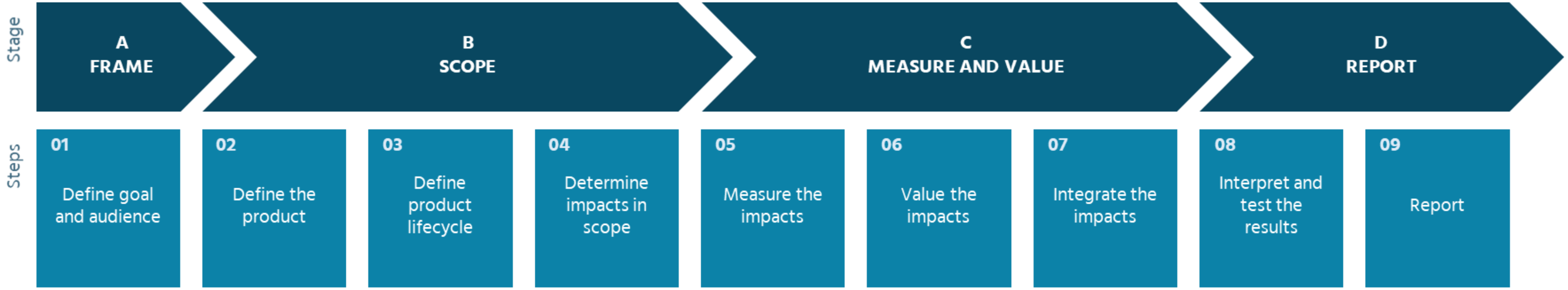
ANNEX REVIEW PROCESS

The review process used in this project is based on the true price assessment method, involving different impacts experts for different parts of the analysis and a general validation round.



- The review process in this project covers the process, scoping, modelling, data, and reporting steps of a true price assessment, following the assessment guide.
- One general validation round on process and the model as a whole has been executed by a team member not involved in the project. Additional validation rounds have been executed by other team members not involved in the project for parts of the analysis, such as: the framing and scoping and the waste phase of the model. The final report has been reviewed by the project director.
- All validation remarks, questions, and comments have been noted. They have been processed by the project team. The processing has been checked by the validators.
- Moreover, all steps, choices, and assumptions have been discussed and signed off by the client.

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Results per diaper system in all scenarios

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ANNEX BASELINE SCENARIO - SINGLE USE CONVENTIONAL DIAPER SYSTEM

Life cycle stage	Contribution to climate change	Scarce blue water use	Land occupation	Water pollution	Fossil fuel depletion	Underpayment	Total
Single use diapers production & consumption	79,4	2,2	60,5	58,0	97,0	27,0	324,1
Waste treatment	52,0	0,2	0,1	2,7	2,4	0,0	57,4
Benefits of waste treatment	-31,5	-0,2	-0,4	-7,2	-29,8	-0,2	-69,3
TP gap	**131,4**	**2,4**	**60,6**	**60,7**	**99,4**	**27,0**	**381,5**
Total benefits	-31,5	-0,2	-0,4	-7,2	-29,8	-0,2	-69,3

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ANNEX BASELINE SCENARIO - SINGLE USE BIOBASED DIAPER SYSTEM

Life cycle stage	Contribution to climate change	Scarce blue water use	Land occupation	Water pollution	Fossil fuel depletion	Underpayment	Total
Single use diapers production & consumption	79,5	3,2	63,7	62,6	84,8	21,2	315,0
Waste treatment	39,3	0,2	0,1	2,8	2,5	0,0	44,9
Benefits of waste treatment	-26,2	-0,2	-0,4	-6,1	-24,7	-0,1	-57,7
TP gap	**118,8**	**3,4**	**63,8**	**65,4**	**87,3**	**21,2**	**359,9**
Total benefits	-26,2	-0,2	-0,4	-6,1	-24,7	-0,1	-57,7

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ANNEX BASELINE SCENARIO - REUSABLE DIAPER SYSTEM

Life cycle stage	Contribution to climate change	Scarce blue water use	Land occupation	Water pollution	Fossil fuel depletion	Underpayment	Total
Single use diapers production & consumption	7,2	0,3	5,8	5,7	7,7	1,9	28,6
Reusable diapers production & consumption	7,2	15,5	6,2	7,3	5,6	3,1	44,9
Inlay consumption	1,5	0,1	0,6	0,8	1,1	0,5	4,6
Washing of reusable diapers	57,6	15,7	1,3	36,6	45,6	0,0	156,8
Waste treatment of single use diapers	3,6	0,0	0,0	0,3	0,2	0,0	4,1
Incineration of inlays	0,2	0,0	0,0	0,1	0,1	0,0	0,4
Wastewater treatment	3,0	0,0	0,1	14,0	1,5	0,0	18,6
Benefits of waste treatment of single use diapers	-2,4	0,0	0,0	-0,6	-2,2	0,0	-5,2
Benefits of waste treatment of inlays	-0,2	0,0	0,0	-0,1	-0,2	0,0	-0,5
TP gap	**80,3**	**31,6**	**14,0**	**64,8**	**61,8**	**5,5**	**258,0**
Total benefits	-2,6	0,0	0,0	-0,7	-2,4	0,0	-5,7

