# Comparative Life Cycle Assessment of Hand Drying Systems: Excel Hand Dryers and Paper Towel Systems

May 2023

**Authors:**
TrueNorth Collective
Julissa Freund – LCA Practitioner
Cher Xue – Program Manager, Carbon Strategy

**Commissioner:**
Excel Dryer Inc.

**Review Panel (LCA) or Verifier (EPD):**
Anna Lasso – LCACP, Smart EPD (chair)
Dr. Thomas Gloria – LCACP, Industrial Ecology Consultants
Alison Conroy – LCACP, Independent Consultant

# Contents

# List of Tables

# List of Figures

# Acronyms

| | |
|---|---|
| ABS | Acrylonitrile butadiene styrene |
| EPD | Environmental Product Declaration |
| ESL | Estimated Service Life |
| GWP | Global Warming Potential |
| C | Carcinogenics |
| NC | Non-Carcinogenics |
| E | Ecotoxicity |
| WC | Water Consumption |
| IR | Infrared |
| LCA | Life Cycle Assessment |
| LCI | Life Cycle Inventory |
| LCIA | Life Cycle Impact Assessment |
| PCR | Product Category Rule |
| RSL | Reference Service Life |
| SB | Brushed Stainless Steel |
| SS | Stainless Steel |

# 1. Executive Summary

Excel Dryer is a family-run company dedicated to innovation and cutting-edge technology backed by handmade quality and personal service. Excel Dryer commissioned TrueNorth Collective to conduct a Life Cycle Assessment (LCA) and create Environmental Product Declarations (EPDs) on its four hand dryers, (XLERATOR® Hand Dryer, XLERATOReco® Hand Dryer, ThinAir® Hand Dryer, and XLERATORsync®) that have reached high use energy efficiency.

The LCA method examines a broad range of environmental impacts at all stages of a product life cycle, from "cradle-to-grave", including all material, energy, water, and pollutant inputs and outputs. The goal of this report is to support the comparative assessment between paper towels and hand dryers as two methods for commercial application and to also provide the necessary background data to support the Environmental Product Declarations (EPD) creation for the four Excel hand dryer products.

The comparative portion of this study compares the cradle-to-grave life cycle impacts of four Excel Hand Dryers with a paper towel baseline, which includes paper towel containing 0% and 100% recycled content with 2 sheets per use of hand drying. The paper towel scenario includes other materials besides the paper towel tissues for a complete paper towel hand drying station (i.e., wastebin, waste liner, dispenser, dispenser batteries, and dispenser infrared (IR) sensor). The comparison is based on drying 260,000 pairs of hands (The functional unit of the EPD model is 100,000 pairs of hands, as dictated by the Product Category Rules).

For both the comparative LCA and EPD, six impact categories are considered: IPCC 2013's Global Warming Potential and TRACI 2.1's Acidification Potential, Eutrophication Potential, Smog Formation Potential, Ozone Depletion Potential and Fossil Depletion Potential. For the comparative LCA, four additional impact categories are considered on top of the ones listed above: ReCiPe's Water Consumption and TRACI 2.1's Carcinogenics, Non Carcinogenics, and Ecotoxicity. The comparative results indicate that the Excel dryers have between 80% to 97% fewer impacts than the paper towel baseline containing 0% recycled content, and 81% to 96% fewer impacts than the paper towel baseline containing 100% recycled content. The Excel dryers' life cycle impacts are driven by the use stage, while the life cycle impacts of the paper towel baselines are driven by the raw material and manufacturing stages. **Figure 1** below summarizes the trend of the comparative results in cradle-to-grave Global Warming Potential.

A sensitivity analysis on use intensity is conducted to evaluate the effect of dry time of the hand dryers (increases to twice of the dry time per use, namely "1 cycle" and "2 cycles"), and the amount of paper towels used per hand drying (increases from 1 sheet to 4 sheets per use). As shown in **Figure 2** below, dryers have fewer environmental impacts no matter how many sheets of paper towel are used per hand drying, even when dryers run double of the dry time duration.

Another sensitivity analysis on use phase electricity grid carbon intensity is conducted to evaluate the effect of different electricity grid mix on running the hand dryers. As shown in **Figure 2** below, represented by XLERATORsync®, which has the highest impacts among the four studied Excel dryers, it achieves from 58% to 98% reduction in global warming potential impacts, compared with paper towel baselines. Even with a high carbon intensity electricity grid (i.e., 100% coal), the impacts of XLERATORsync® increase by 147%, from 857 kg $CO_2$eq to 2120 kg $CO_2$eq, it still achieves a 58% or 52%

reduction in global warming potential impacts, compared with paper towel scenarios with 0% or 100% recycled content, respectively.

A final sensitivity analysis on allocation of recycled content is conducted to evaluate the effect of different allocation of recycled content of the paper towel scenario containing 100% recycled content. As shown in **Figure 2** below, no matter which allocation method is used it does not change whether paper towels are preferred over the Excel dryers. This is due to the majority of paper towel burden coming from paper towel manufacturing, which is unaffected by either allocation choice.

Overall, the comparative analysis results are favorable for the four studied Excel dryers. The energy efficiency of Excel dryers enables the dryers to have a great advantage when comparing with paper towel baselines, especially for the models that use less energy per hand drying. The cradle-to-grave global warming potential of dryers can be 83% less than the cradle-to-grave global warming potential of paper towel baseline with 0% recycled content (81% less that the impacts of paper towel baseline with 100% recycled content), as shown by the results of XLERATOReco®, the most energy efficiency model among the four Excel products. XLERATOReco® is the no heat version of the standard XLERATOR® hand dryer and uses less energy during use (530W, 120V, compared to 1450W, 120V for XLERATOR®).

Furthermore, with the importance of decarbonizing the buildings sector is widely recognized now and to achieve the Paris Agreement goals, the global buildings and construction sector must achieve net-zero emissions by 2050, and all new buildings must be net-zero carbon starting in 2030. To reduce the direct emissions from the building sector, it involves major effort for most old buildings and all new ones to comply with zero-carbon-ready building energy code. It means achieving high energy efficiency and either using renewable energy directly, such as photovoltaics (PV), solar thermal hot water, and hydrogen, or using an energy supply that will be fully decarbonized by 2050. In addition, increasing the electrification of buildings using technologies available today, alongside a decarbonizing grid, is the primary solution for addressing building emissions from indirect sources. In both cases, Excel dryers can provide the building sector a better solution through the dryer’s high energy efficiency, low maintenance needs and electrification of hand drying.

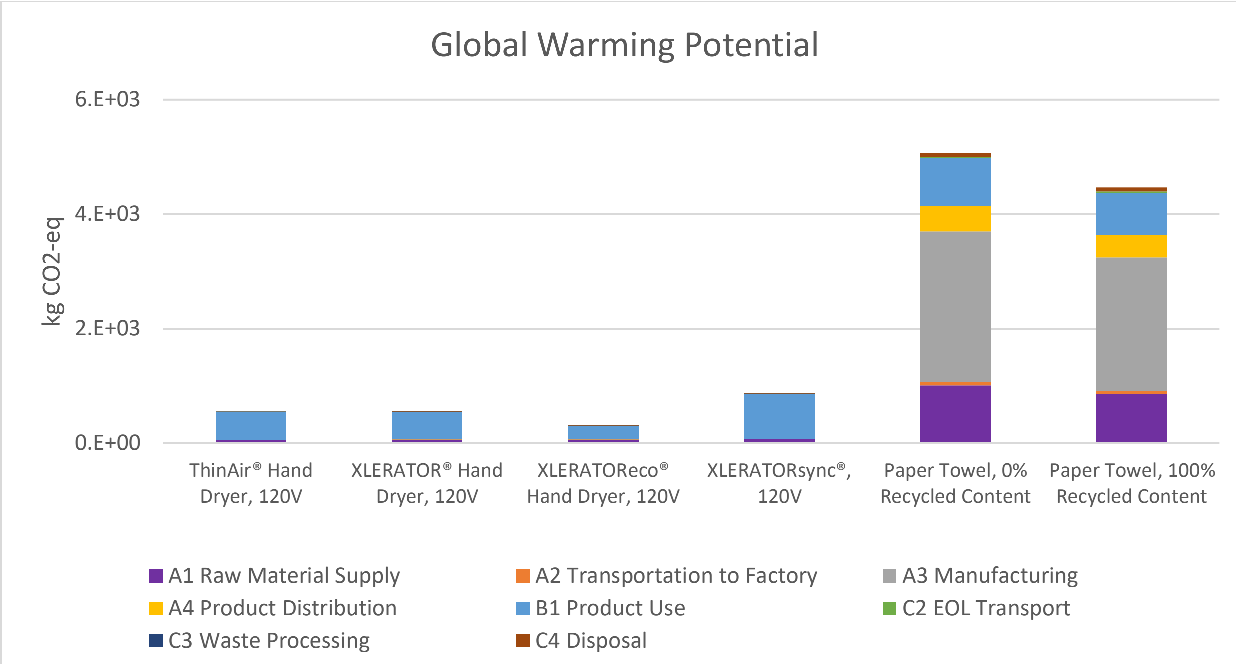



Figure 1: Comparative LCA: Global Warming Potential

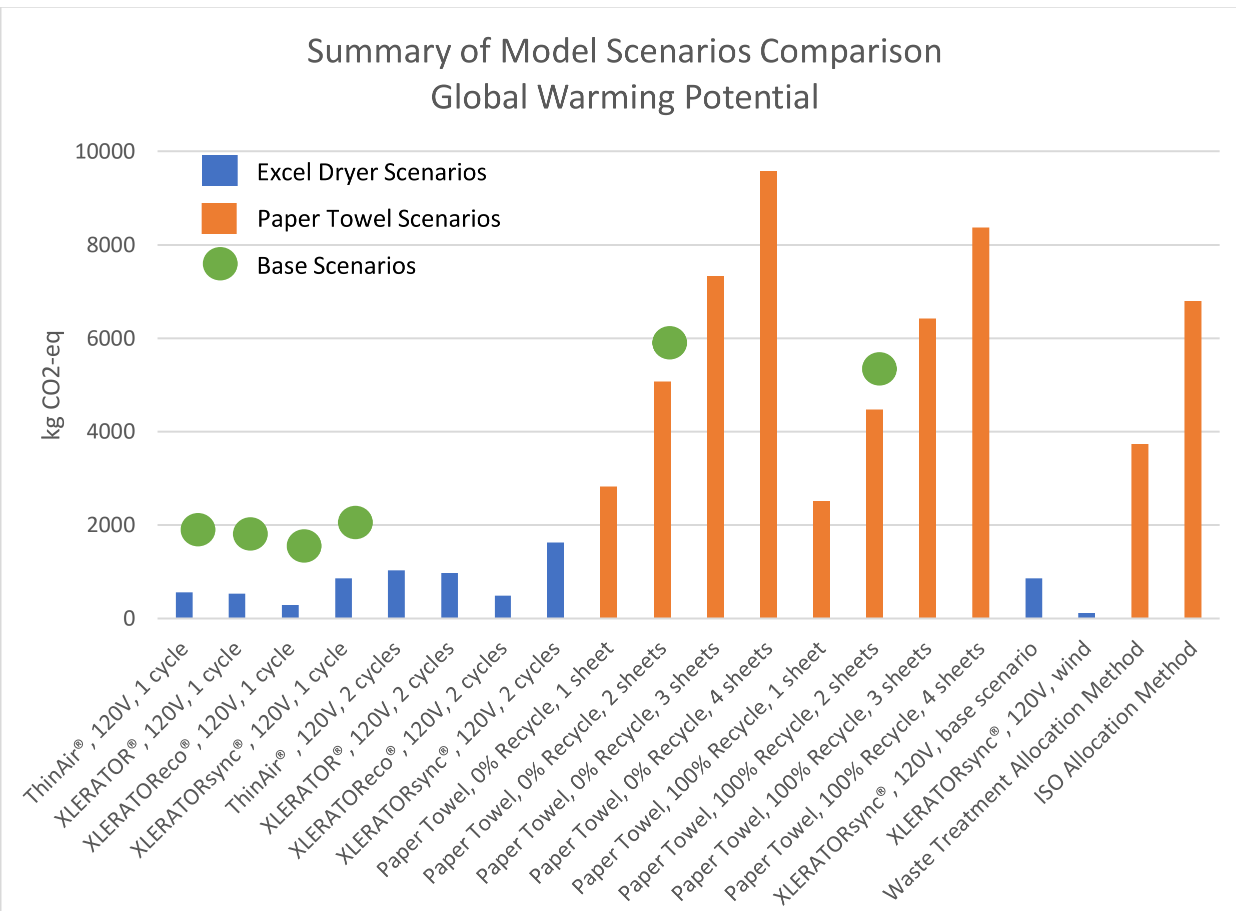



Figure 2: All Model Scenarios

## 2. Project Overview

Excel Dryer is a family-run company dedicated to innovation and cutting-edge technology backed by handmade quality and personal service. Excel Dryer commissioned TrueNorth Collective to conduct a Life Cycle Assessment (LCA) and create Environmental Product Declarations (EPDs) on its four hand dryers, (XLERATOR® Hand Dryer, XLERATOReco® Hand Dryer, ThinAir® Hand Dryer, and XLERATORsync®). **Figure 3** to **Figure 6** below present a schematic of the four Excel hand dryers.


Figure 3: XLERATOR® Hand Dryer as shown in Model XL-W White Epoxy Painted Cover


Figure 4: XLERATOReco® Hand Dryer as shown in Model XL-W-ECO White Epoxy Painted Cover

Figure 5: ThinAir® Hand Dryer as shown in Model TA-SB Stainless

Figure 6: XLERATORsync® Hand Dryer as shown in Model XL-SYNC-C with Chrome Nozzle

There are many alternatives to hot air hand dryers in fulfilling the function of hand drying, most notably paper towels. While a comparison in energy between paper towels and hand dryers during the consumer use phase per dry seems straightforward, it is not clear how the Excel hand dryers compare with paper towel in all the life cycle stages throughout the entire life cycle, and for a complete set of environmental performance metrics. This report is the second iteration of an existing report published in 2009 and aims to provide updated results for Excel dryers and paper towels considering the potential product innovations.

LCA is a credible framework to evaluate environmental impacts and identify low impact/ high benefit practices and support decisions that lead to reduced environmental impacts across multiple categories – from ecosystem health to resource depletion. In this study, LCA is applied to assess environmental performance and to publish EPD's, following applicable Product Category Rules (PCR) and ISO standards.

The LCA will be conducted in accordance with the following standards:

- ISO 14040: Environmental management – Life cycle assessment – Principles and framework, International Organization for Standardization, 2006 (ISO 14040, 2006).
- ISO 14044: Environmental management – Life cycle assessment – Requirements and Guidelines, International Organization for Standardization, 2006 (ISO 14044, 2006).
- Product Category Rules for Hand Dryers – For preparing and Environmental Product Declaration (EPD) for the Product Category: Hand Dryers, (UL 10007, Version 1, 2016).
- ISO 14025: Environmental labels and declarations — Type III environmental declarations — Principles and procedures, International Organization for Standardization, 2006 (ISO 14025, 2006).

This report is intended as an LCA background report that will support a public comparative assertion and will support the generation of EPDs. TrueNorth will then be conducting the EPDs for Excel Dryer on its four hand dryers.

The results of the comparative LCA and EPD are intended to be communicated externally. This study is undergoing a critical review by panel of experts and LCA/EPD verification by SmartEPD, the EPD program operator selected by Excel Dryer.

# 3. Goal and Scope Definition

The first phase of an LCA defines the goal and scope of the study. According to (ISO 14044, 2006), the goal of the study should clearly specify the intended application, reasons for carrying out the study, the intended audience, and whether the results are intended to be disclosed to the public. The scope describes the most important aspects of the study, including the declared unit, system boundaries, cut-off criterion, allocation, impact assessment method assumptions and limitations.

For the EPDs, many of these components are specified in the Hand Dryers Products Product Category Rules (PCR):

- Product Category Rules for Hand Dryers – For preparing and Environmental Product Declaration (EPD) for the Product Category: Hand Dryers, (UL 10007, Version 1, 2016).[1]

### 3.1 Objective

One of the goals of this study is to understand the environmental impacts associated with each stage in the life cycle of the four Excel hand dryers, comparing with a paper towel baseline. The targeted audience include Excel Dryer internal leadership and R&D teams, purchasers of different hand-drying systems and Excel Dryer USA customers. The primary intended applications include informing Excel Dryer of product improvement opportunities and purchasers of hand-drying systems to assist in their purchasing decisions. The report will be made available to anyone who's interested in understanding the environmental impacts of different hand-drying systems and the comparative results of Excel hand dryers and paper towel baseline. It is intended to provide these audiences with information needed to make a valid comparison of the life cycle environmental impacts of the systems under assessment. It is important to note that the impacts described here are estimates of potential impacts, rather than direct measurements of real impacts.

