SUMMARY REPORT

Life Cycle Assessment of Disposable and Reusable Nappies in the UK 2023

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Life Cycle Assessment (LCA) of Disposable and Reusable Nappies in the UK

About children and nappies

Nappies play a key role in a child's health and well-being, as well as ensuring convenient hygiene for the whole family. They are used to absorb and contain excreta produced by a child in their early years particularly the first 2.5 years of life. After this period, children are generally less dependent due to potty training, with nappies being used mostly at night-time or not at all.

The environmental impacts and economic costs of nappies is an increasingly important factor amongst policy makers, industry and wider society. Published environmental analysis for nappies in the UK using Life Cycle Assessment (LCA) methodology is old, dating back to 2008. Since then, there have been advances in the design and materials used in both disposable and reusable nappies, in the efficiency of washing machines and tumble dryers, the grid energy mix at a national level as well as changes to the way the materials are dealt with at end of life.

In 2021, Defra commissioned the environmental consultancy Giraffe Innovation (UK) to provide an independent and objective Life Cycle Assessment study of nappy use in the UK. Life Cycle Assessment (LCA) is a technique used to assess the environmental performance of a product over the entire life cycle, from raw material extraction through to product manufacture, distribution, use and final disposal. The study is aligned with the latest methods laid down in international standards (ISO14040/ISO14044).

Positively, since the previous LCA study it can be generally stated that the sector has made improvements in the design, material intensity and environmental impact of their respective products. For example, the disposable nappy results show a ~27% reduction in the carbon footprint (CO_2eq) and the reusable nappy carbon footprint shows a ~38.5% reduction compared to a 'flat cloth' (Terrys) modelled in the previous study[1].

The nappies that are used today in the UK fall into two distinct groups, disposables and reusables. These two forms, although fulfilling essentially the same function, are fundamentally different in material composition, design and in use. Disposable nappies are single use items with no need for washing. Once used, the nappies containing excreta are generally thrown away with other household waste. Reusables are home laundered and re-used a number of times with excreta often flushed down the toilet.

[1] Please note this study is based on aggregated data sets so comparisons are indicative of a range of products and direct comparisons can't be made on a product-by-product basis. As the previous studies used different life cycle indicators, LCA system and modelling methodology, direct comparisons with the previous reports should be done with caution.

Study aims

The goal of this study is to determine the cumulative environmental impact of the use of a disposable and a reusable nappy system for the first 2.5 years of a child's life in the UK.

For each nappy studied, all key inputs were considered including materials, production, transportation, use (number of changes and flushing of faeces, washing), and end of life treatment.

The results of this study are predicated upon aggregated data sets (2020-2021) for disposable nappies from major manufactures and 4 reusable nappy producers combining 8 different reusable nappies from 13 different washable/ reusable nappy components (nappy systems). The results are therefore based upon the following nappy formats:

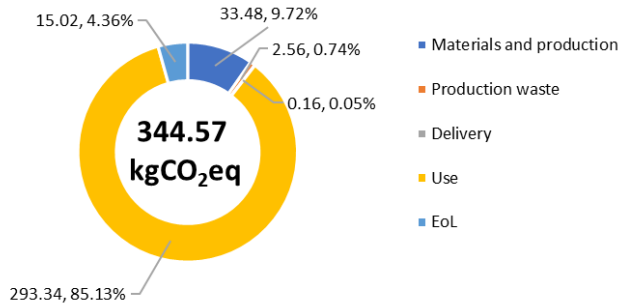
- **Disposable nappies** - single use nappies with super absorbent polymer (SAP) and cellulose fluff to retain the urine. They are available in a range of sizes from new-born upwards.
- **Reusable nappies (home laundered)** covered in this study are available in three different designs:
    - 'Pocket nappy' - consist of a waterproof outer and a fleece inner. An opening along the back of the nappy allows an absorbent pad to be inserted and to change soiled pads.
    - 'All-in-one nappy' - incorporates an absorbent inner ('core') with an attached waterproof outer layer sewn together and can be used without additions as a complete nappy system.
    - 'All in two nappy' - incorporates an inner absorbent pad ('insert') that attaches to the outer waterproof layer ('wrap') with poppers to form a one-piece nappy. The pads can be removed for washing independently of each other and reuse. Both the absorbent inner and waterproof outer must be used together to comprise a complete nappy system.