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ANNEX FULLTIME USE OF CLOTH DIAPERS INCL FIRST 3 MONTHS - REUSABLE DIAPER SYSTEM

Life cycle stage	Contribution to climate change	Scarce blue water use	Land occupation	Water pollution	Fossil fuel depletion	Underpayment	Total
Single use diapers production & consumption	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Reusable diapers production & consumption	12,2	26,4	10,5	12,4	9,6	5,3	76,4
Inlay consumption	1,7	0,1	0,6	0,9	1,3	0,6	5,2
Washing of reusable diapers	64,9	17,7	1,4	41,3	51,4	0,0	176,7
Waste treatment of single use diapers	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Incineration of inlays	0,2	0,0	0,0	0,1	0,1	0,0	0,4
Wastewater treatment	3,4	0,0	0,1	15,8	1,6	0,0	20,9
Benefits of waste treatment of single use diapers	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Benefits of waste treatment of inlays	-0,2	0,0	0,0	0,0	-0,2	0,0	-0,4
TP gap	**82,4**	**44,2**	**12,6**	**70,5**	**64,0**	**5,9**	**279,6**
Total benefits	-0,2	0,0	0,0	0,0	-0,2	0,0	-0,4

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ANNEX TIMELY TOILET TRAINING - BASELINE SCENARIO - REUSABLE DIAPER SYSTEM

Life cycle stage	Contribution to climate change	Scarce blue water use	Land occupation	Water pollution	Fossil fuel depletion	Underpayment	Total
Single use diapers production & consumption	7,2	0,3	5,8	5,7	7,7	1,9	28,6
Reusable diapers production & consumption	7,2	15,5	6,2	7,3	5,6	3,1	44,9
Inlay consumption	1,2	0,1	0,4	0,6	0,8	0,4	3,5
Washing of reusable diapers	40,3	11,0	0,9	25,6	31,9	0,0	109,7
Waste treatment of single use diapers	3,6	0,0	0,0	0,3	0,2	0,0	4,1
Incineration of inlays	0,2	0,0	0,0	0,0	0,0	0,0	0,2
Wastewater treatment	2,1	0,0	0,1	9,8	1,0	0,0	13,0
Benefits of waste treatment of single use diapers	-2,4	0,0	0,0	-0,5	-2,2	0,0	-5,1
Benefits of waste treatment of inlays	-0,2	0,0	0,0	0,0	-0,2	0,0	-0,4
TP gap	**61,8**	**26,9**	**13,4**	**49,3**	**47,2**	**5,4**	**204,0**
Total benefits	-2,6	0,0	0,0	-0,5	-2,4	0,0	-5,5

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ANNEX TIMELY TOILET TRAINING - BASELINE SCENARIO - SINGLE USE BIOBASED DIAPER SYSTEM

Life cycle stage	Contribution to climate change	Scarce blue water use	Land occupation	Water pollution	Fossil fuel depletion	Underpayment	Total
Single use diapers production & consumption	61,9	2,5	49,6	48,7	65,9	16,5	245,1
Waste treatment	30,5	0,1	0,0	2,2	1,9	0,0	34,7
Benefits of waste treatment	-20,3	-0,2	-0,3	-4,7	-19,2	-0,1	-44,8
TP gap	**92,4**	**2,6**	**49,6**	**50,9**	**67,8**	**16,5**	**279,8**
Total benefits	-20,3	-0,2	-0,3	-4,7	-19,2	-0,1	-44,8

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ANNEX TIMELY TOILET TRAINING -BASELINE SCENARIO - SINGLE USE CONVENTIONAL DIAPER SYSTEM

Life cycle stage	Contribution to climate change	Scarce blue water use	Land occupation	Water pollution	Fossil fuel depletion	Underpayment	Total
Single use diapers production & consumption	61,7	1,7	47,0	45,1	75,4	21,0	251,9
Waste treatment	40,4	0,1	0,0	2,1	1,9	0,0	44,5
Benefits of waste treatment	-24,5	-0,2	-0,3	-5,6	-23,2	-0,1	-53,9
TP gap	**102,1**	**1,8**	**47,0**	**47,2**	**77,3**	**21,0**	**296,4**
Total benefits	-24,5	-0,2	-0,3	-5,6	-23,2	-0,1	-53,9

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ANNEX TIMELY TOILET TRAINING - PARTTIME USE OF CLOTH DIAPERS EXCL FIRST 3 MONTHS- REUSABLE DIAPER SYSTEM