The second goal of this study is to publish EPDs, which transparently communicate the environmental impacts associated with each of the four Excel hand dryers over its lifetime. Having the product EPDs will support fulfillment of customer product transparency requests with credible, third-party verified documentation, enable a competitive advantage with an approach capable of demonstrating how Excel Dryer products may contribute to achievement of maximum green building certification credit.

This study is based on the attributional LCA approach, which describes the physical reality of an existing supply chain by quantifying the energy and material flows to and from an existing life cycle.

### 3.2 System Description Overview

The products under study are options for providing hand-drying services in public restrooms. The baseline product is paper towels, including scenarios regarding the percent of recycled content from 0% to 100%. The other products are Excel hand dryers. **Table 1** below summarizes the main features of each product in this study.

---

[1] *UL has given a one-year extension for the PCR.*

Table 1: Key Characteristics of the Products Studied

| | XLERATOR® Hand Dryer | XLERATOReco® Hand Dryer | ThinAir® Hand Dryer | XLERATORsync® | Paper Towels |
|---|---|---|---|---|---|
| **Declared Product** | Hand dryer operating at 120V, 208V, 230V | Hand dryer operating at 120V, 208V, 230V | Hand dryer operating at 120V, 208V, 230V | Hand dryer operating at 120V | Dispenser, wastebin, waste liners and paper towels |
| **Use phase inputs and assumptions** | Drying time 1 cycle: 8 sec<br><br>plus 0.7 sec shutdown at half power and standby electricity draw | Drying time 1 cycle: 10 sec<br><br>plus 0.7 sec shutdown at half power and standby electricity draw | Drying time 1 cycle: 14 sec with 915 watts of electricity draw<br><br>plus 0.7 second shutdown at half power | Drying time 1 cycle: 14 sec with 1440 watts of electricity draw<br><br>plus 0.7 second shutdown at half power | 2 sheets of paper towel(s) with 0% and 100% recycled content<br><br>2.56 g or 2.25 g per towel for 0% and100% recycled content, respectively |
| **Housing components** | Zinc, stainless steel or reinforced resin (even combination of 3 optional covers) | Zinc, stainless steel or reinforced resin (even combination of 3 optional covers) | ABS or SB (even combination of 2 optional covers) | ABS | Polypropylene |
| **Internal components** | Motor, fan, optical sensor, wiring | Motor, fan, optical sensor, wiring | Motor, fan, optical sensor, wiring | Motor, fan, optical sensor, wiring | Motor, optical sensor, batteries |
| **Manufacturing location** | East Longmeadow, MA, USA | | | | USA |
| **Distribution** | Shipped as single units or on pallets to distributor | | | | |
| **Supply chain distances** | Varies, modeled for > or = 90% of material by weight and scaled up to represent all supplier transportation | | | | 750 km by truck and 750 km by ship for all components |
| **Packaging materials** | Plastic linear bag within corrugated cardboard box, with molded pulp end caps, some with foam inserts | | | | Dispenser in plastic liner bag within corrugated cardboard box, with molded pulp end caps; towels in corrugated cardboard box |
| **Recycling rates** | Packaging recycled at national material average; dryer components not recycled | | | | Packaging recycled at national material average; dispenser components not recycled; towels not recycled |

## 3.3 Functional Unit

A functional unit identifies the primary function(s) of a system based on which alternative systems are considered functionally equivalent (ISO 14040, 2006). This facilitates the determination of reference flows for each system, which in turn enables the comparison of two or more systems.

The purpose of the products in question is to dry hands after washing in a public restroom. The definition of drying a pair of hands is to dry one's hands to a dryness threshold equaling 0.25 grams residual moisture or less, which is consistent with the PCR for hand dryers (UL 10007, Version 1, 2016) and apply to both use cases of paper towels and hand dryers. According to the NSF Protocol P335 (NSF, 2007), hygiene is part of the protocol for commercial hand dryers. Although hygiene is another purpose for hand dryers that is of interest to the scientific community (Materials Systems Laboratory, 2011), hygiene is not considered in this study. For the comparative analysis, the functional unit is to dry 260,000 pairs of hands, assuming 500 uses per week over a 10-year lifetime. This 10-year lifetime was suggested by Excel Dryer as a lower range of the likely lifetime of such systems. The same functional unit was used in the previous version of the comparative analysis.

For EPD creation, per the referenced PCR for hand dryers (UL 10007, Version 1, 2016), the functional unit is 100,000 instances of hand drying. According to the PCR, total years of estimated service life (ESL) is based on the product's reference service life (RSL) and an average frequency of 200 uses per day (73,000 uses per year). The RSL is 10 years, therefore, ESL is equivalent to 730,000 uses.

The corresponding reference flow is calculated as shown in **Table 2** below. The reference flow is one or a fraction of one complete hand dryer and will be applied to Life Cycle Inventory (LCI) in applicable life cycle stages and Life Cycle Impact Assessment (LCIA) results are communicated based on this unit.

Table 2: Declared Unit

| Purpose | RSL | Functional Unit/ESL | Reference Flow |
|---|---|---|---|
| **Comparative Analysis** | 260,000 uses over 10 years of service life | 260,000 Hand Drying Instance | One unit of product |
| **EPD Creation** | 730,000 uses over 10 years of service life | 100,000 Hand Drying Instance | 0.137 unit of product (100,000/730,000) |

### 3.4 Study Boundaries

The system boundary for the comparative analysis and EPDs are cradle-to-grave, covering supplied raw materials (A1), transport from suppliers to Excel Dryer (A2), production of manufactured products (A3), transport out of Excel facilities (A4), use of the product (B1), transport to end-of-life facilities (C2), and waste processing and disposal of the product (C3 and C4).

For the comparative study, **Figure 7** and **Figure 8** illustrates the paper towel baseline system boundary.

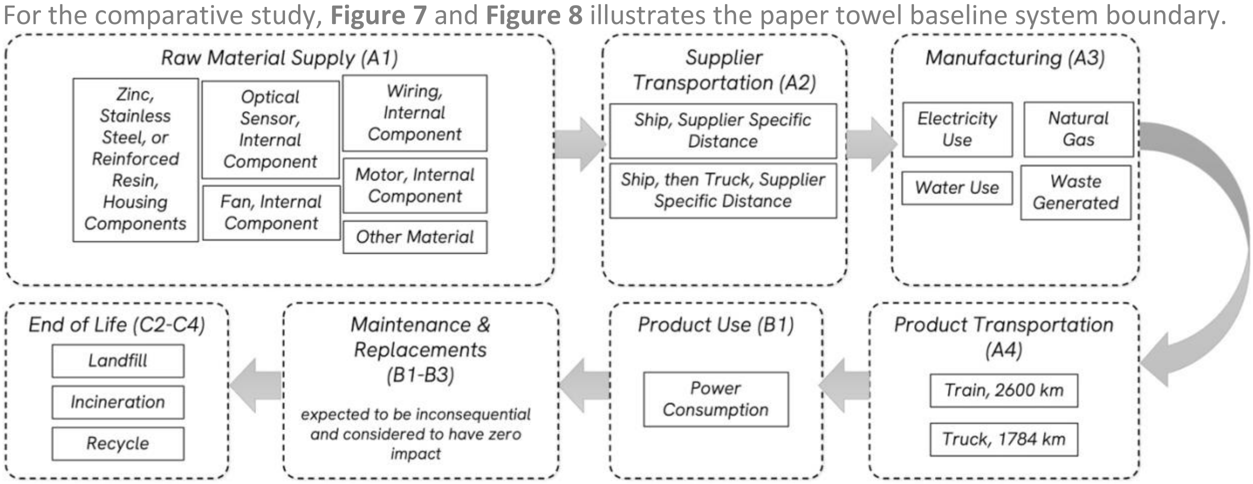


Figure 7: Illustrates the System Boundary of Excel Hand Dryers

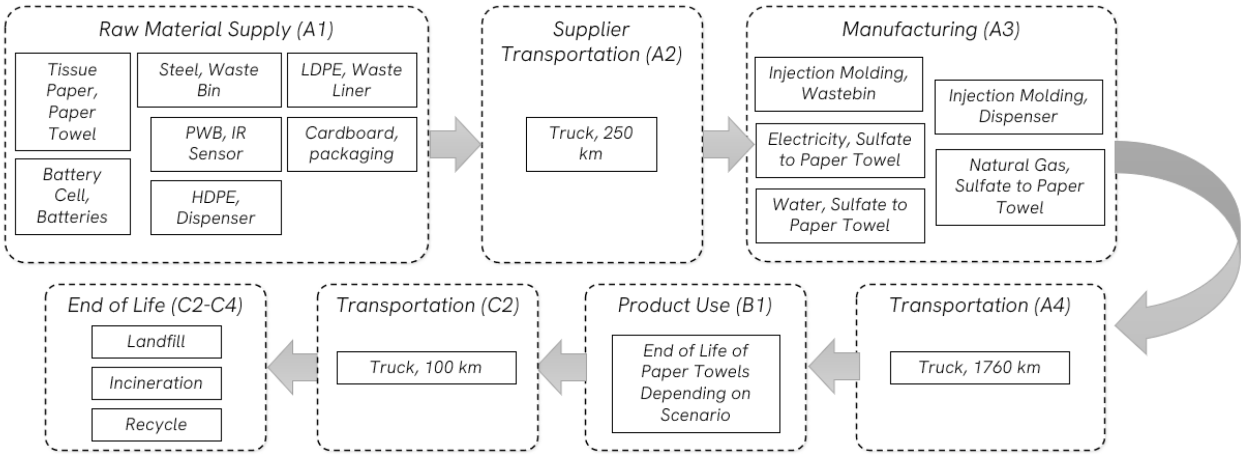



Figure 8: Illustrates the System Boundary of Paper Towel Baseline

For the EPDs, per the guiding PCR (UL 10007, Version 1, 2016), the system boundaries of the LCA and EPD shall follow the modular structure in line with ISO 21930 (ISO 21930, 2017), as shown in **Table 3**.

Table 3: System Boundary Modules

| PRODUCT STAGE | | | Installation STAGE | | USE STAGE | | | End of Life STAGE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | A2 | A3 | A4 | A5 | B1 | B2 | B3 | C1 | C2 | C3 | C4 |
| Raw Material Supply | Transport | Manufacturing | Transport from gate to site | Assembly/ Install | Use | Maintenance | Replacement | Removal | Transport | Waste Processing | Disposal |
| X | X | X | X | MND | X | X | X | MND | X | X | X |

*MND: module not declared

### 3.5 Excluded Processes

A number of processes are excluded from the study, as allowed by the PCR (UL 10007, Version 1, 2016). Typically, in an LCA, some aspects within the set boundaries are excluded due to statistical insignificance or irrelevancy to the goal and scope. The following activities were excluded from the scope and boundaries for this study:

- Installation module (A5) is not declared as it identified as an optional life cycle stage according to the PCR.
- Modules B2 and B3 were considered to have zero impact and are therefore not shown in the results of this EPD. In the case of B2, the cleaning process involves blowing dust off the product and wiping down the cover as needed. These activities are expected to be inconsequential in the life cycle of the product system and therefore maintenance impacts are excluded. In the case of B3, Replacement is not relevant because the functional unit is shorter than the predicted reference service life (RSL), which is the cycles of operation over the estimated service life (ESL).
- Removal module (C1) is not declared and is optional reported elements according to the PCR.

In addition, the following activities were excluded:

- Human activities (e.g., employee travel to and from work)
- R&D (i.e., the laboratory and inputs related to the development of the technologies)
- Services (e.g., the use of purchased marketing, consultancy services and business travel).
- Construction of capital equipment and maintenance and operation of support equipment

### 3.6 Cut-Off Criteria

All known mass and energy flows are included; no known flows are excluded. All upstream and downstream activities are included using a combination of primary and secondary data. While the majority of inventory data are sourced from primary resources, representative proxies are used to close gaps in the absence of primary data.

### 3.7 Allocation & Recycling

While conducting an LCA, if the life cycles of more than one product are connected, allocation of the process inputs should be avoided by using the system boundary expansion approach. In accordance with the PCR (UL 10007, Version 1, 2016) and (ISO 14040, 2006) series, mass should be used as the primary basis for co-product allocation. The allocations of relevance for calculation (appropriation of impacts across various products) shall be indicated, at least:

- Allocation in the use of recycled and/or secondary raw materials.
- Allocation of energy, ancillary and operating materials used for individual products in a factory.

No multi-output allocation was necessary in the foreground of the study. Allocation of secondary data taken from ecoinvent v3.8 cut-off by classification has allocation applied to it.

For the cradle-to-grave boundaries, this study uses the cut-off approach method for recycling. According to this approach, the first life of a material bears the environmental burdens of its production (e.g., raw material extraction and processing) and the second life (e.g., scrap input) bears the burdens of refurbishment (e.g., collection and refining of scrap). The burdens from waste treatment are taken by the life after which they occur. However, due to one of the paper towel scenarios being made out of 100% recycle content, two allocation strategies were tested and can be seen in the fourth sensitivity analysis.

### 3.8 Impact Assessment Method

Impact assessment methods are used to convert LCI data (environmental emissions and raw material extractions) into a set of environmental impacts. For the comparative LCA, Excel Dryer products are assed based on all the impact categories listed in **Table 4**. While the EPD is only looking at the first six impact categories in **Table 4**, which is in compliance with the PCR (UL 10007, Version 1, 2016).

Table 4: Life Cycle Impact Assessment Categories

| Impact Category | Description | Unit | Method |
|---|---|---|---|
| **GWP 100** | Global Warming Potential (GWP) | kg $CO_2$ eq. | IPCC 2013 GWP100 – Fossil V100 (IPCC, 2013) |
| **AP** | Acidification Potential | kg $SO_2$ eq. | TRACI 2.1<br>(Bare, Norris, Pennington, & McKone, 2003)<br>(Bare, Gloria, & Norris, 2006) |
| **EP** | Eutrophication Potential | kg N eq. | TRACI 2.1<br>(Bare, Norris, Pennington, & McKone, 2003)<br>(Bare, Gloria, & Norris, 2006) |
| **SFP** | Smog Formation Potential | kg $O_3$ eq. | TRACI 2.1<br>(Bare, Norris, Pennington, & McKone, 2003)<br>(Bare, Gloria, & Norris, 2006) |
| **ODP** | Ozone Depletion Potential | kg CFC-11 eq. | TRACI 2.1<br>(Bare, Norris, Pennington, & McKone, 2003)<br>(Bare, Gloria, & Norris, 2006) |
| **FDP** | Fossil Depletion Potential | MJ Surplus | TRACI 2.1<br>(Bare, Norris, Pennington, & McKone, 2003)<br>(Bare, Gloria, & Norris, 2006) |
| **C** | Carcinogenic | CTUh | TRACI 2.1<br>(Bare, Norris, Pennington, & McKone, 2003)<br>(Bare, Gloria, & Norris, 2006) |

| | | | |
|---|---|---|---|
| **NC** | Non-Carcinogenic | CTUh | TRACI 2.1<br>(Bare, Norris, Pennington, & McKone, 2003)<br>(Bare, Gloria, & Norris, 2006) |
| **E** | Ecotoxicity | CTUe | TRACI 2.1<br>(Bare, Norris, Pennington, & McKone, 2003)<br>(Bare, Gloria, & Norris, 2006) |
| **WC** | Water Consumption | m3 | ReCiPe 2016 v1.1 midpoint, Hierarchist perspective, V1.06 |

These six impact categories are globally deemed mature enough to be included in Type III environmental declarations. Other categories are being developed and defined and LCA should continue making advances in their development. However, the EPD users shall not use additional measures for comparative purposes.

Global Warming Potential (GWP): Aligned with the purpose of low carbon energy sources and high priority environmental issues, this impact category is deemed to be of high interest and relevance. Biogenic, land transformation, and fossil categories are assessed and included in estimating GWP values.
Ozone depletion potential and Smog formation: To include potential environmental impacts associated with stratospheric ozone depletion and atmospheric ozone creation, mentioned categories are added to the study.
Acidification and Eutrophication: These two categories are considered relevant to the study due to potential release of chemicals to air and water through processing and fuel combustion.
Fossil fuel depletion: Since studied solution can replace nonrenewable sources of power generation, this category is deemed relevant and therefore, is added to the assessment.

A more detailed description of the impact categories is provided in **Appendix A**: Description of impact categories.