Results

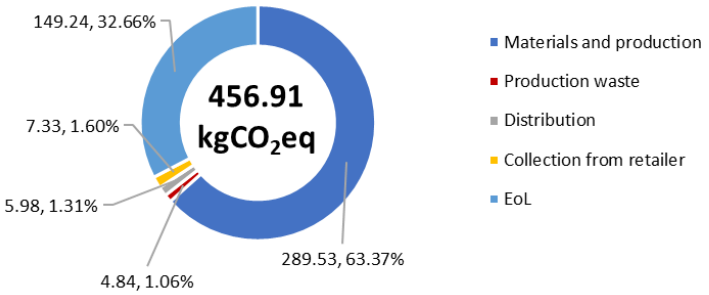
The study provides the results from an environmental analysis across 18 environmental impact categories, each given equal significance. As an example of the impacts, the Global warming potential (GWP) (carbon footprint) for disposable nappies for the first 2.5 years of a child's life is 456.91kgCO_2eq. The largest environmental impact (CO_2eq) is due to the materials and production (~63%) followed by the end of life (EOL) treatment of the nappies, faeces and urine (~33%). For the reusable nappies for the 2.5 years of use is 344.57kgCO_2eq. The use phase (energy use in washing and detergent impact) is by far the largest contributory factor to the carbon footprint (~85%).

To put these results in context for one child using reusable nappies, over 2.5 years, this is comparable with driving a car[2] ~1223 miles or ~4.8 return journeys from London to Nottingham in the UK. For one child using disposable nappies over 2.5 years, these impacts are roughly comparable with driving a car[3] ~1622 miles or ~6.4 return journeys from London to Nottingham in the UK.

Reusable nappy system carbon footprint (kgCO_2eq)



Disposable nappy carbon footprint (kgCO_2eq)



Although attention is often given to the Global warming potential (CO_2eq) the LCA methodology highlights variation in results across 18 main environmental impact categories plus consumer water and material consumption. The disposable nappies have a higher environmental impact in 7 categories: Global warming potential (GWP) (KgCO_2eq), Freshwater eutrophication (kg P eq), Terrestrial ecotoxicity (kg 1,4-DCB), Human non carcinogenic toxicity (kg 1,4-DCB), Land use (m^2 a crop eq), Fossil resource scarcity (kg oil eq), and water use in manufacturing (m^3). In addition, the overall consumption of materials used is also higher than reusable nappies.

Reusable nappies have a higher environmental impact across 11 of the impact categories: Stratospheric ozone depletion (kg CFC11 eq), Ionizing Radiation (kBq Co-60 eq), Ozone formation-human health (kg NOx eq), Fine particulate matter formation (kg PM2.5 eq), Ozone Formation-terrestrial ecosystems (kg NOx eq), Terrestrial

[2] Petrol golf CO_2e per mile = 0.28159g. UK Government GHG Conversion Factors for Company Reporting 2021
[3] Ibid

acidification (kg SO_2 eq), Marine eutrophication (kg N eq), Freshwater ecotoxicity (kg 1,4-DCB), Marine ecotoxicity (kg 1,4-DCB), human Carcinogenic toxicity (kg 1,4-DCB), Mineral resource scarcity (kg Cu eq) plus Water Consumption (flushing of toilet and washing machine use) (m^3). The main contributing factors (aside from materials) is electricity used in pre-washing, washing and drying operations detergent use and the treatment of wastewater (toilet flushing and washing machine).