Life cycle stage	Contribution to climate change	Scarce blue water use	Land occupation	Water pollution	Fossil fuel depletion	Underpayment	Total
Single use diapers production & consumption	42,4	1,7	34,0	33,4	45,2	11,3	168,0
Reusable diapers production & consumption	1,8	3,9	1,5	1,8	1,4	0,8	11,2
Inlay consumption	0,4	0,0	0,2	0,2	0,3	0,1	1,2
Washing of reusable diapers	26,9	7,3	0,6	17,1	21,3	0,0	73,2
Waste treatment of single use diapers	20,9	0,1	0,0	1,5	1,3	0,0	23,8
Incineration of inlays	0,1	0,0	0,0	0,0	0,0	0,0	0,1
Wastewater treatment	1,4	0,0	0,1	6,5	0,7	0,0	8,7
Benefits of waste treatment of single use diapers	-13,9	-0,1	-0,2	-3,2	-13,1	-0,1	-30,5
Benefits of waste treatment of inlays	-0,1	0,0	0,0	0,0	-0,1	0,0	-0,3
TP gap	**93,9**	**13,0**	**36,4**	**60,5**	**70,2**	**12,2**	**286,2**
Total benefits	-14,0	-0,1	-0,2	-3,2	-13,2	-0,1	-30,8

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ANNEX PARTTIME USE OF CLOTH DIAPERS EXCL FIRST 3 MONTHS - REUSABLE DIAPER SYSTEM

Life cycle stage	Contribution to climate change	Scarce blue water use	Land occupation	Water pollution	Fossil fuel depletion	Underpayment	Total
Single use diapers production & consumption	51,2	2,1	41,0	40,3	54,6	13,7	202,9
Reusable diapers production & consumption	1,8	3,9	1,5	1,8	1,4	0,8	11,2
Inlay consumption	0,6	0,0	0,2	0,3	0,4	0,2	1,7
Washing of reusable diapers	38,4	10,4	0,8	24,4	30,4	0,0	104,4
Waste treatment of single use diapers	25,3	0,1	0,0	1,8	1,6	0,0	28,8
Incineration of inlays	0,1	0,0	0,0	0,0	0,0	0,0	0,1
Wastewater treatment	2,0	0,0	0,1	9,3	1,0	0,0	12,4
Benefits of waste treatment of single use diapers	-16,7	-0,1	-0,2	-3,9	-15,8	-0,1	-36,9
Benefits of waste treatment of inlays	-0,2	0,0	0,0	0,0	-0,1	0,0	-0,4
TP gap	**119,4**	**16,5**	**43,6**	**77,9**	**89,4**	**14,7**	**361,5**
Total benefits	-16,9	-0,1	-0,2	-3,9	-15,9	-0,1	-37,3

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ANNEX PARTTIME USE OF CLOTH DIAPERS INCL FIRST 3 MONTHS- REUSABLE DIAPER SYSTEM

Life cycle stage	Contribution to climate change	Scarce blue water use	Land occupation	Water pollution	Fossil fuel depletion	Underpayment	Total
Single use diapers production & consumption	49,8	2,0	39,9	39,2	53,0	13,3	197,2
Reusable diapers production & consumption	3,0	6,6	2,6	3,1	2,4	1,3	19,0
Inlay consumption	0,6	0,0	0,2	0,3	0,5	0,2	1,8
Washing of reusable diapers	41,3	11,2	0,9	26,3	32,7	0,0	112,4
Waste treatment of single use diapers	24,6	0,1	0,0	1,7	1,6	0,0	28,0
Incineration of inlays	0,1	0,0	0,0	0,0	0,0	0,0	0,1
Wastewater treatment	3,4	0,0	0,1	15,8	1,6	0,0	20,9
Benefits of waste treatment of single use diapers	-16,3	-0,1	-0,2	-3,8	-15,4	-0,1	-35,9
Benefits of waste treatment of inlays	-0,2	0,0	0,0	0,0	-0,2	0,0	-0,4
TP gap	**122,8**	**19,9**	**43,7**	**86,4**	**91,8**	**14,8**	**379,4**
Total benefits	-16,5	-0,1	-0,2	-3,8	-15,6	-0,1	-36,3