Each impact category above was characterized by a unit of measure to which the resource and emission flows have been normalized. To aggregate the substances into the impact categories, substances are multiplied by their characterization factor to convert into an equivalent substance (e.g., $CO_2$) and then added together to create a total for each impact category (e.g., global warming potential).

The following resource inventory metrics are included, as required by the specified PCR (Section 4.1, Part A).

Table 5: Inventory Metrics

| Resource Category Indicators | Description | Unit |
|---|---|---|
| **RPRE** | Use of renewable primary energy excluding renewable primary energy resources used as raw materials | MJ, net calorific value (LHV) |
| **RPRM** | Use of renewable primary energy resources used as raw materials | MJ, LHV |
| **NRPRE** | Use of non-renewable primary energy excluding nonrenewable primary energy resources used as raw materials | MJ, LHV |
| **NRPRM** | Use of non-renewable primary energy resources used as raw materials | MJ, LHV |
| **FW** | Use of net fresh water resources | kg |

Following the ACLCA guidance document, the $RPR_M$ and $NRPR_M$ inventory metrics were calculated manually using net calorific value (lower heating value) (MJ/kg) for the raw materials with energy content that were used as materials (ACLCA, 2019). The $RPR_E$ and $NRPR_E$ were calculated as the difference between the total renewable and non-renewable primary energy, provided by the Cumulative Energy Demand (LHV) method, and the $RPR_M$ and $NRPR_M$ inventory metrics, respectively (Frischknecht, et al., 2007) (Weidema B P, 2013). The PCR and the ACLCA guidance document do not indicate if packaging materials should be included in this calculation therefore packaging is excluded from these metric calculations.

The following output flows and waste category indicators are included, as required by the specified PCR (Section 4.1, Part A).

Table 6: Output flows and Waste Category Indicators

| Output Flows and Waste Category Indicators | Description | Unit |
|---|---|---|
| **HWD** | Hazardous waste disposed | kg |
| **NHWD** | Non-hazardous waste disposed | kg |
| **HLRW** | Radioactive waste disposed | kg |
| **CRU** | Components for re-use | kg |
| **MR** | Materials for recycling | kg |
| **MER** | Materials for energy recovery | kg |
| **EEE** | Exported electrical energy | MJ, LHV per energy carrier |
| **ETE** | Exported thermal energy | MJ, LHV per energy carrier |

The following carbon emissions and removals category indicators are included, as required by the specified PCR (Section 4.1, Part A).

### 3.9 Type and Format of the report

In order to comply with the ISO 14044 (ISO 14044, 2006) requirements, this study reports the results and conclusions of the LCA completely and accurately without bias to the intended audience. The results, data, methods, assumptions, and limitations are presented in a transparent manner and in sufficient details to allow the reader to comprehend the complexities and trade-offs inherent in the LCA. This report allows the results and interpretation to be used in a manner consistent with the goals of the study supporting comparative assertions.

### 3.10 Critical Review and Verification

To ensure conformance with the ISO 14040 (ISO 14044, 2006) and ISO 14071 (ISO 14071, 2014) series standard requirements and conventions in performing Life Cycle Assessments, this study has received a formal critical review by a panel of experts.

Table 7: Panel Members

| Name | Affiliation |
|---|---|
| **Anna Lasso, chairperson** | LCACP, SmartEPD |
| **Dr. Thomas Gloria** | LCACP, Industrial Ecology Consultants |
| **Alison Conroy** | LCACP, Independent Consultant |

The EPDs and underlying LCA model are also verified by SmartEPD, the EPD program operator selected by Excel Dryer.

### 3.11 Limitations of the Study

There are several limitations in the current study that might be made a focus of future work in examining such systems.

- A significant limitation is the lack of complete and transparent information on current dispenser studies for the paper towel baseline scenario. This limitation led to the absence of several processes for the manufacturing of the dispenser. An additional area of inadequate data is regarding the type of material the optical sensor is made of. Both uncertainties are likely to produce a different result from the paper systems. Although these limitations are highlighted in this report, future opportunities might exist to fine tune the data.

### 3.12 Limitations of LCA Methodology

LCA's ability to consider the entire life cycle of a product makes it an attractive tool for the assessment of potential environmental impacts. Nevertheless, like other environmental management analysis tools, LCA has several limitations.

With the current availability of data, it is nearly impossible to follow the entire supply chain associated with the product in a company-specific way. Many of the processes within the supply chains are modeled using average industry data with varying amounts of specificity (e.g., data on a more-or-less specific technology or region). This makes it difficult to accurately determine how well the unit process data represents the actual factors in the products' life cycle.

Furthermore, LCA is based on a linear extrapolation of emissions with the assumption that all the emissions contribute to an environmental effect. This is contrary to threshold-driven environmental and toxicological mechanisms. Thus, while linear extrapolation is a reasonable approach for more global and regional impact categories such as Global Warming Potential (GWP) and Acidification, it may not accurately represent the actual on-the-ground human- and ecotoxicity-related impacts.

Additionally, even if the study has been critically reviewed, it should be noted that, as for any LCA, the impact assessment results generated for this study are relative expressions and do not predict impacts on category endpoints, exceeding thresholds, or risks (ISO 14040, 2006). It should also be noted that, even though LCA covers a wide range of environmental impact categories, some types of environmental impacts (e.g., noise, social, and economic impacts) are typically not included in LCA.

The results of the study are only applicable to the defined scenarios. Any adjustment of the study boundaries or processes may change the results. Environmental declarations from different programs may not be comparable (ISO 14025, 2006). Even when the same PCR is followed, different LCA software and background LCI datasets may lead to different results for upstream or downstream of the life cycle stages declared.

## 4. Life Cycle Inventory Data

The second phase of an LCA involves collection of LCI data. LCI data contains the details of the resources flowing into a process and the emissions flowing from a process to air, soil and water.

### 4.1 Calculation Tool

Once all the required data was obtained and the associated flows were normalized to the reference flows as shown in **Table 2** above. System modeling was performed using the commercial LCA software SimaPro (version 9.4), developed by PRé Sustainability, the Netherlands. This software allows the calculation of life cycle inventories and impact assessment, contribution analysis, parameterization and related sensitivity analysis.

### 4.2 LCI Data Collection

The study uses a combination of primary and secondary data. Where primary data were not available, ecoinvent v3.8, Cut-off at Classification and the DATASMART LCI Package, Long Trail Sustainability, version 2021.1., which contains detailed peer reviewed LCI data was used. Each data point was reviewed and verified individually.

### 4.3 LCI Data Collection for Excel Dryer

Under the direction of TrueNorth, primary data listed below was collected by Excel through customizable templates, emails and web calls, and reviewed internally by TrueNorth to ensure completeness and credibility. Common practices such as mass balance, energy balance and stoichiometry were considered. Final model inputs were reviewed by the client to verify key assumptions.

- Facility-wide manufacturing and production data from 2020-2022 was provided by Excel Dryer. Manufacturing inventories were assigned using a mass allocation approach based on provided data of production volumes.
- Electricity consumption amount from grid and solar production and other utility consumption amount in 2020-2022 was provided by Excel Dryer. 3-year weight average utility consumption amount was calculated based on production volumes.
- Product Bill of Materials with material type and weight.
- Supplier information for components, including supplier name and address.

Additional data was sourced from the previous EPD model and comparative analysis conducted by Excel.

### 4.4 LCI Data Collection for Paper Towel

Secondary data are sourced from a variety of literature sources, verified public reports and widely used databases. For the paper towel baseline, a combination of secondary data was sourced from a LCA report commissioned by Dyson, Inc. (Materials Systems Laboratory, 2011), a second LCA report commissioned by Excel Dryer, Inc. (US, 2009), a SCS Global Services Report (Suresh & Schultz, 2018), and the specifications associated with the Enmotion Impulse 8" paper towel dispenser by Georgia Pacific (Georgia Pacific, 2023) and was utilized as the main sources for the inventory data.

The paper towel calculator was used to get the weight per sheet, calculation of this specification can be found in **Appendix F**: Additional Calculations for Paper Towel Scenarios. The Georgia Pacific source was used for the weight per sheet as well and overall dispenser information. Both reports were used for the dispenser material, IR sensor weight, waste bin material and weight, waste liner weight and material. Calculation and allocation of waste liner weight can be found in **Appendix F**: Additional Calculations for Paper Towel Scenarios. Using those two reports, it is assumed the liners are used 5 times a week, with

52 weeks in a year. A liner itself weighs 0.033 kg and after 10 years, the system will use 85.5 kg of liners which is allocated to the raw materials and then disposed of at the end-of-life stage.

For all secondary data, each data point was reviewed and verified individually. Detailed description of processes and further documentation is provided in subsequent sections.

## 4.5 Life Cycle Inventory of Excel Dryer Model

### 4.5.1 Raw Material Supply (A1)

Raw materials used in various parts of Excel Dryers and ecoinvent v3.8 processes representing raw materials and supplier processing are provided in **Table 8**. The amount of each inventory in each hand dryer can be found in **Table 29** in **Appendix B**:  Life Cycle Inventory**.**

Table 8: Raw Materials Within Excel Dryers

| Material | SD2 | Quality Level | Library Process (Raw Material) | Library Process (Raw Material Processing) |
|---|---|---|---|---|
| **ABS** | 1.05 | 1,1,1,2,1,na | Acrylonitrile-butadiene-styrene copolymer {RoW}\| production \| Cut-off, U | Injection moulding {RoW}\| processing \| Cut-off, U |
| **ABS_PC** | 1.05 | 1,1,1,2,1,na | 60% of Polycarbonate {RoW}\| production \| Cut-off, U<br>40% of Acrylonitrile-butadiene-styrene copolymer {RoW}\| production \| Cut-off, U | Injection moulding {RoW}\| processing \| Cut-off, U |
| **Acrylic** | 1.05 | 1,1,1,2,1,na | Polymethyl methacrylate, sheet {RoW}\| production \| Cut-off, U | Injection moulding {RoW}\| processing \| Cut-off, U |
| **Carbon** | 1.05 | 1,1,1,2,1,na | Graphite {RoW}\| production \| Cut-off, U | |
| **Glass reinforced resin** | 1.05 | 1,1,1,2,1,na | Glass fibre reinforced plastic, polyester resin, hand lay-up {RoW}\| production \| Cut-off, U | Injection moulding {RoW}\| processing \| Cut-off, U |
| **Phenolic** | 1.05 | 1,1,1,2,1,na | Phenol {RoW}\| market for phenol \| Cut-off, U | |
| **LDPE** | 1.05 | 1,1,1,2,1,na | Packaging film, low density polyethylene {RoW}\| production \| Cut-off, U | |
| **Mica** | 1.05 | 1,1,1,2,1,na | Sodium silicate, solid {RoW}\| sodium silicate production, furnace process, solid product \| Cut-off, U | |
| **Rubber** | 1.05 | 1,1,1,2,1,na | Synthetic rubber {RoW}\| production \| Cut-off, U | |
| **Vinyl** | 1.05 | 1,1,1,2,1,na | Polyvinylidenchloride, granulate {RoW}\| production \| Cut-off, U | |
| **Polyurethane foam** | 1.05 | 1,1,1,2,1,na | Polyurethane, flexible foam, flame retardant {RoW}\| polyurethane production, flexible foam, TDI-based, flame retardant \| Cut-off, U | |
| **Stainless steel** | 1.05 | 1,1,1,2,1,na | Steel, chromium steel 18/8, hot rolled {RoW}\| production \| Cut-off, U | Casting, steel, lost-wax {RoW}\| casting, steel, lost-wax \| Cut-off, U |
| **Nichrome** | 1.05 | 1,1,1,2,1,na | Iron-nickel-chromium alloy {RoW}\| production \| Cut-off, U | |
| **Aluminum** | 1.05 | 1,1,1,2,1,na | Aluminium, cast alloy {GLO}\| aluminium ingot, primary, to market \| Cut-off, U | Metal working machine operation, average process heat/US- US-EI U |
| **Steel** | 1.05 | 1,1,1,2,1,na | Steel, low-alloyed, hot rolled {GLO}\| market for \| Cut-off, U | Metal working machine operation, average process heat/US- US-EI U |
| **Copper** | 1.05 | 1,1,1,2,1,na | Copper, cathode {GLO}\| market for \| Cut-off, U | Wire drawing, copper {RoW}\| processing \| Cut-off, U |
| **Brass** | 1.05 | 1,1,1,2,1,na | Brass {RoW}\| production \| Cut-off, U | |
| **Paper** | 1.05 | 1,1,1,2,1,na | Paper, woodcontaining, lightweight coated {RoW}\| production \| Cut-off, U | |
| **PCB** | 1.05 | 1,1,1,2,1,na | 50% of Printed wiring board, through-hole mounted, unspecified, Pb free {GLO}\| production \| Cut-off, U<br>50% of Printed wiring board, through-hole mounted, unspecified, Pb containing {GLO}\| production \| Cut-off, U | |

| | | | | |
|---|---|---|---|---|
| **Electronics (Non-PCB/IC)** | 1.05 | 1,1,1,2,1,na | Transistor, wired, small size, through-hole mounting {GLO}\| production \| Cut-off, U | |
| **Electronics_IC** | 1.05 | 1,1,1,2,1,na | 50% of Integrated circuit, logic type {GLO}\| production \| Cut-off, U<br>50% of Integrated circuit, memory type {GLO}\| production \| Cut-off, U | |
| **Polyethylene** | 1.05 | 1,1,1,2,1,na | 50% of Polyethylene, high density, granulate {RoW}\| production \| Cut-off, U<br>50% of Polyethylene, low density, granulate {RoW}\| production \| Cut-off, U | |
| **Phenolic_thermoset_resin** | 1.05 | 1,1,1,2,1,na | Phenolic resin {RoW}\| production \| Cut-off, U | |
| **Zinc** | 1.05 | 1,1,1,2,1,na | Zinc {RoW}\| primary production from concentrate \| Cut-off, U | Metal working machine operation, average process heat/US- US-EI U |
| **Nylon** | 1.05 | 1,1,1,2,1,na | Nylon 6-6, glass-filled {RoW}\| production \| Cut-off, U | |

### 4.5.2 Packaging (A1)

Different packaging items are used depending on the model and a standard packaging includes a plastic liner bag within corrugated cardboard box, with molded pulp end caps. Ecoinvent v3.8 processes representing packaging materials are provided in the **Table 9**. The amount of each inventory in each hand dryer can be found in **Table 29** in **Appendix B**: Life Cycle Inventory.

Table 9: Packaging Materials for Excel Dryers

| Material | SD2 | Quality Level | Library Process |
|---|---|---|---|
| **Cardboard** | 1.05 | 1,1,1,2,1,na | Corrugated board box {RoW}\| production \| Cut-off, U |
| **Molded Pulp** | 1.05 | 1,1,1,2,1,na | 50% of Recycled pulp, from AOCC, 0% water/US U<br>50% of Recycled pulp, from OCC, 0% water/US U |
| **Plastic bag** | 1.05 | 1,1,1,2,1,na | Packaging film, low density polyethylene {RoW}\| production \| Cut-off, U |
| **Paper** | 1.05 | 1,1,1,2,1,na | Kraft paper {RoW}\| kraft paper production \| Cut-off, U |
| **Foam** | 1.05 | 1,1,1,2,1,na | 1/3 of Polyurethane, flexible foam {RoW}\| polyurethane production, flexible foam, TDI-based, low density \| Cut-off, U<br>1/3 of Polyurethane, flexible foam {RoW}\| polyurethane production, flexible foam, TDI-based, high density \| Cut-off, U<br>1/3 of Polyurethane, flexible foam {RoW}\| polyurethane production, flexible foam, MDI-based \| Cut-off, U |

### 4.5.3 Transportation to Factory (A2)

Materials used in the production of Excel Dryers are sourced from multiple suppliers. Supplier name and address was provided by Excel on a per part basis (e.g., a screw). Transportation distance between suppliers and Excel facility in East Longmeadow, Massachusetts is estimated using Google Maps and other online tools. It is assumed that the product is transported by truck if the supplier is in North America and by sea, then by truck if the supplier is overseas.

The model summed up the part weights by supplier name first and modeled the corresponding shipping distance of that supplier based on the product % by weight. Due to the large number of parts and lack of supplier info for smaller parts, transportation is modeled for 94% on average of the overall product by weight. The transportation module is then scaled up based on the factor (i.e., 1/0.94 = 1.06).

Transportation modes and distances representing the current supply chain network are found in **Table 10**.