Impact category	Unit	Disposable nappy	Reusable nappy system	Units difference	% Difference	Main cause for difference
Global warming potential	kg CO_2eq	456.91	344.57	112.34	25%	Nappy materials/EOL
Stratospheric ozone depletion	kg CFC11 eq	2.33E-04	4.13E-04	1.79E-04	77%	Energy, detergent, water use and EOL[a]
Ionizing radiation	kBq Co-60 eq	46.01	88.02	42	91%	Electricity use
Ozone formation, Human health	kg NOx eq	0.85	0.95	0.1	12%	Electricity use
Fine particulate matter formation	kg PM2.5 eq	0.45	0.55	0.1	22%	Electricity use
Ozone formation, Terrestrial ecosystems	kg NOx eq	0.89	0.97	0.08	9%	Electricity use
Terrestrial acidification	kg SO_2 eq	1.04	1.3	0.27	26%	Electricity use
Freshwater eutrophication	kg P eq	0.23	0.17	0.06	26%	SAP/PP[c]/EoL
Marine eutrophication	kg N eq	0.06	0.26	0.2	333%	Wastewater treatment/electricity use
Terrestrial ecotoxicity	kg 1,4-DCB	1903.33	1657.93	245.4	13%	Distribution, SAP[b] and EOL
Freshwater ecotoxicity	kg 1,4-DCB	26.16	28.18	2.02	8%	Energy, detergent and water use
Marine ecotoxicity	kg 1,4-DCB	35.61	46.1	10.49	29%	Electricity use/ EOL
Human carcinogenic toxicity	kg 1,4-DCB	18.82	19.09	0.27	1%	Minimal difference
Human non-carcinogenic toxicity	kg 1,4-DCB	486.54	478.33	8.21	2%	Minimal difference
Land use	m^2 a crop eq	73.06	61.69	11.37	16%	Pulp
Mineral resource scarcity	kg Cu eq	0.74	1.29	0.55	74%	Electricity and detergent use
Fossil resource scarcity	kg oil eq	153.16	112.48	40.68	27%	SAP/PP
Water consumption manufacturing use	m^3	7.8	7.11	0.68	9%	Minimal difference

Note [a] end of life, [b] super absorbent polymer, [c] polypropylene

The main causes for the differences between the two types of nappies are:

- The quantity of materials used in the disposable materials compared to the reusables.
- Electricity used for prewashing, washing and tumble drying the reusable nappies.
- Water used by the washing machine and toilet flushing.
- The treatment of the wastewater and detergent.

Sensitivity Analysis

Although not critical to the conclusions of the study, a sensitivity analysis was undertaken in order to determine variables that will impact on the total environmental impacts of the results.

Consumer research[4] has indicated that since the last LCA study, a percentage of children are being potty trained at a later stage in their development. The results also showed that at 2.5 years 37% of babies using disposables and 35% of babies using reusable nappies were still in nappies. This is an increase of 19.4% and 17.4% respectively over the previous LCA studies. Key variables and assumptions have been tested to determine their influence on the results of the inventory analysis and impact assessment. Due to the behavioural differences in the use of nappies such as extended potty training as well as end of life treatment the following have been evaluated:

- Extended use of nappies (delay in potty training).
- Reduced use of nappies (counterfactual – accelerated potty training).

[4] You Gov – Children Potty Training. UK18 sample@ 30th March to 7th April 2021. Commissioned by Bambino Mio. n= 728

- Energy recovery from incineration (energy from waste) at end of life.
- Washing and drying of nappies.
- Reuse of nappies for a second child.
- Flushing of faeces off the disposable nappies.
- Washing and drying of nappies.
- Retailer and consumer transport.

Overall, across the various sensitivities applied to the data the changes to usage pattern (e.g., extended nappy use) does not significantly alter the environmental impact categories where each nappy type has a higher or lower impact although it does increase the Global warming potential (CO_2eq) by 9% for disposable nappies and 3% for reusable nappies.

Conclusions

This updated LCA study shows the latest environmental impacts and the main source for these impacts between nappy formats in the UK. The study was supported by key industry representatives.

User behaviour plays an important role in understanding and mitigating the environmental impact of nappies. Consumer research indicates that children are being potty trained at a later stage in their development. If this behaviour is indicative, further interventions such as educating parents on the merits of potty training at an earlier stage would have positive benefits from an environmental and social point of view.

There is currently limited nappy recycling undertaken in the UK. This merits further investigation into the potential benefits of nascent technologies and infrastructure for disposable nappy recycling. Those developing these products can use this study to help shape more sustainable designs of nappies and to deliver more sustainable and circular waste management.

Whilst the disposable nappies have a higher Global warming potential (CO_2eq), reusable nappies have a higher impact in other environmental categories. These are mainly due to the electricity used in prewashing, washing and tumble drying the reusable nappies, water used by the washing machine and toilet flushing and the treatment of the wastewater and detergent.

As we re-examine the impacts of what we produce, use, and the waste we generate we need an evidence-based approach to understanding of all the environmental impacts of products and services. This where these Life Cycle Assessment (LCA) results can be used.