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ANNEX WASHING IN 90⁰ DEGREES - REUSABLE DIAPER SYSTEM

Life cycle stage	Contribution to climate change	Scarce blue water use	Land occupation	Water pollution	Fossil fuel depletion	Underpayment	Total
Single use diapers production & consumption	7,2	0,3	5,8	5,7	7,7	1,9	28,6
Reusable diapers production & consumption	7,2	15,5	6,2	7,3	5,6	3,1	44,9
Inlay consumption	1,5	0,1	0,6	0,8	1,1	0,5	4,6
Washing of reusable diapers	85,6	16,1	1,9	54,0	67,8	0,0	225,4
Waste treatment of single use diapers	3,6	0,0	0,0	0,3	0,2	0,0	4,1
Incineration of inlays	0,2	0,0	0,0	0,1	0,1	0,0	0,4
Wastewater treatment	3,0	0,0	0,1	14,0	1,5	0,0	18,6
Benefits of waste treatment of single use diapers	-2,4	0,0	0,0	-0,5	-2,2	0,0	-5,1
Benefits of waste treatment of inlays	-0,2	0,0	0,0	0,0	-0,2	0,0	-0,4
TP gap	**108,3**	**32,0**	**14,6**	**82,2**	**84,0**	**5,5**	**326,6**
Total benefits	-2,6	0,0	0,0	-0,5	-2,4	0,0	-5,5

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ANNEX WASHING IN 40⁰ DEGREES - REUSABLE DIAPER SYSTEM

Life cycle stage	Contribution to climate change	Scarce blue water use	Land occupation	Water pollution	Fossil fuel depletion	Underpayment	Total
Single use diapers production & consumption	7,2	0,3	5,8	5,7	7,7	1,9	28,6
Reusable diapers production &consumption	7,2	15,5	6,2	7,3	5,6	3,1	44,9
Inlay consumption	1,5	0,1	0,6	0,8	1,1	0,5	4,6
Washing of reusable diapers	48,1	15,5	1,1	30,7	38,1	0,0	133,5
Waste treatment of single use diapers	3,6	0,0	0,0	0,3	0,2	0,0	4,1
Incineration of inlays	0,2	0,0	0,0	0,1	0,1	0,0	0,4
Wastewater treatment	3,0	0,0	0,1	14,0	1,5	0,0	18,6
Benefits of waste treatment of single use diapers	-2,4	0,0	0,0	-0,5	-2,2	0,0	-5,1
Benefits of waste treatment of inlays	-0,2	0,0	0,0	0,0	-0,2	0,0	-0,4
TP gap	**70,8**	**31,4**	**13,8**	**58,9**	**54,3**	**5,5**	**234,7**
Total benefits	-2,6	0	0	-0,5	-2,4	0	-5,5

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ANNEX TUMBLE DRYING- REUSABLE DIAPER SYSTEM

Life cycle stage	Contribution to climate change	Scarce blue water use	Land occupation	Water pollution	Fossil fuel depletion	Underpayment	Total
Single use diapers production & consumption	7,2	0,3	5,8	5,7	7,7	1,9	28,6
Reusable diapers production & consumption	7,2	15,5	6,2	7,3	5,6	3,1	44,9
Inlay consumption	1,5	0,1	0,6	0,8	1,1	0,5	4,6
Washing of reusable diapers	103,0	18,0	2,2	64,8	81,6	0,0	269,6
Waste treatment of single use diapers	3,6	0,0	0,0	0,3	0,2	0,0	4,1
Incineration of inlays	0,2	0,0	0,0	0,1	0,1	0,0	0,4
Wastewater treatment	3,0	0,0	0,1	14,0	1,5	0,0	18,6
Benefits of waste treatment of single use diapers	-2,4	0,0	0,0	-0,5	-2,2	0,0	-5,1
Benefits of waste treatment of inlays	-0,2	0,0	0,0	0,0	-0,2	0,0	-0,4
TP gap	**125,7**	**33,9**	**14,9**	**93,0**	**97,8**	**5,5**	**370,8**
Total benefits	-2,6	0,0	0,0	-0,5	-2,4	0,0	-5,5

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ANNEX 50% INCINERATION - 50% RECYCLING - REUSABLE DIAPER SYSTEM

Life cycle stage	Contribution to climate change	Scarce blue water use	Land occupation	Water pollution	Fossil fuel depletion	Underpayment	Total
Single use diapers production & consumption	6,9	0,3	5,8	5,7	7,7	1,9	28,3
Reusable diapers production & consumption	7,2	15,5	6,2	7,3	5,6	3,1	44,9
Inlay consumption	1,5	0,1	0,6	0,8	1,1	0,5	4,6
Washing of reusable diapers	57,6	15,7	1,3	36,6	45,6	0,0	156,8
Waste treatment of single use diapers	2,2	0,0	0,0	0,2	0,2	0,0	2,6
Incineration of inlays	0,2	0,0	0,0	0,1	0,1	0,0	0,4
Wastewater treatment	1,6	0,0	0,1	7,1	0,8	0,0	9,6
Benefits of waste treatment of single use diapers	-1,8	-0,1	-0,2	-0,7	-2,4	-0,4	-5,6
Benefits of waste treatment of inlays	-0,7	0,0	0,0	-0,2	-0,6	0,0	-1,6
TP gap	**77,2**	**31,6**	**14,0**	**57,8**	**61,1**	**5,5**	**247,2**
Total benefits	-2,5	-0,1	-0,2	-0,9	-3,0	-0,4	-7,2