Table 10: Transportation Modes for Excel Dryers

| Materials | Transportation Mode | Library Process |
|---|---|---|
| **All products from various cities in North America to MA** | Truck | Transport, freight, lorry 16-32 metric ton, EURO3 {RoW}\| transport, freight, lorry 16-32 metric ton, EURO3 \| Cut-off, U |
| **All products from oversea to MA** | Ship, then truck | Transport, freight, sea, container ship {GLO}\| transport, freight, sea, container ship \| Cut-off, U<br>Transport, freight, lorry 16-32 metric ton, EURO3 {RoW}\| transport, freight, lorry 16-32 metric ton, EURO3 \| Cut-off, U |

### 4.5.4 Manufacturing (A3)

The manufacturing process at Excel facility in East Longmeadow, Massachusetts is mostly assembly and there is no major difference during assembly among all models. Total amount of electricity consumption was modeled based on the utility bill provided by Excel. Besides electricity consumption from the grid, Excel also has on-site solar production and provided the total amount of solar consumption.

In addition to electricity, total consumption of natural gas, water and waste generated at the facility was collected via the data collection template.

The weighted average of total energy and resource consumption amount is calculated using the data provided for 3 years from 2020 to 2022 and is allocated to each dryer based on the production volume.

Table 11: Utility Consumption and Allocation

| Utility Type | SD2 | Quality Level | Library Process | Amount (3 year weighted average) | Unit |
|---|---|---|---|---|---|
| Electricity from grid | 1.05 | 1,1,1,2,1,na | Electricity, medium voltage, at grid, eGrid, NPCC/US US-EI U | 94636 | kWh |
| Electricity from on-site solar production | 1.05 | 1,1,1,2,1,na | Electricity, medium voltage, at grid, eGrid, NPCC/US US-EI U_solar copy[2] | 255141 | kWh |
| Natural Gas | 1.05 | 1,1,1,2,1,na | Natural gas, burned in industrial furnace >100kW/US- US-EI U | 17458 | kWh |
| Water | 1.05 | 1,1,1,2,1,na | Water, decarbonised {US}\| market for water, decarbonised \| Cut-off, U | 341391 | Gal |
| Sewer | 1.05 | 1,1,1,2,1,na | Wastewater, average {RoW}\| treatment of, capacity 1E9l/year \| Cut-off, U | 310191[3] | Gal |

The information module manufacturing includes:

- A3, generation of electricity, steam and heat from primary energy resources used in manufacturing including their extraction, refining and transport.
- A3, emissions from the combustion of secondary fuels and waste used in the manufacturing process.
- A3, waste management from manufacturing packaging and manufacturing wastages transport up to the recycler or disposal.

[2] This is a modified ecoinvent unit process of Electricity, medium voltage, at grid, eGrid, NPCC/US US-EI U by changing the electricity mix to 100% solar to represent Excel's onsite solar production.

[3] Not all water goes to the sewer. Excel estimated the amount of water used by the sprinkler system based on permit application. The sprinkler system uses about 120 gallons per day for 260 days.

### 4.5.5 Product Distribution Stage (A4)

Products are shipped out from Excel facility in East Longmeadow, Massachusetts as single units or on pallets to a distributor. Average distances were provided by Excel.
Transportation modes and distances representing the current supply chain network are found in **Table 12**.

Table 12: Transportation Modes and Distances of Excel Dryers

| Material and Link | Transportation Mode | Amount | Unit |
|---|---|---|---|
| **MA to distributor** | Train | 2600 | km |
| **MA to distributor** | Truck | 1784 | km |

A4 is optional reported elements according to the PCR.

### 4.5.6 Product Use (B1)

Dry time, power and energy consumption are based on the average test results provided by Excel. Except for XLERATORsync®, which only operates with a 120 Voltage, the other three models work with 120V, 230, and 208V.

Average operational and standby power consumption are summarized in Table 13 below based on the power and usage provided in

Table 14 and Table 15. There are three modes of operation which include: (1) operating mode when the dryer is on for hand drying; (2) run-on mode which is between when the dryer's controls stop dryer operation and when the dryer's supply current returns to normal levels in standby model; and (3) standby mode which is the state of the hand dryer between instances of hand drying.

Table 13: Energy Consumption for Excel Dryers

| Product | 120V | 230V | 208V | 120V | 230V | 208V | 120V | 230V | 208V |
|---|---|---|---|---|---|---|---|---|---|
| **Unit** | Average Operational Power Consumption over RSL (kWh) | | | Average Standby Power Consumption over RSL (kWh) | | | Total RSL Power Consumption over RSL (kWh) | | |
| **ThinAir® Hand Dryer** | 365 | 355 | 299 | 5 | 6 | 6 | 370 | 361 | 299 |
| **XLERATOR® Hand Dryer** | 336 | 326 | 269 | 5 | 6 | 6 | 341 | 333 | 275 |
| **XLERATOReco® Hand Dryer** | 152 | 144 | 122 | 5 | 6 | 6 | 158 | 150 | 128 |
| **XLERATORsync®** | 574 | n.a. | n.a. | 6 | n.a. | n.a. | 580 | n.a. | n.a. |

Table 14: Power Wattage for Excel Dryers

| Product | 120V | 230V | 208V | 120V | 230V | 208V | 120V | 230V | 208V | 120V | 230V | 208V |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unit** | Operating Power (Watts) | | | Run-on Power (Watts[4]) | | | Average Operational Power (Watts[5]) | | | Average Standby Power (Watts) | | |
| **ThinAir® Hand Dryer** | 915 | 890 | 750 | 457.5 | 445 | 375 | 894 | 869 | 733 | 0.44 | 0.54 | 0.5 |

[4] Run-On watts are exactly 50% of operating Watts.
[5] Weighted average power based on lifetime operational and standby time in hours

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **XLERATOR® Hand Dryer** | 1450 | 1410 | 1160 | 725 | 705 | 580 | 1393 | 1354 | 1114 | 0.44 | 0.54 | 0.5 |
| **XLERATOReco® Hand Dryer** | 530 | 500 | 425 | 265 | 250 | 212.5 | 513 | 484 | 411 | 0.44 | 0.54 | 0.5 |
| **XLERATORsync®** | 1440 | n.a. | n.a. | 720 | n.a. | n.a. | 1406 | n.a. | n.a. | 0.5 | n.a. | n.a. |

Table 15: Operational and Standby Time for Excel Dryers

| Product | Dry time | Run-on time per use | Lifetime Total Dry time | Lifetime Total Run-on Time | Total Operating Time | Total Standby Time |
|---|---|---|---|---|---|---|
| **Unit** | Sec | Sec | RSL hours | RSL hours | RSL hours | RSL hours |
| **ThinAir® Hand Dryer** | 14 | 0.7 | 389 | 19 | 408 | 11592 |
| **XLERATOR® Hand Dryer** | 8 | 0.7 | 222 | 19 | 241 | 11758 |
| **XLERATOReco® Hand Dryer** | 10 | 0.7 | 278 | 19 | 297 | 11703 |
| **XLERATORsync®** | 14 | 0.7 | 389 | 19 | 408 | 11592 |

### 4.5.7 End-of-Life (C2-C4)

Activities included in the End-of-life stage are the transportation of the hand dryer to the end-of-life facility, waste processing and disposal. It is assumed the hand dryer is sent to the end-of-life processing facility with an average distance of 50km by truck. The percentages for the landfill, incineration, and recycling were sourced from the general US waste scenario located in SimaPro, as shown in **Table 16** below.

Table 16: End-of-Life of Excel Dryers

| Material | Library Process | % of Disposal |
|---|---|---|
| **Hand dryer** | Waste electric and electronic equipment {GLO}\| treatment of, shredding \| Cut-off, U | 100% |
| **Metal and other material** | Disposal, steel, 0% water, to inert material landfill/US* US-EI U | 80% |
| | Disposal, steel, 0% water, to municipal incineration/US* US-EI U | 20% |
| **Cardboard** | Core board (waste treatment) {GLO}\| recycling of core board \| Cut-off, U | 68.2% |
| | Disposal, packaging cardboard, 0% water, to sanitary landfill/US* US-EI U | 25.7% |
| | Disposal, packaging cardboard, 0% water, to municipal incineration/US* US-EI U | 6.1% |
| **Molded pulp and paper** | Paper (waste treatment) {GLO}\| recycling of paper \| Cut-off, U | 68.2% |
| | Disposal, packaging paper, 0% water, to sanitary landfill/US* US-EI U | 25.7% |
| | Disposal, packaging paper, 0% water, to municipal incineration/US* US-EI U | 6.1% |
| **Plastics bag and foam** | Inert waste {RoW}\| treatment of, sanitary landfill \| Cut-off, U | 80.9% |
| | Municipal solid waste {RoW}\| treatment of, incineration \| Cut-off, U | 19.1% |

## 4.6 Life Cycle Inventory of Paper Towel Baseline

### 4.6.1 Raw Material Supply (A1)

The raw materials used in various parts of the paper towel baseline needed to provide 260,000 pairs of hands over a 10-year lifetime and the ecoinvent v3.8 processes representing raw materials and supplier processing are provided in **Table 17**.

Table 17: Raw Materials Within Paper Towel Baseline

| Material | Library Process (Raw Material) | Library Process (Raw Material Processing) |
|---|---|---|
| **A1 Battery RM** | Battery cell, Li-ion {GLO}\| production \| Cut-off, U | |
| **A1 Dispenser RM** | Polyethylene, high density, granulate {GLO}\| market for \| Cut-off, U | Injection moulding {RoW}\| processing \| Cut-off, U |
| **A1 IR Sensor RM** | 50% of Printed wiring board, through-hole mounted, unspecified, Pb free {GLO}\| production \| Cut-off, U<br>50% of Printed wiring board, through-hole mounted, unspecified, Pb containing {GLO}\| production \| Cut-off, U | |
| **A1 Paper Towel RM (0% Recycled)** | Sulfate pulp, bleached {RoW}\| market for sulfate pulp, bleached \| Cut-off, U | |
| **A1 Paper Towel RM (100% Recycled)** | Sulfate pulp, bleached {RoW}\| market for sulfate pulp, bleached \| Cut-off, U | |
| **A1 Waste Bin RM** | Steel, chromium steel 18/8 {GLO}\| market for \| Cut-off, U | Metal working, average for chromium steel product manufacturing {GLO}\| market for \| Cut-off, U |
| **A1 Waste Liner RM** | Packaging film, low density polyethylene {RoW}\| production \| Cut-off, U | |

### 4.6.3 Packaging (A1)

Per the reference study, only one packaging item is used for the paper towel baseline. ecoinvent v3.8 processes representing packaging materials are provided in **Table 18**.

Table 18: Packaging Materials for Paper Towel Baseline

| Material | Library Process |
|---|---|
| **A1 Cardboard RM** | Corrugated board box {RoW}\| market for corrugated board box \| Cut-off, U |

### 4.6.4 Transportation to Factory (A2)

In the absence of more accurate data, transportation of the materials used in the production of the paper towel baseline was based on the (Materials Systems Laboratory, 2011) report. In the previous report, it was assumed all the materials within the paper towels were manufactured in the US. Therefore, it was assumed that the rest of the paper towel baseline is manufactured in the US as well.

Transportation modes and distances representing the current supply chain network are found in **Table 19**.

Table 19: Transportation Modes and Factors of Paper Towel Baseline

| Material and Link | Transportation Mode | Amount | Unit |
|---|---|---|---|
| **Raw materials to plant** | Truck | 250 | km |

### 4.6.5 Manufacturing (A3)

The paper towel containing 0% recycled content is assumed to use pulp manufactured via the sulfate process, which is the most dominant pulping process that accounts for 80% of the world's pulp product (Materials Systems Laboratory, 2011). The pulp is then transported to a manufacturing plant where the paper towels are produced. The manufacturing data for this scenario is based on the MIT study (Materials Systems Laboratory, 2011).

Given the lack of available data for paper towel containing 100% recycled content, it was assumed that the manufacturing for the deinked pulp was equal to the manufacturing of the 0% recycled paper towel (Materials Systems Laboratory, 2011). It also assumed that the energy and emissions from the production of both paper towels are the same as well. However, wood in the sulfate pulp process was replaced with 1.5 kg of wastepaper. This assumption addresses key differences in raw material acquisition (Materials Systems Laboratory, 2011).

Overall, it is assumed that both scenarios are manufactured in the USA to be consistent with the previous assumptions in the report. Major value add activities are modeled using proxies from ecoinvent 3.8 library. Based on the reference study, major processes include injection molding, processing chromium steel, and processing of pulp to product paper tissues. Electricity needed for manufacturing included in the paper towel material, injection molding, and metal working processes, proxies were used from the ecoinvent database.

### 4.6.6 Product Distribution Stage (A4)

Similar to A2, it is assumed that the product distribution is the same as the (Materials Systems Laboratory, 2011) report due to the absence of more accurate data.

Transportation modes and distances representing the current supply chain network are found in **Table 20**.

Table 20: Transportation Modes and Distances of Paper Towel Baseline

| Material and Link | Transportation Mode | Amount | Unit |
|---|---|---|---|
| **Warehouse to washroom** | Truck | 1760 | km |

A4 is optional reported elements according to the PCR.

### 4.6.7 Product Use (B1)

Paper towels are used and disposed of therefore the use stage includes the end-of-life of paper towels used for 260,000 instances of hand drying. Based on the reference studies, both paper towel baselines use the same number of paper towel sheets per instance of hand drying, requiring 2 sheets of paper towels for each instance of hand drying. It was also noticed in a 2019 study (Suen, So, Yeung, Lo, & Lam, 2019), that the majority of people they surveyed try to limit the use of paper towel to two sheets. Ecoinvent v3.8 processes representing end of life of the paper towel baseline are provided in **Table 21**.

Table 21: Use Stage of Paper Towel Baseline

| Material | Library Process | % of Disposal |
|---|---|---|
| **Paper towel containing 0% recycled content** | Municipal solid waste {RoW}\| treatment of, sanitary landfill \| Cut-off, U | 100% |

| | | |
|---|---|---|
| **Paper towel containing 100% recycled content** | Municipal solid waste {RoW}\| treatment of, sanitary landfill \| Cut-off, U | 100% |

The use phase of the dispenser in the paper towel baseline is based on the battery use of the dispenser needed for 260,000 instances of hand drying. The initial 4 batteries needed to operate the dispenser is represented by the raw material A1 Battery RM. Due to the batteries having a lifetime of 4 years and the comparative LCA being evaluated for a 10-year lifetime, the remaining batteries needed for those 10 years are included in the use stage. Ecoinvent v3.8 process representing battery life of the paper towel baseline, which does not include charging of the battery, are provided in **Table 22**.

Table 22: Use Stage of Dispenser for Paper Towel Baseline

| Material | Library Process |
|---|---|
| **B1 Battery RM** | Battery cell, Li-ion {GLO}\| production \| Cut-off, U |

### 4.6.8 End of Life (C2-C4)

Activities included in the End-of-life stage are the transportation of the dispenser, waste bin, and waste liners to the end-of-life facility, waste processing and disposal. The percentages for the landfill, incineration, and recycling were sourced from the general US waste scenario located in SimaPro, as shown in **Table 23** below.

Using the same assumption as the (Materials Systems Laboratory, 2011) report, it is assumed the paper towel baselines are sent to the end-of-life processing facility with an average distance of 100 km by truck.

Table 23: End of Life Stage of Paper Towel Baseline

| Material | Library Process | % Of Disposal |
|---|---|---|
| **Dispenser** | Municipal solid waste {RoW}\| treatment of, sanitary landfill \| Cut-off, U | 54.1% |
| | Municipal solid waste {RoW}\| treatment of, incineration \| Cut-off, U | 12.8% |
| | Steel and iron (waste treatment) {GLO}\| recycling of steel and iron \| Cut-off, U | 33.1% |
| **Battery** | Municipal solid waste {RoW}\| treatment of, sanitary landfill \| Cut-off, U | 65.5% |
| | Municipal solid waste {RoW}\| treatment of, incineration \| Cut-off, U | 16% |
| | Aluminium (waste treatment) {GLO}\| recycling of aluminium \| Cut-off, U | 18.5% |
| **IR Sensor** | Municipal solid waste {RoW}\| treatment of, sanitary landfill \| Cut-off, U | 65.5% |
| | Municipal solid waste {RoW}\| treatment of, incineration \| Cut-off, U | 16% |
| | Aluminium (waste treatment) {GLO}\| recycling of aluminium \| Cut-off, U | 18.5% |
| **Wastebin** | Municipal solid waste {RoW}\| treatment of, sanitary landfill \| Cut-off, U | 73.9% |
| | Municipal solid waste {RoW}\| treatment of, incineration \| Cut-off, U | 17.4% |
| | PP (waste treatment) {GLO}\| recycling of PP \| Cut-off, U | 8.7% |

| | | |
|---|---|---|
| **Waste Liner** | Municipal solid waste {RoW}\| treatment of, sanitary landfill \| Cut-off, U | 73.9% |
| | Municipal solid waste {RoW}\| treatment of, incineration \| Cut-off, U | 17.4% |
| | PE (waste treatment) {GLO}\| recycling of PE \| Cut-off, U | 8.7% |
| **Cardboard** | Municipal solid waste {RoW}\| treatment of, sanitary landfill \| Cut-off, U | 25.7% |
| | Municipal solid waste {RoW}\| treatment of, incineration \| Cut-off, U | 6.1% |
| | Core board (waste treatment) {GLO}\| recycling of core board \| Cut-off, U | 68.2% |

## 4.7 Fuels and Energy

Hand dryer and paper towel activities are modeled using region-specific proxies from ecoinvent databases. Ecoinvent v3.8 references eGRID 2020 for background grid mixes. Other sources of fuels and energy are modeled based on the most representative fuel mix and technology.