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ANNEX 50% INCINERATION - 50% RECYCLING - SINGLE USE BIOBASED DIAPER SYSTEM

Life cycle stage	Contribution to climate change	Scarce blue water use	Land occupation	Water pollution	Fossil fuel depletion	Underpayment	Total
Single use diapers production & consumption	75,6	3,2	63,7	62,6	84,8	21,2	311,1
Waste treatment	23,7	0,1	0,1	2,0	2,0	0,0	27,9
Benefits of waste treatment	-26,1	-0,8	-2,5	-9,8	-32,4	-4,9	-76,5
TP gap	**99,3**	**3,3**	**63,8**	**64,6**	**86,8**	**21,2**	**339,0**
Total benefits	-26,1	-0,8	-2,5	-9,8	-32,4	-4,9	-76,5

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ANNEX 50% INCINERATION - 50% RECYCLING - SINGLE USE CONVENTIONAL DIAPER SYSTEM

Life cycle stage	Contribution to climate change	Scarce blue water use	Land occupation	Water pollution	Fossil fuel depletion	Underpayment	Total
Single use diapers production & consumption	79,4	2,2	60,5	58,0	97,0	27,0	324,1
Waste treatment	30,1	0,1	0,1	2,0	1,9	0,0	34,2
Benefits of waste treatment	-31,4	-0,4	-0,4	-8,0	-39,8	-7,5	-87,5
TP gap	**109,5**	**2,3**	**60,6**	**60,0**	**98,9**	**27,0**	**358,3**
Total benefits	-31,4	-0,4	-0,4	-8,0	-39,8	-7,5	-87,5

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ANNEX PRODUCTION OF RAW MATERIALS - TP GAP PER DIAPER MATERIAL

Impact	Virgin cellulose pulp	Polypropylene	Sodium Polyacrylate	Polyester	Polyethylene	Polylactic Acid (PLA)	Viscose	Cotton	Bamboo
Contribution to climate change	0,11	0,45	0,54	0,48	0,67	0,48	0,50	1,56	0,26
Scarce blue water use	0,01	0,01	0,01	0,02	0,02	0,05	0,03	9,46	0,00
Land occupation	1,07	0,00	0,01	0,02	0,01	0,13	0,19	3,77	0,00
Water pollution	0,07	0,16	0,49	0,18	0,24	0,35	0,26	3,75	0,06
Fossil fuel depletion	0,08	0,83	0,55	0,83	0,85	0,39	0,37	0,75	0,20
Underpayment	0,08	0,29	0,09	0,29	0,29	0,08	0,16	1,11	0,13
Total	**1,42**	**1,73**	**1,69**	**1,81**	**2,09**	**1,49**	**1,51**	**20,40**	**0,66**

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Results are given in EUR2021/kg raw material

Materiality matrices

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ANNEX MATERIALITY TABLE - SINGLE USE CONVENTIONAL

Baseline scenario

Impacts	Raw materials & manufacturing	Usage	After life*
Contribution to climate change	+	-	++
Air pollution	++	-	++
Water pollution	+	-	+
Soil pollution	+/-	-	+/-
Land use	+	-	-
Land transformation	+	-	-
Fossil fuel depletion	++	-	-
(Other) non-renewable material depletion	+	-	-
Scarce water use	+	-	-
Soil degradation	+/-	-	+/-
Overuse of other renewable resources	+/-	-	+/-
Child labour	+/-	-	+/-
Forced labour	+/-	-	+/-
Gender discrimination	+/-	-	+/-
Underpayment in the value chain	+/-	-	+/-
Lack of social security	+/-	-	+/-
Excessive and underpaid overtime	+/-	-	+/-
Insufficient income	+/-	-	+/-
Occurrence of harassment	+/-	-	+/-
Lack of freedom of association	+/-	-	+/-
Negative effects of employee health & safety	+/-	-	+/-
Negative effects of community health & safety	+/-	-	+/-
Animal welfare below standards	-	-	-
Breach of indigenous rights	-	-	-
Breach of land rights	-	-	-
Occurrence of corruption	-	-	-
Tax evasion	-	-	-
Deliberate misinformation/lack of transparency	-	-	-
Negative effects of consumer health & safety	-	-	-
Breaches of privacy	-	-	-

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ANNEX MATERIALITY TABLE - SINGLE USE BIOPOLYMER

Baseline scenario

Impacts	Raw materials & manufacturing	Usage	After life*
Contribution to climate change	+	-	++
Air pollution	++	-	++
Water pollution	+	-	+
Soil pollution	+/-	-	+/-
Land use	+	-	-
Land transformation	+	-	-
Fossil fuel depletion	++	-	-
(Other) non-renewable material depletion	+	-	-
Scarce water use	+	-	-
Soil degradation	+/-	-	+/-
Overuse of other renewable resources	+/-	-	+/-
Child labour	+/-	-	+/-
Forced labour	+/-	-	+/-
Gender discrimination	+/-	-	+/-
Underpayment in the value chain	+/-	-	+/-
Lack of social security	+/-	-	+/-
Excessive and underpaid overtime	+/-	-	+/-
Insufficient income	+/-	-	+/-
Occurrence of harassment	+/-	-	+/-
Lack of freedom of association	+/-	-	+/-
Negative effects of employee health & safety	+/-	-	+/-
Negative effects of community health & safety	+/-	-	+/-
Animal welfare below standards	-	-	-
Breach of indigenous rights	-	-	-
Breach of land rights	-	-	-
Occurrence of corruption	-	-	-
Tax evasion	-	-	-
Deliberate misinformation/lack of transparency	-	-	-
Negative effects of consumer health & safety	-	-	-
Breaches of privacy	-	-	-

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ANNEX MATERIALITY TABLE - REUSABLE CLOTH

Baseline scenario

Impacts	Raw materials & manufacturing	Usage	After life*
Contribution to climate change	+	++	+
Air pollution	+	++	+
Water pollution	+	++	+
Soil pollution	+/-	+/-	+/-
Land use	++	-	-
Land transformation	++	-	-
Fossil fuel depletion	++	++	-
(Other) non-renewable material depletion	+	+	-
Scarce water use	++	++	-
Soil degradation	+/-	-	+/-
Overuse of other renewable resources	+/-	-	+/-
Child labour	+/-	-	+/-
Forced labour	+/-	-	+/-
Gender discrimination	+/-	-	+/-
Underpayment in the value chain	+/-	-	+/-
Lack of social security	+/-	-	+/-
Excessive and underpaid overtime	+/-	-	+/-
Insufficient income	+/-	-	+/-
Occurrence of harassment	+/-	-	+/-
Lack of freedom of association	+/-	-	+/-
Negative effects of employee health & safety	+/-	-	+/-
Negative effects of community health & safety	+/-	-	+/-
Animal welfare below standards	-	-	-
Breach of indigenous rights	-	-	-
Breach of land rights	-	-	-
Occurrence of corruption	-	-	-
Tax evasion	-	-	-
Deliberate misinformation/lack of transparency	-	-	-
Negative effects of consumer health & safety	-	-	-
Breaches of privacy	-	-	-

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ANNEX MATERIALITY ANALYSIS - PROCESS & SOURCES

Process

- The materiality analysis follows the True Price Assessment Method, which describes a materiality assessment as: an evaluation of which impacts are relevant per phase of a product's lifecycle. Any activity in any lifecycle phase that causes, contributes to, or is directly linked to one of the true price impacts is a reason to consider an impact material for the specific lifecycle phase (GRI, 2021).
- This materiality analysis is based on secondary sources and stakeholder engagement (input FDP). Based on these sources, the expected materiality was determined per impact per lifecycle step per diaper system. This was done in order of magnitude. The results are put together in the materiality tables on the next pages.
- This process ensures an un-biased, holistic approach to limit the chance to overlook material impacts. The final selection has been based on the expected materiality, strategic relevance for FDP, and feasibility. This has been aligned with FDP. Due to limited resources and data availability, not all material impacts could be included.

Main sources

- Life cycle assessment of bio-based products: a disposable diaper case study
- Source: https://www.sciencedirect.com/science/article/abs/pii/S0959652619342349
- Description: LCA of a bioplastic based diaper (PLA). 3 EoL scenarios are hypothized and analyzed
- Life cycle: cradle to gate

- Life cycle assessment, comparison of biopolymer and traditional diaper systems
- Source: https://www.vttresearch.com/sites/default/files/pdf/tiedotteet/1997/T1876.pdf
- Description: Environemntal impacts of biobased diapers (PLA) are assessed and compared to traditional diapers.
- Life cycle: cradle to grave

- Single-use nappies and their alternatives
- Source: https://www.lifecycleinitiative.org/wp-content/uploads/2021/03/UNEP-D003-Nappies-Report_lowres.pdf
- Description: Meta-analysis of LCA studies on conventional single-use diapers and their alternatives.
- Life cycle: cradle to grave

Other sources:

- https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1061.2287&rep=rep1&type=pdf
- https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/291130/scho0808boir-e-e.pdf
- https://www.ch.ic.ac.uk/marshall/4I10/Nappies.pdf
- https://link.springer.com/article/10.1007/s10924-019-01525-9
- https://p2infohouse.org/ref/30/29640.pdf