## 4.8 Data Quality

Life cycle inventory data used in this study are evaluated based on three categories: precision and completeness, consistency and reproducibility, and representativeness.

Precision and completeness: Foreground data are sourced from primary information provided by the client and has been reviewed internally to ensure precision and completeness. In order to balance out seasonal variations, operations data over a 12-month period is used to represent production activities. In addition, key model input such as mass balance, energy balance and emission inventory are reviewed by TrueNorth Collective team. The primary data from the manufacturer are based on the year 2020. Raw material inputs were based on standard product weight and formulation. Secondary data is used to represent raw materials extraction and processing, end of life, and transportation, and primary and secondary data are represented ecoinvent v3.8 and DATASMART LCI Package (Long Trail Sustainability, 2021).

Ecoinvent v3.8 is used as the main database for background data. This version is published in 2021. Ecoinvent is widely used in research and industry to support life cycle assessment practices. Each version of this database goes through thorough review process and documentation of precision and completeness is available by the provider.

Consistency and reproducibility: To ensure consistency, primary data were collected at the same level of granularity. All input and output information, modelling assumptions and dataset choices are provided in this report for the purpose of reproducibility.

Representativeness: Refer to the sections above for details about representativeness.

### 4.8.1 Exceptions

There are no exceptions in inclusion of value-add activities and all flows are included in this study.

### 4.8.2 Technology Coverage

This study uses a mix of primary and secondary data and is intended to represent the specific environmental profile of Excel Dryer's manufacturing technology, supply chain and product use. For the paper towel baseline, the study uses secondary data and best information available to compare the two hand drying methods.

#### 4.8.3 Geographic Coverage

Excel dryer facilities are located in East Longmeadow, MA. For grid electricity consumption, the MA electricity mix was used, and for solar electricity consumption, the MA electricity unit process was modified by changing the energy mix (100% solar and 0% for all other type of energy).

For the paper towel baseline, location of sourcing and manufacturing the materials were sourced from the (Materials Systems Laboratory, 2011) report. Therefore, it was assumed that everything within the paper towel baseline is based in the US. This also allows the paper towel scenario to be consistent with the Excel hand dryer scenarios. The manufacturing of the pulp to paper towel relied on US electricity grid. Manufacturing processes for the wastebin and paper towel dispenser were modeled using region-specific proxies from ecoinvent databases.

#### 4.8.4 Time Coverage

Primary data from Excel dryer represents operations from 2020. In addition, secondary data are modeled using ecoinvent v3.8 and DATASMART LCI Package. The paper towel baselines are based on several sources which range from 2009-2023.

#### 4.8.5 Treatment of Missing data

No known data was excluded in this study.

### 4.9 Assumptions & Estimations

There are several assumptions that were made in the current study.

- For the Excel dryers, an average of 10% of components by total product weight do not have supplier location and transportation details. The supplier transportation is modeled and scaled up based on the 90% that do have supplier information.
- For the Excel dryer, due to lack of data of where the products are sold to within the United States, electricity use during consumer use phase is modeled using the US average grid. Carbon intensity varies depending on the source of electricity (grid mix). As use phase dominates the life cycle impacts, changes in where the products are used could have an impact on the comparative analysis. Therefore, a sensitivity analysis on use phase electricity grid mix is conducted.
- When there are similar ecoinvent unit processes that could be applied to model the same component, due to lack of primary data from suppliers, an average is taken from the existing unit processes. For example, for PCB boards, 50% of Printed wiring board, through-hole mounted, unspecified, Pb free {GLO}| production | Cut-off, U, and 50% of Printed wiring board, through-hole mounted, unspecified, Pb containing {GLO}| production | Cut-off, U is used for modeling. This could cause inaccuracy in the model results.

## 5. Life Cycle Assessment Results

### 5.1 LCA Results of Comparative analysis – Base Scenario

The following sections summarize the key characterized results of the comparative LCA Including contribution analyses of the Excel dryers and paper towel baseline, uncertainty analyses showing the robustness of the results, and comparative analyses of the dryers compared to the paper towel baseline. Explanations of each type of analysis Is provided below.

**Contribution:** Contribution analyses identify the environmental hot spots in the life cycle of each system, identifying the processes that contribute the most and aiding in providing a deeper understanding of what is driving the environmental performance of the system and identifying opportunities for process improvement.

**Uncertainty**: Uncertainty analyses determine how data quality affects the reliability and robustness of the results. The results are considered to have a high level of certainty and statistically significant, when one option was shown to have greater impacts in 90% or more of the Monte Carlo simulations. The results are considered to have a low level of certainty when the percentage was less than 90%, therefore statistically significant conclusions could not be drawn in those instances.

**Comparative**: Comparative analyses show which option has more or less environmental impacts in a given impact category.

The following sections show the results for the Excel Dryer, Paper Towel Baseline, and the comparison between the dryers and paper towels.

### 5.1.1 Excel Dryer Results

**Figure 9** to **Figure 12** summary the environmental impacts of the four Excel dryers by contribution of life cycle stages. The absolute values are presented in **Appendix C**: Life Cycle Assessment Results – Comparative Analysis Base Scenario.

B1 use stage dominates all impact categories for the ThinAir® Hand Dryer, contributing 55% to 92%, and XLERATORsync®, contributing 60% to 92%. Besides the impact category carcinogenics, B1 stage also dominates the remaining impact categories for the XLERATOR® Hand Dryer, contributing 57% to 89%. Besides the impact categories carcinogenics, non-carcinogenics, and ecotoxicity, B1 stage dominates the remaining impact categories for the XLERATOReco® Hand Dryer, contributing 56% to 79%. The B1 use stage impacts are driven by Excel customer electricity consumption.

A1 raw materials stage has the second highest impacts for all the Excel dryers across all impact categories and is the number one driver for the impact categories that were dominated by the B1 stage, ranging from 7% to 47% for the ThinAir® Hand Dryer, 10% to 53% for the XLERATOR® Hand Dryer, 19% to 70% for the XLERATOReco® Hand Dryer, and 6% to 33% for the XLERATORsync® Hand Dryer.

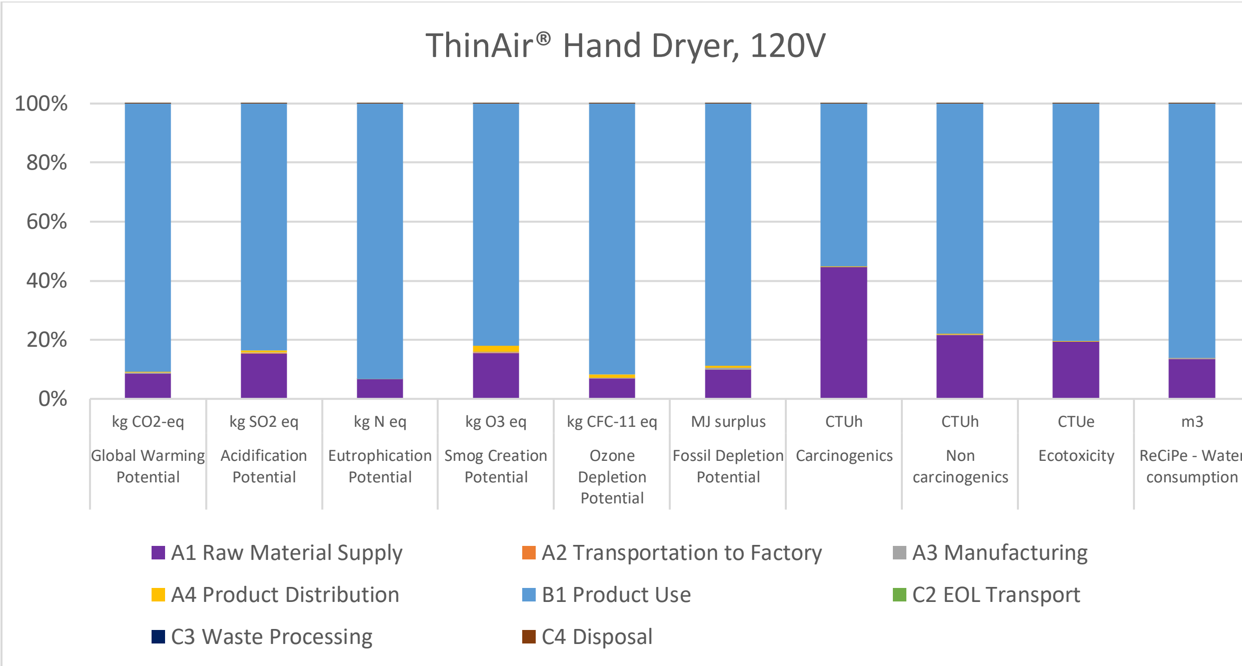



Figure 9: Contribution Analysis of ThinAir® Hand Dryer, 120V, Per Functional Unit: 260,000 Hand Drying Instances

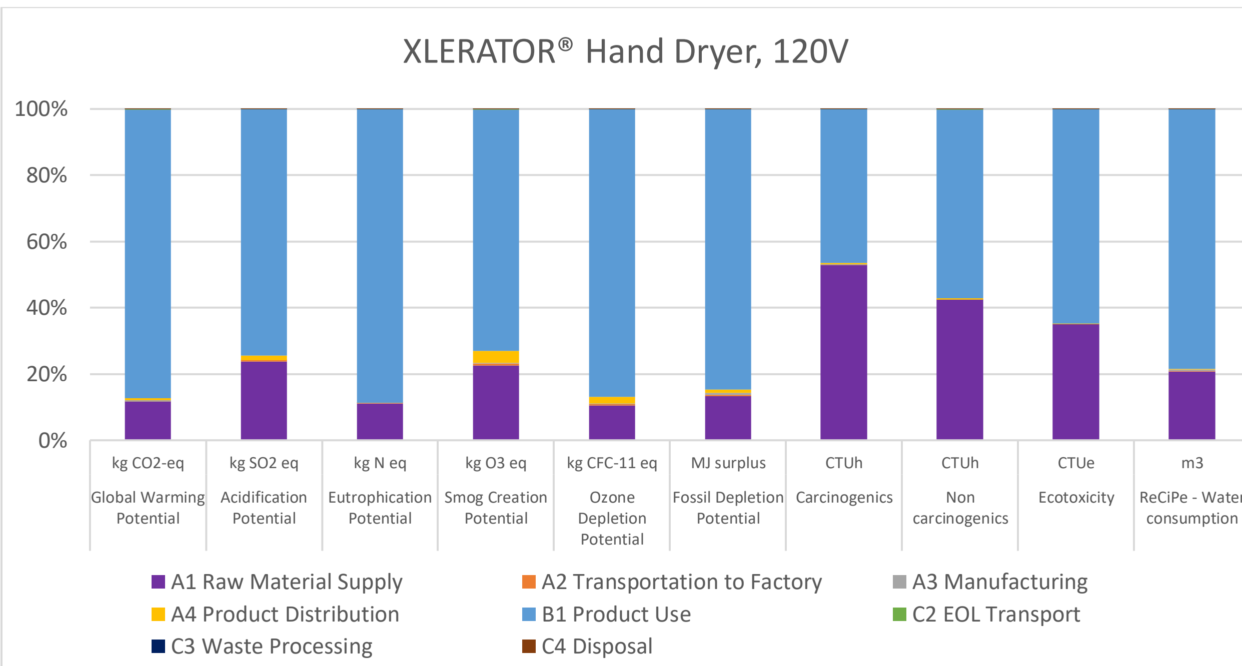



Figure 10: Contribution Analysis of XLERATOR® Hand Dryer, 120V, Per Functional Unit: 260,000 Hand Drying Instances

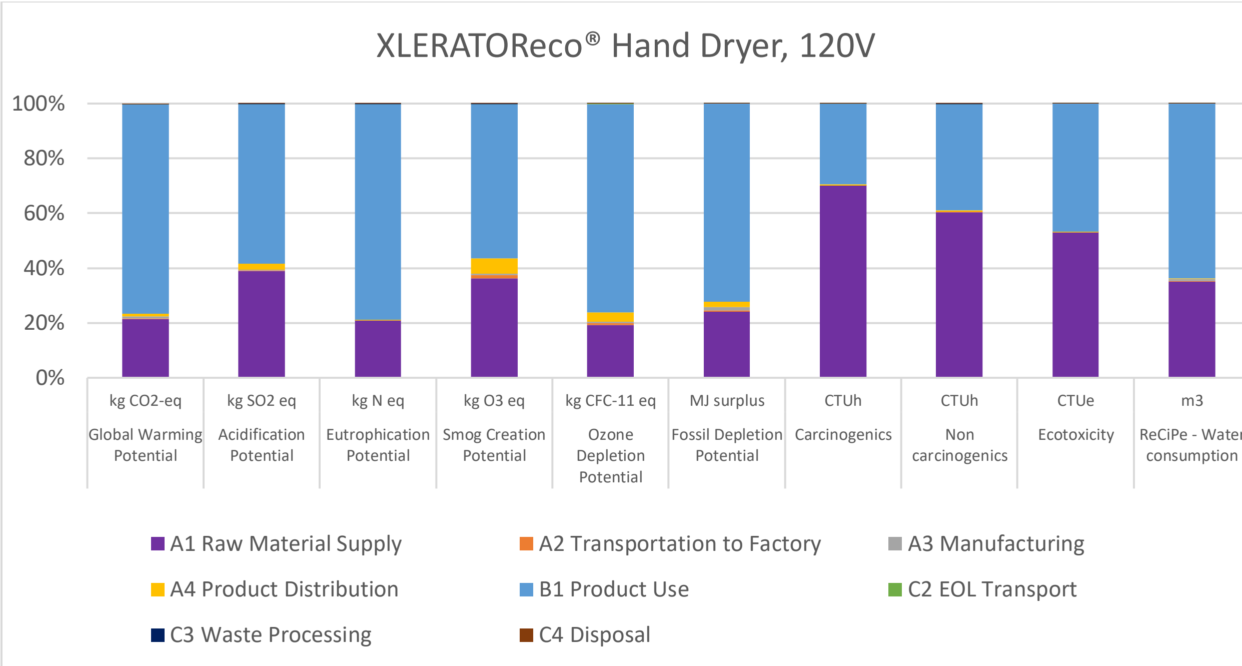



Figure 11: Contribution Analysis of XLERATOReco® Hand Dryer, 120V, Per Functional Unit: 260,000 Hand Drying Instances

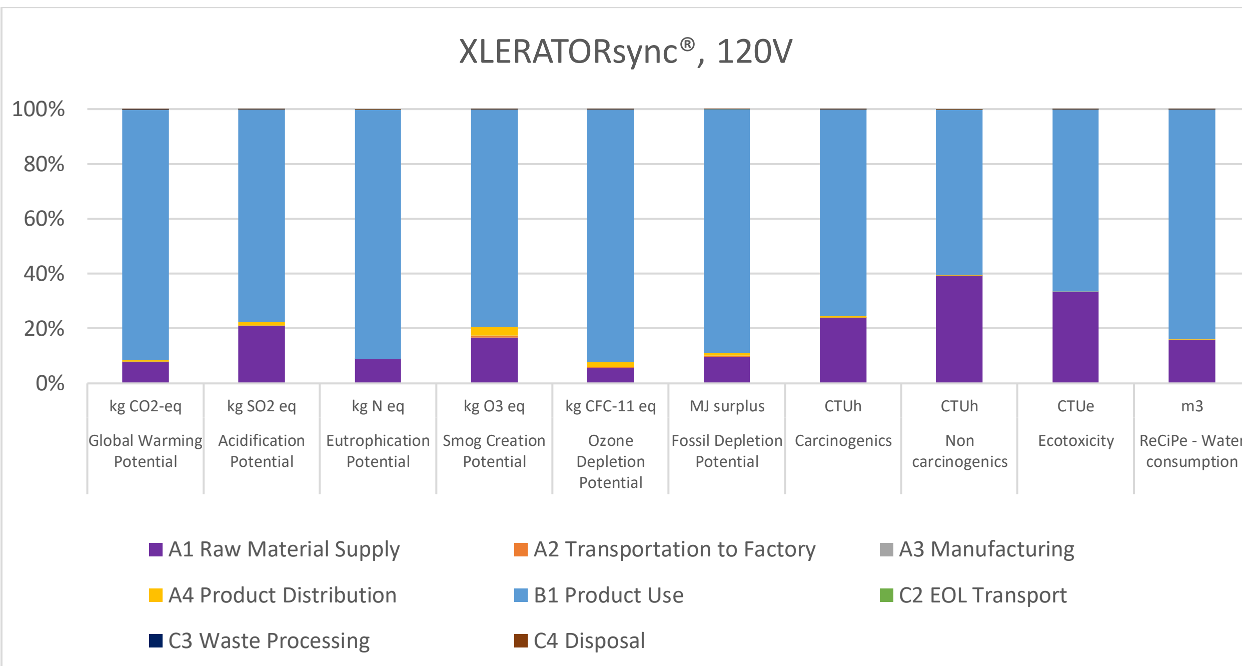



Figure 12: Contribution analysis of XLERATORsync®, 120V, Per Functional Unit: 260,000 Hand Drying Instances

The uncertainty analysis shown in **Figure 13** indicates that the environmental impacts of the ThinAir® Hand Dryer, 120V could be around 41% lower to 60% higher in global warming potential, acidification, smog, fossil fuel depletion, and ecotoxicity, due to variations in data. Eutrophication, ozone depletion, carcinogenics, and non-carcinogenics results are more uncertain due to variations in data, ranging from 89% lower to 387% higher, which is shown in **Figure 13** as well. Results for water consumption are highly uncertain, ranging from 2981% lower to 2031% higher, which is driven by the data uncertainty in the underlying secondary data.