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High-level life-cycles

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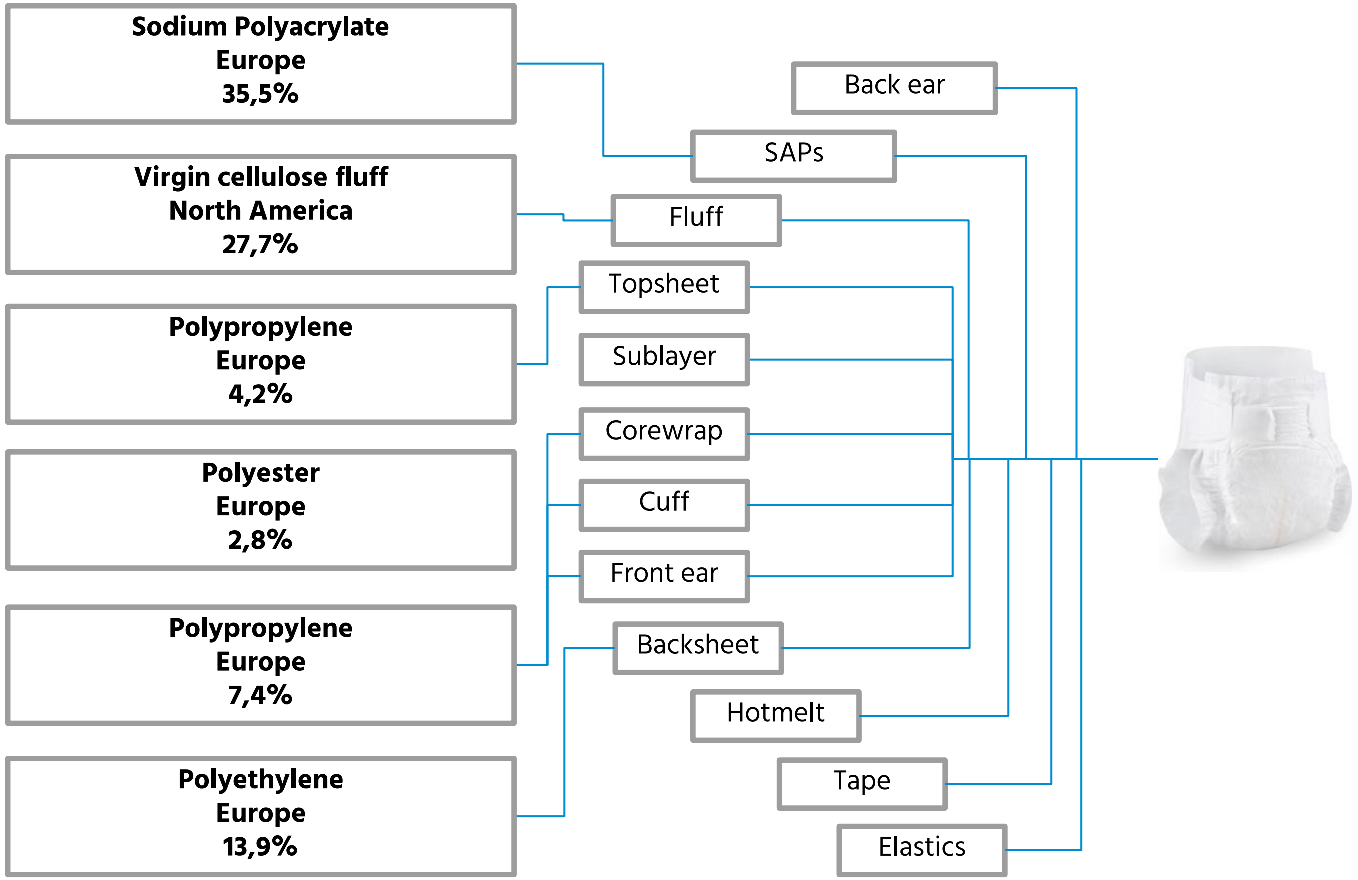
PRODUCT LIFECYCLE - SINGLE USE CONVENTIONAL [1/2]

Raw materials & manufacturing | Usage | End of life

Mining, processing and production of raw materials



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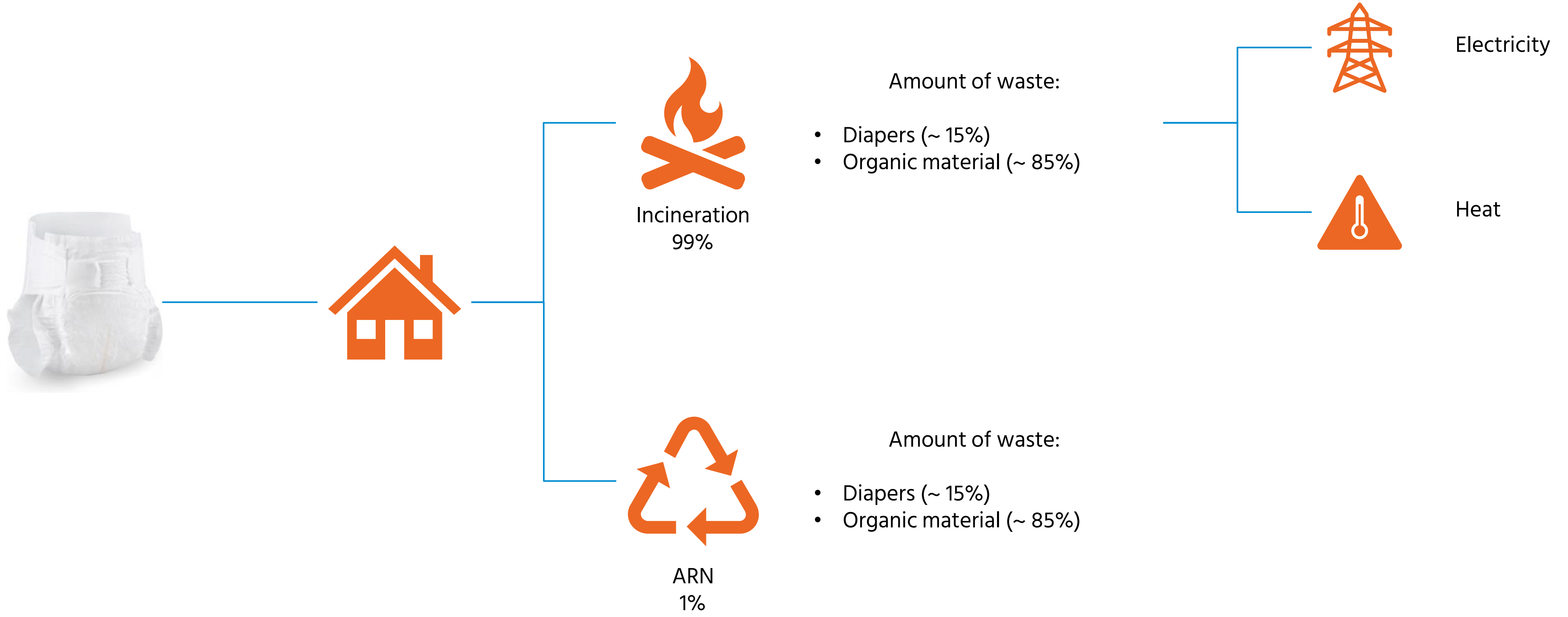
PRODUCT LIFECYCLE - SINGLE USE CONVENTIONAL [2/2]

Raw materials & manufacturing | Usage | End of life



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PRODUCT LIFECYCLE - SINGLE USE BIOPOLYMER [1/2]

Raw materials & manufacturing | Usage | End of life

Mining/cultivation, processing and production of raw materials

Sodium Polyacrylate
Europe
35,5%

Virgin cellulose fluff
North America
27,7%

Polypropylene
Europe
4,2%

Polyester
Europe
2,8%

Polypropylene
Europe
7,4%

Polylactic Acid (PLA)
Europe
13,9%

Back ear
SAPs
Fluff
Topsheet
Sublayer
Corewrap
Cuff
Front ear
Backsheet
Hotmelt
Tape
Elastics

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PRODUCT LIFECYCLE - SINGLE USE BIOPOLYMER [2/2]

Raw materials & manufacturing | Usage | End of life

Incineration
99%

Amount of waste:

- Diapers (~ 15%)
- Organic material (~ 85%)

Electricity

Heat

ARN
1%

Amount of waste:

- Diapers (~ 15%)
- Organic material (~ 85%)

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PRODUCT LIFECYCLE - REUSABLE CLOTH [1/3]

Cultivation, processing and production of raw materials

Bamboo
China*
85g (37%)

Cotton
India or China**
68g (29%)

Polyester
Europe
17g + 60g (33%)

Viscose
Europe
2,3g (1%)

Inner diaper

Diaper cover

Inlay

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PRODUCT LIFECYCLE - REUSABLE CLOTH [2/3]

Raw materials & manufacturing | **Usage** | End of life

Number of diapers per kid - Parttime

Number of diapers:
- Washable
- Disposable
- Viscose inlay

Number of diapers per kid - Fulltime

Number of diapers:
- Washable
- Disposable
- Viscose inlay

Total number of changes per kid: TBD

- Number of weeks they wear washable diapers
- Number of washes per week
- Impact per wash:
    - Water use
    - Energy use
    - Machine specifications:

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PRODUCT LIFECYCLE - REUSABLE CLOTH [3/3]

Raw materials & manufacturing | Usage | **End of life**

Amount of waste per baby:

- Dry diapers (~ 15%):
- Organic material (~ 85%)

After X life cycles

Incineration
99%

Electricity

Heat

AVR
1%

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