The uncertainty analysis shown in **Figure 14** indicates that the environmental impacts of the XLERATOR® Hand Dryer, 120V could be around 40% lower to 55% higher in global warming potential, acidification, smog, fossil fuel depletion, and ecotoxicity, due to variations in data. Eutrophication, ozone depletion, carcinogenics, and non-carcinogenics results are more uncertain due to variations in data, ranging from 81% lower to 281% higher, which is shown in **Figure 14** as well. Results for water consumption are highly uncertain, ranging from 1911% lower to 1289% higher, which is driven by the data uncertainty in the underlying secondary data.

The uncertainty analysis shown in **Figure 15** indicates that the environmental impacts of the XLERATOReco® Hand Dryer, 120V could be around 41% lower to 59% higher in global warming potential, acidification, smog, fossil fuel depletion, and ecotoxicity, due to variations in data. Eutrophication, ozone depletion, carcinogenics, and non-carcinogenics results are more uncertain due to variations in data, ranging from 68% lower to 224% higher, which is shown in **Figure 15** as well. Results for water consumption are highly uncertain, ranging from 2849% lower to 2205% higher, which is driven by the data uncertainty in the underlying secondary data.

The uncertainty analysis shown in **Figure 16** indicates that the environmental impacts of the XLERATORsync® Hand Dryer, 120V could be around 44% lower to 60% higher in global warming potential, acidification, smog, fossil fuel depletion, and ecotoxicity, due to variations in data. Eutrophication, ozone depletion, carcinogenics, and non-carcinogenics results are more uncertain due to variations in data, ranging from 70% lower to 380% higher, which is shown in **Figure 16** as well. Results for water consumption are highly uncertain, ranging from 1862% lower to 1509% higher, which is driven by the data uncertainty in the underlying secondary data.

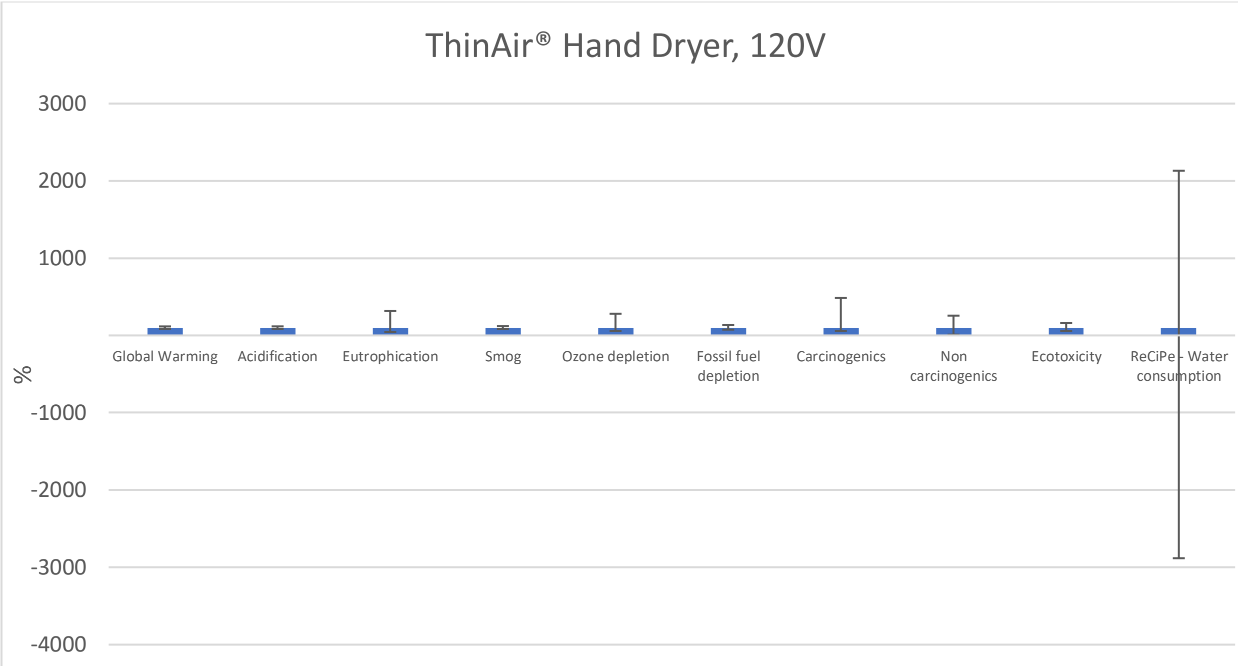



Figure 13: Uncertainty Analysis of ThinAir® Hand Dryer, 120V, Per Functional Unit: 260,000 Hand Drying Instances

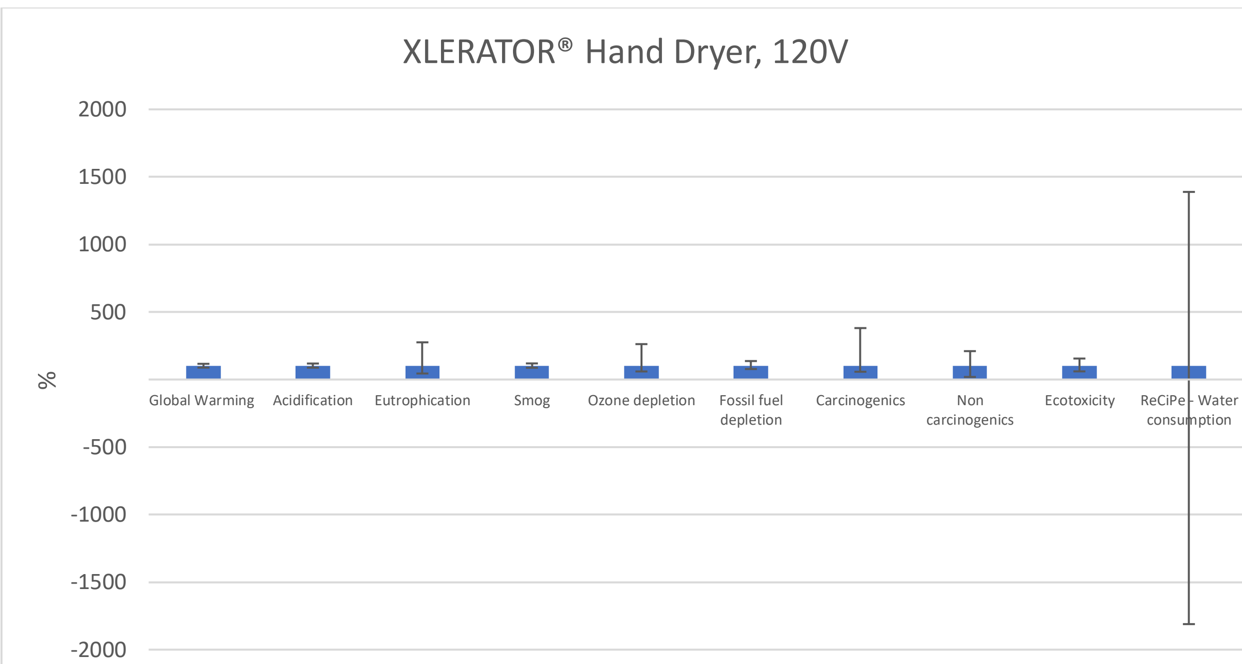



Figure 14: Uncertainty Analysis of XLERATOR® Hand Dryer, 120V, Per Functional Unit: 260,000 Hand Drying Instances

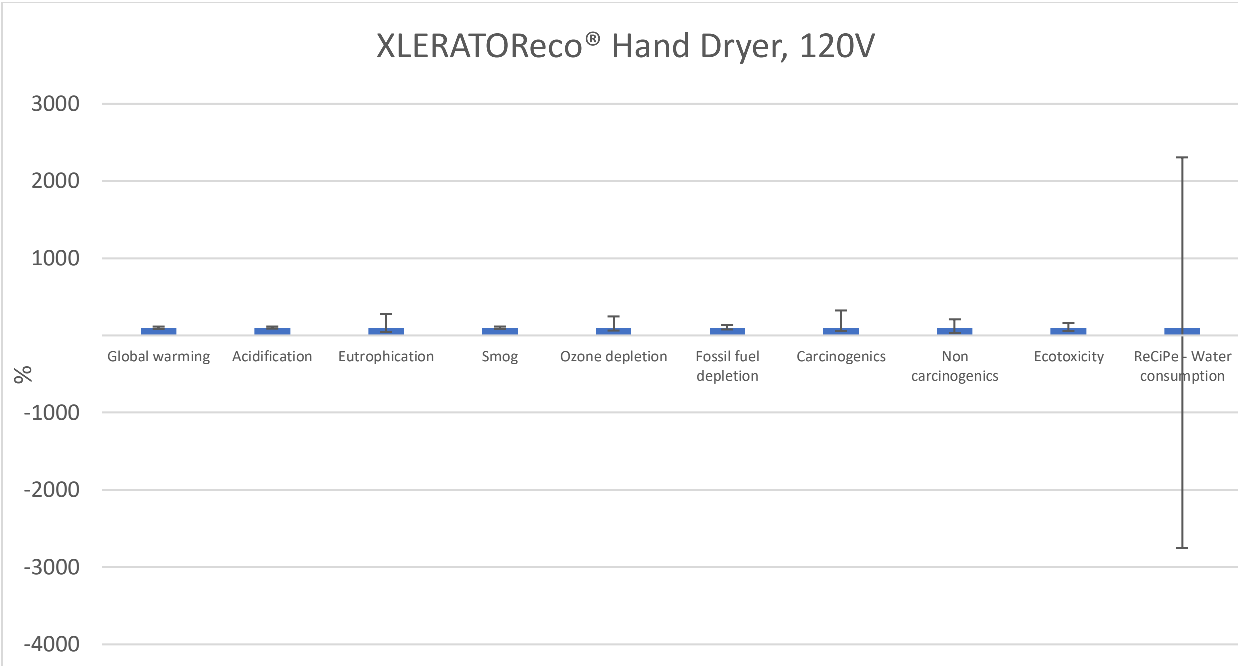



Figure 15: Uncertainty Analysis of XLERATOReco® Hand Dryer, 120V, Per Functional Unit: 260,000 Hand Drying Instances

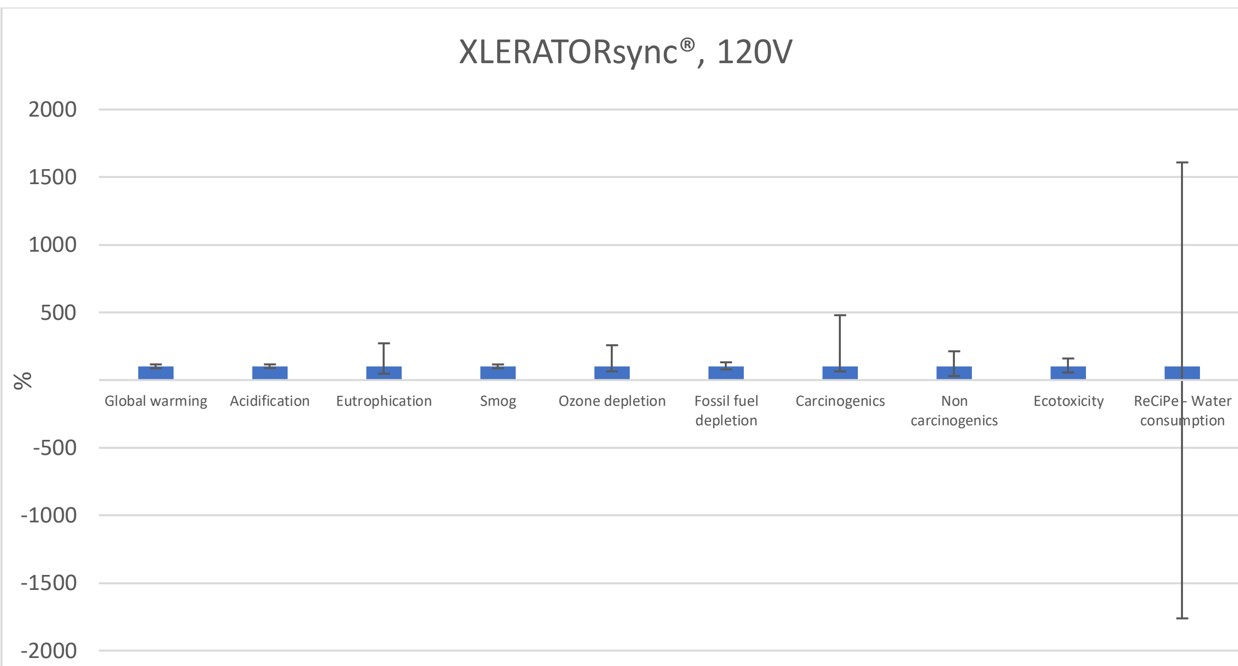



Figure 16: Uncertainty Analysis of XLERATORsync® Hand Dryer, 120V, Per Functional Unit: 260,000 Hand Drying Instances

### 5.1.2 Paper Towel Baseline Results

As shown in **Figure 17** and **Figure 18** below, for both scenarios of paper towel production - one with 0% recycled content and the other with 100% recycled content - the A1 raw materials stage stands out as the primary contributor to impacts across several categories, followed by A3 manufacturing stage. Specifically, in the context of acidification, smog, human carcinogenic toxicity, and water consumption categories, A1 accounts for 39% to 70% of the total impact for the 0% recycled content scenario.

Similarly, for the smog, human carcinogenic toxicity, and water consumption categories of the 100% recycled content scenario, A1 impacts also make up 39% to 70%.

The bulk of these A1-related impacts are largely driven by the sulfate pulp material employed in both scenarios. More specifically, it's the production of bleached sulfate pulp from softwood and eucalyptus that imposes the greatest impact within the sulfate pulp materials. In the case of the paper towel containing 0% recycled content, sulfate pulp contributes to 44% to 88% of the A1 impacts across various impact categories, whereas for the paper towel containing 100% recycled content, this contribution ranges from 76% to 86%. However, as addressed in section **4.6.5**, an inherent assumption is that the energy and emissions utilized in the production of both types of paper towels are identical, thus adding an element of uncertainty to the results. This uncertainty necessitates further, more detailed investigations into recycled fiber, including the identification of the specific types of fibers used in recycled paper towels. For instance, a future study might explore whether eucalyptus fiber is indeed the appropriate choice for this kind of paper towel.

Besides paper towel, it is noticed that in A1, for the human carcinogenic toxicity impact category, in the 100% recycled content scenario, the steel waste bin - specifically the production of chromium steel - dominates by contributing 46% of the impact.

As previously discussed, the A3 manufacturing stage also significantly influences the life cycle impacts for both paper towel scenarios across multiple impact categories. For the paper towel scenario with 0% recycled content, A3 accounts for 42% to 58% of the impacts in the global warming, eutrophication, ozone depletion, and fossil depletion categories. Likewise, for the paper towel scenario with 100% recycled content, A3 is responsible for 38% to 58% of the impacts in global warming, acidification, eutrophication, ozone depletion, and fossil depletion categories. Predominantly, these A3-related impacts are derived from the manufacturing process of converting sulfate pulp into paper towels, with electricity and natural gas being the major contributors within this manufacturing process.

Although the A4 product distribution stage does not have the most impact for both scenarios; it accounts for 8.8% of the life cycle greenhouse gas emissions, and does have the second greatest impact for smog creation potenital and ozone depletion potential categories. These impacts are driven by the transportation of the paper towels from the warehouse to the washroom associated with the paper towel refills over the product lifetime.

Lastly, for both scenarios, the human non-carcinogenic toxicity impact category is primarily influenced by the B1 product use stage, accounting for approximately 74% of impacts. These impacts are largely associated with the disposal of paper towels into a landfill.

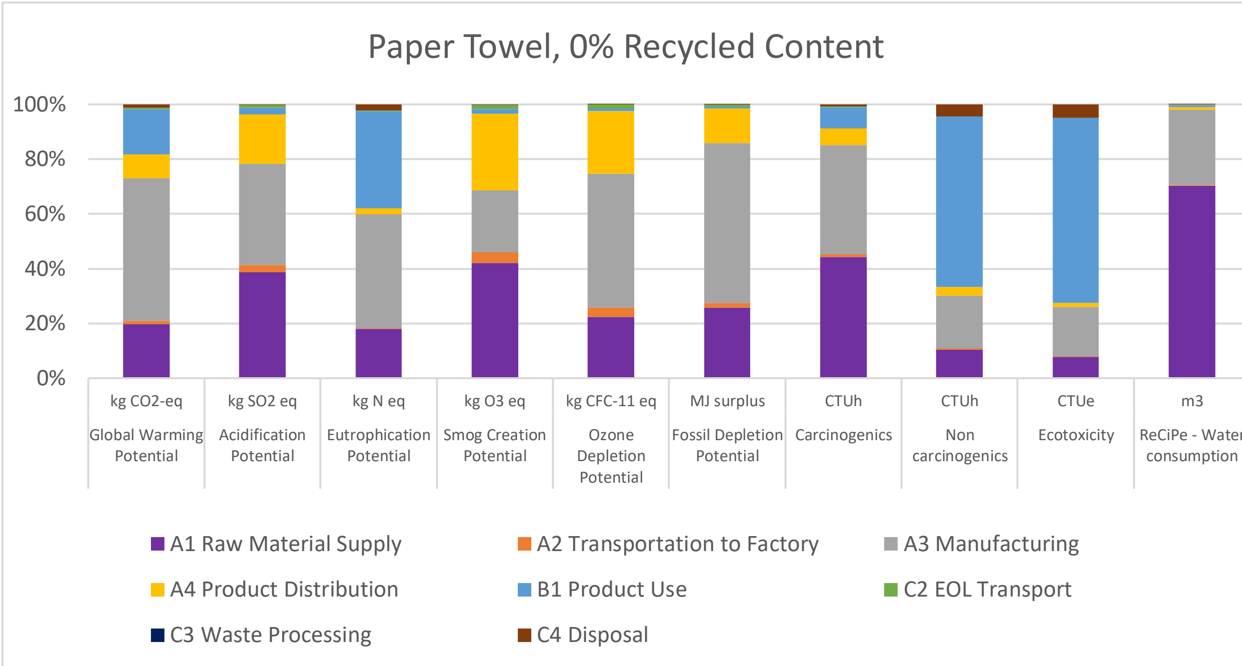



Figure 17: Contribution Analysis of Paper Towel Baseline Containing 0% Recycle Content, Per Functional Unit: 260,000 Hand Drying Instances

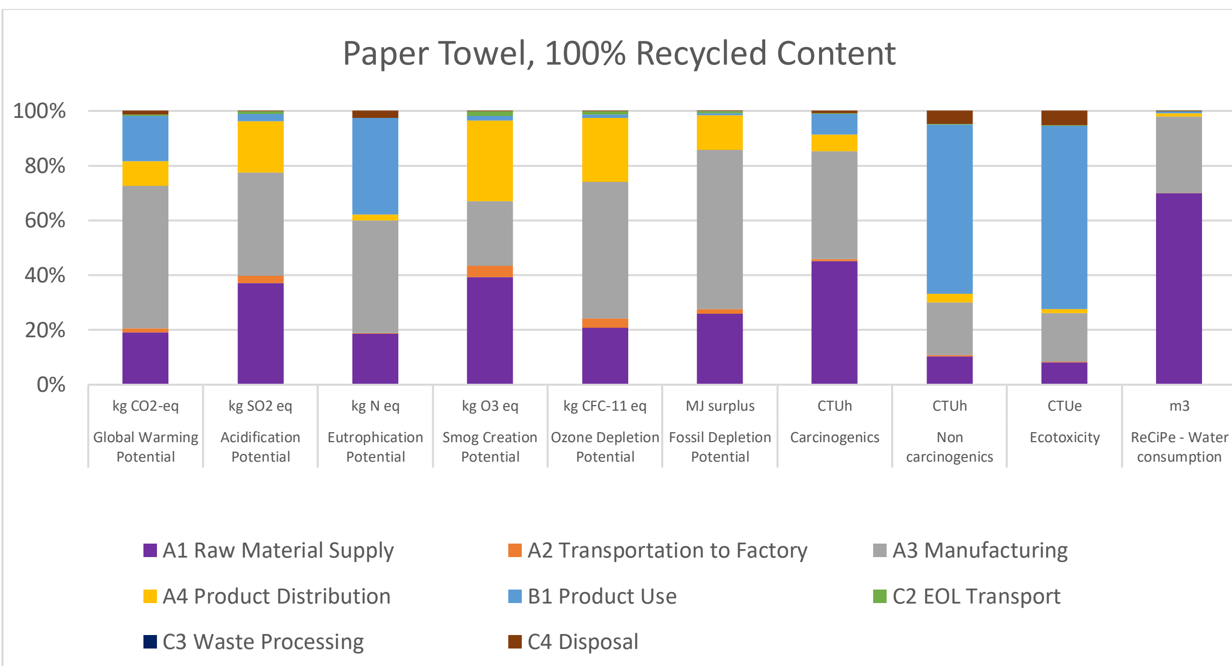



Figure 18: Contribution Analysis of Paper Towel Baseline Containing 100% Recycle Content, Per Functional Unit: 260,000 Hand Drying Instances

Due to variations in data, the uncertainty analysis shown in Figure 19 indicates that the environmental Impacts of the paper towel baseline containing 0% recycle content could be around 34% lower to 85% higher in global warming potential, acidification, smog, fossil fuel depletion, eutrophication, and ozone depletion. Carcinogenics, non-carcinogenics, and ecotoxicity results are more uncertain due to variations in data, ranging from 151% lower to 189% higher, which is shown in **Figure 19** as well. Results for water consumption are highly uncertain, ranging from 1593% lower to 1357% higher, which is driven by the data uncertainty in the underlying secondary data.

Due to variations in data, the uncertainty analysis shown in **Figure 20** indicates that the environmental Impacts of the paper towel baseline containing 100% recycle content could be around 34% lower to 86% higher in global warming potential, acidification, smog, fossil fuel depletion, eutrophication, and ozone depletion. Carcinogenics, non-carcinogenics, and ecotoxicity results are more uncertain due to variations in data, ranging from 155% lower to 215% higher, which is shown in **Figure 20** as well. Results for water consumption are highly uncertain, ranging from 2110% lower to 1735% higher, which is driven by the data uncertainty in the underlying secondary data.

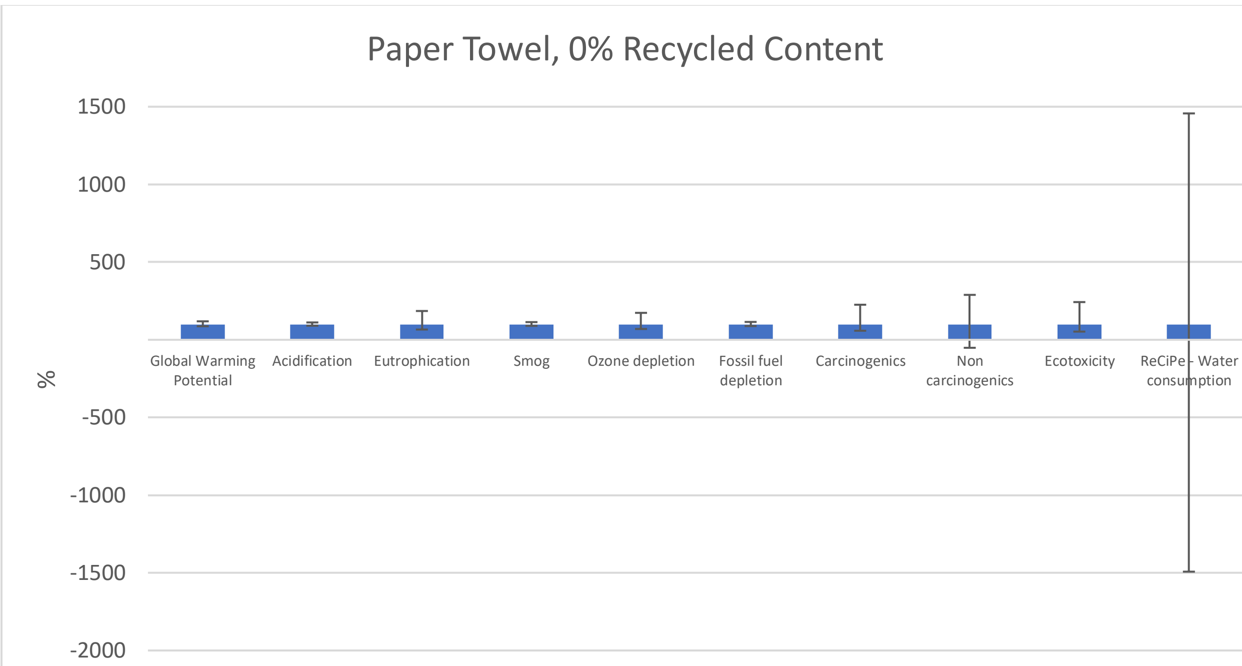



Figure 19: Uncertainty Analysis of Paper Towel Baseline Containing 0% Recycled Content

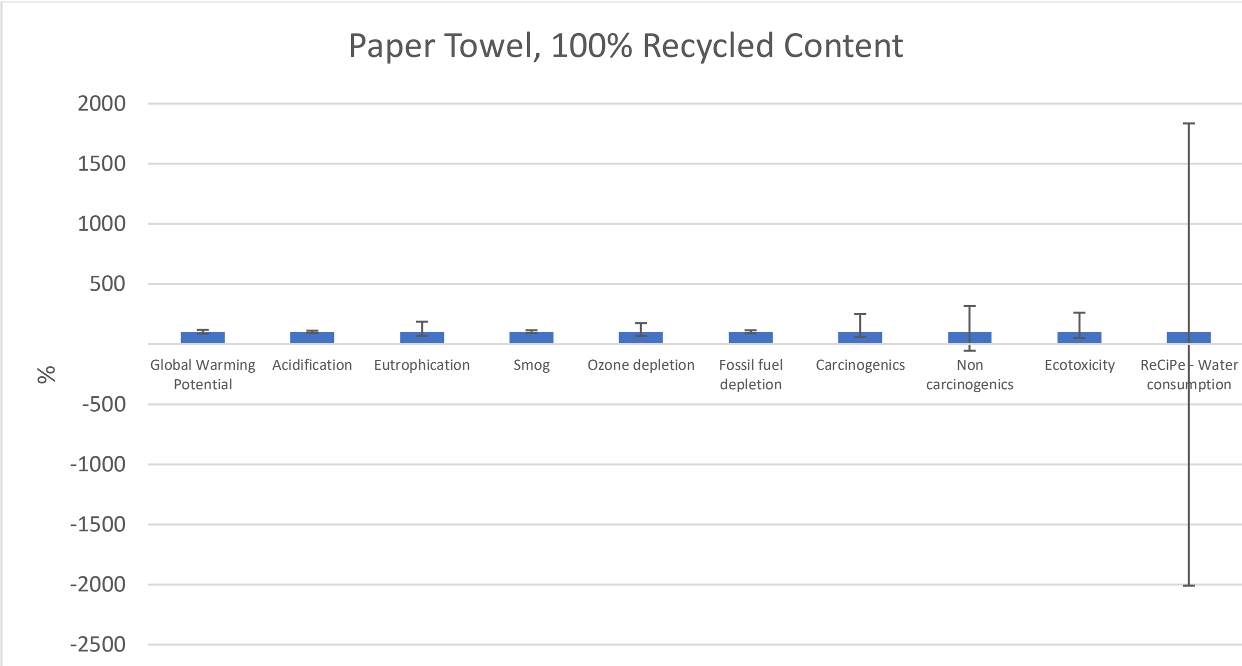



Figure 20: Uncertainty Analysis of Paper Towel Baseline Containing 100% Recycled Content

### 5.1.3 Excel Dryers versus Paper Towel Baseline

**Table 24** below provides a summary of absolute results of the comparative analysis, and **Table 25** below provide a summary of relative results compared to the model scenario that has the highest impact in the impact category. **Figure 21** to **Figure 30** visually present the comparative analysis results for each of the ten impact categories.

Based on the cradle-to-grave comparative analysis, the paper towel baselines have higher environmental impacts than the Excel dryers across all impact categories. The Excel dryers have between 80% to 97% fewer impacts than the paper towel baseline containing 0% recycled content and 81% to 96% fewer impacts than the paper towel baseline containing 100% recycled content. Notably, the XLERATOReco® Excel dryer has the least impact compared to other scenarios. XLERATOReco® is the no heat version of the standard XLERATOR® hand dryer and uses less energy during use (530W, 120V, compared to 1450W, 120V for XLERATOR®).

Table 24: Absolute Results of Comparative analysis of Excel dryers and Paper Towel Baseline, per functional unit: 260,000 hand drying Instances

| Impact Categories | ThinAir® Hand Dryer, 120V | XLERATOR® Hand Dryer, 120V | XLERATOReco® Hand Dryer, 120V | XLERATORsync®, 120V | Paper Towel, 0% Recycle Content | Paper Towel, 100% Recycle Content |
|---|---|---|---|---|---|---|
| Global Warming Potential | 5.54E+02 | 5.33E+02 | 2.90E+02 | 8.57E+02 | 5.07E+03 | 4.46E+03 |
| Acidification Potential | 1.72E+00 | 1.78E+00 | 1.08E+00 | 2.87E+00 | 1.52E+01 | 1.32E+01 |
| Eutrophication Potential | 3.14E+00 | 3.06E+00 | 1.64E+00 | 5.03E+00 | 2.56E+01 | 2.28E+01 |
| Smog Creation Potential | 1.70E+01 | 1.77E+01 | 1.09E+01 | 2.74E+01 | 2.66E+02 | 2.26E+02 |
| Ozone Depletion Potential | 3.62E-05 | 3.54E-05 | 1.93E-05 | 5.61E-05 | 4.67E-04 | 4.05E-04 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Fossil Depletion Potential** | 5.90E+02 | 5.74E+02 | 3.19E+02 | 9.19E+02 | 7.60E+03 | 6.73E+03 |
| **Carcinogenics** | 7.18E-05 | 7.86E-05 | 5.93E-05 | 8.15E-05 | 4.27E-04 | 3.88E-04 |
| **Non-Carcinogenics** | 1.79E-04 | 2.26E-04 | 1.58E-04 | 3.61E-04 | 3.27E-03 | 2.91E-03 |
| **Ecotoxicity** | 1.64E+04 | 1.89E+04 | 1.25E+04 | 3.09E+04 | 2.25E+05 | 2.01E+05 |
| **ReCiPe-Water Consumption** | 3.63E+00 | 3.68E+00 | 2.16E+00 | 5.80E+00 | 6.67E+01 | 5.86E+01 |

Table 25: Comparative Results of Comparative analysis of Excel dryers and Paper Towel Baseline, per functional unit: 260,000 hand drying Instances

| Impact Categories | ThinAir® Hand Dryer, 120V | XLERATOR® Hand Dryer, 120V | XLERATOReco® Hand Dryer, 120V | XLERATORsync®, 120V | Paper Towel, 0% Recycle Content | Paper Towel, 100% Recycle Content |
|---|---|---|---|---|---|---|
| **Global Warming Potential** | 11% | 11% | 6% | 17% | 100% | 88% |
| **Acidification Potential** | 11% | 12% | 7% | 19% | 100% | 87% |
| **Eutrophication Potential** | 12% | 12% | 6% | 20% | 100% | 89% |
| **Smog Creation Potential** | 6% | 7% | 4% | 10% | 100% | 85% |
| **Ozone Depletion Potential** | 8% | 8% | 4% | 12% | 100% | 87% |
| **Fossil Depletion Potential** | 8% | 8% | 4% | 12% | 100% | 89% |
| **Carcinogenics** | 17% | 18% | 14% | 19% | 100% | 91% |
| **Non-Carcinogenics** | 5% | 7% | 5% | 11% | 100% | 89% |
| **Ecotoxicity** | 7% | 8% | 6% | 14% | 100% | 89% |
| **ReCiPe-Water Consumption** | 5% | 6% | 3% | 9% | 100% | 88% |

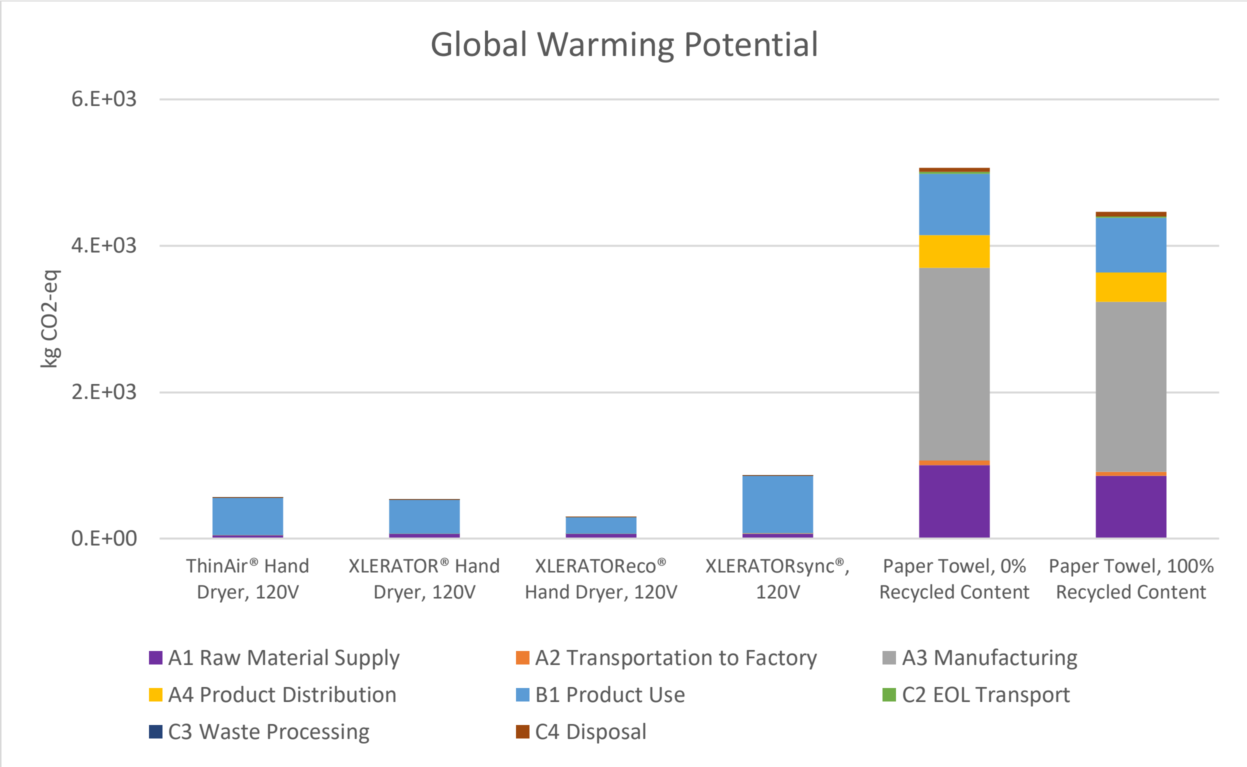



Figure 21: Comparative analysis – Global Warming Potential, per functional unit: 260,000 hand drying Instances

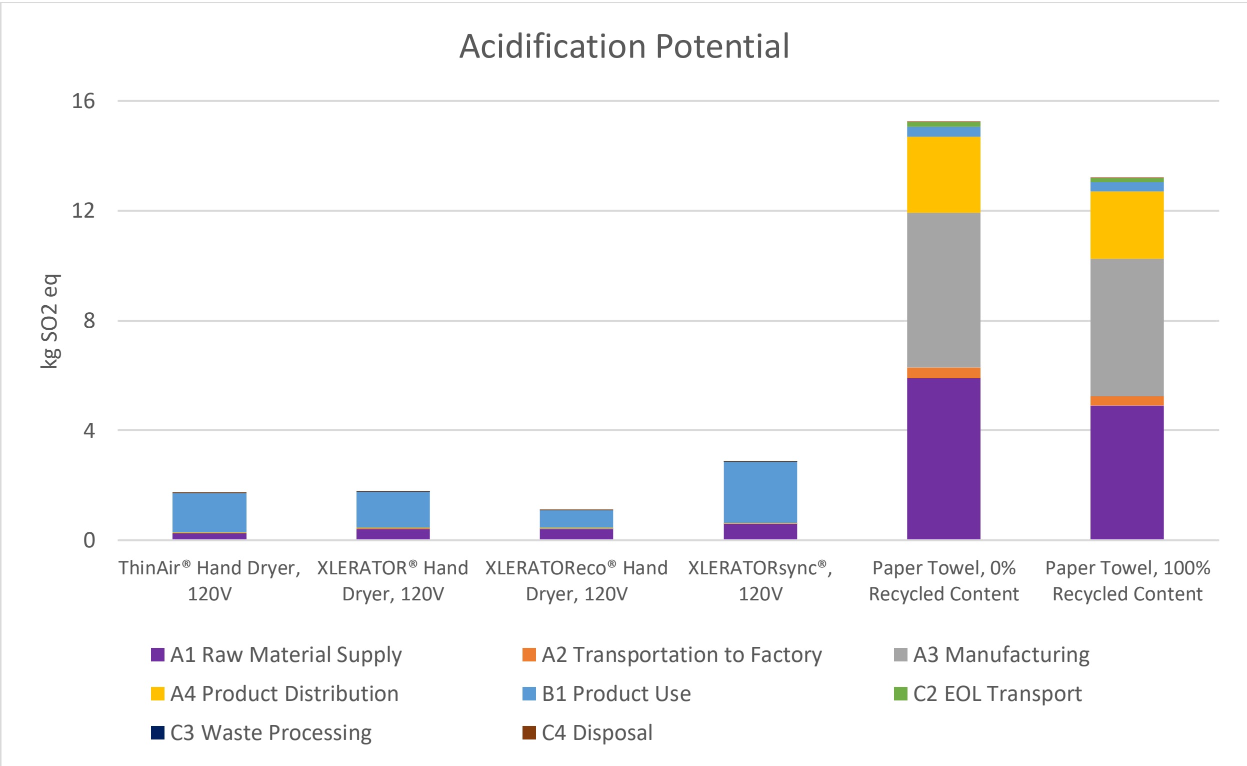



Figure 22: Comparative analysis – Acidification Potential, per functional unit: 260,000 hand drying Instances

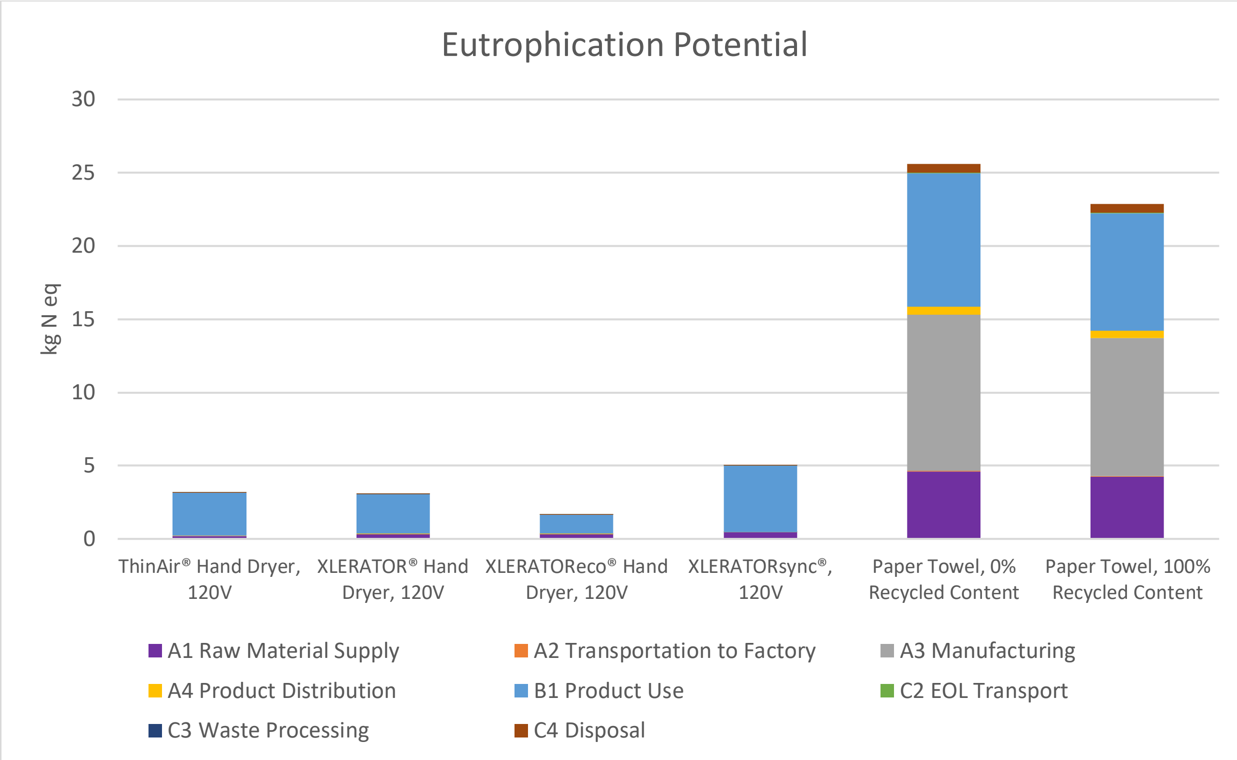



Figure 23: Comparative analysis – Eutrophication Potential, per functional unit: 260,000 hand drying Instances

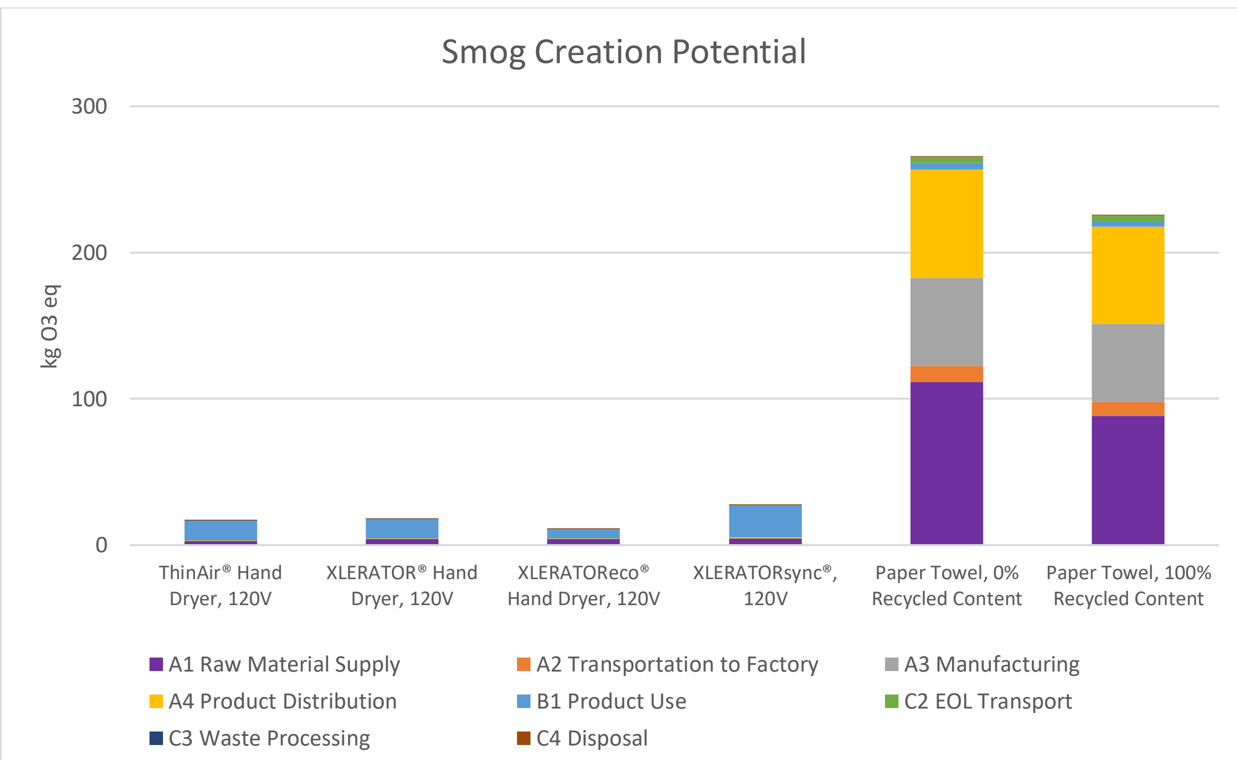



Figure 24: Comparative analysis – Smog Creation Potential, per functional unit: 260,000 hand drying Instances

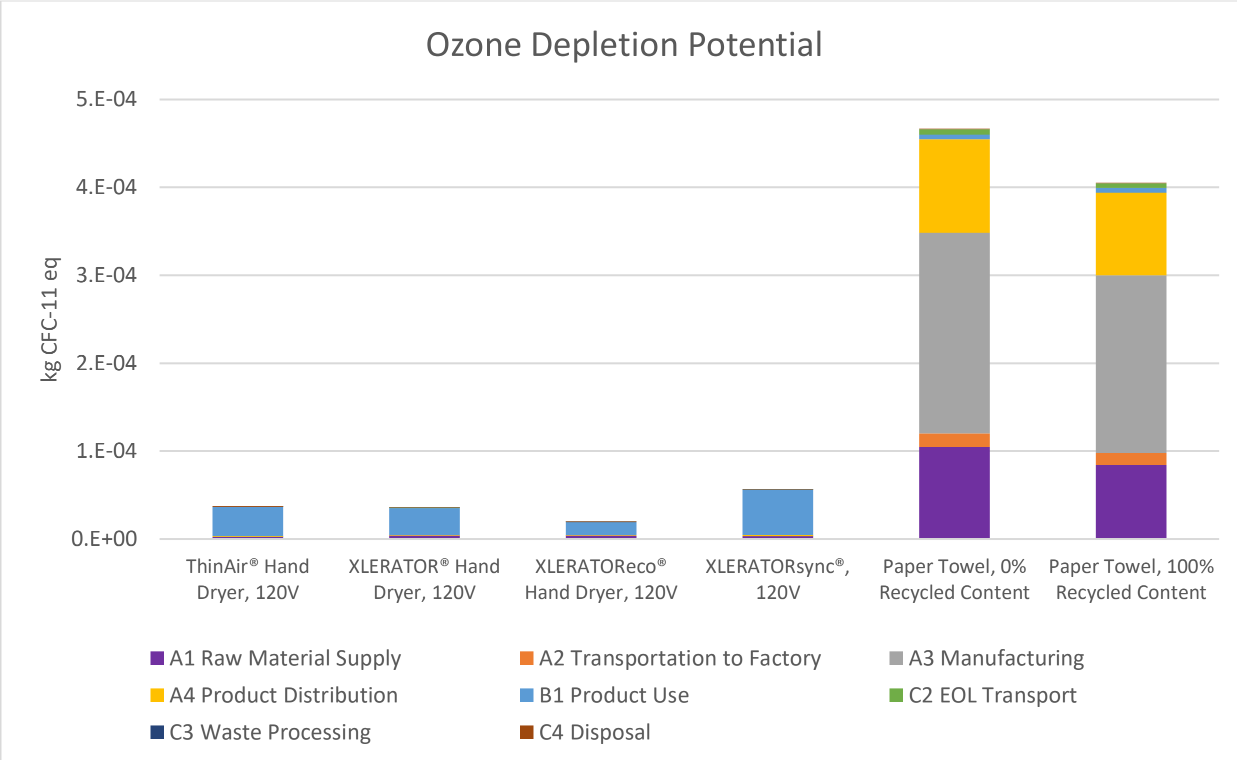



Figure 25: Comparative analysis – Ozone Depletion Potential, per functional unit: 260,000 hand drying Instances

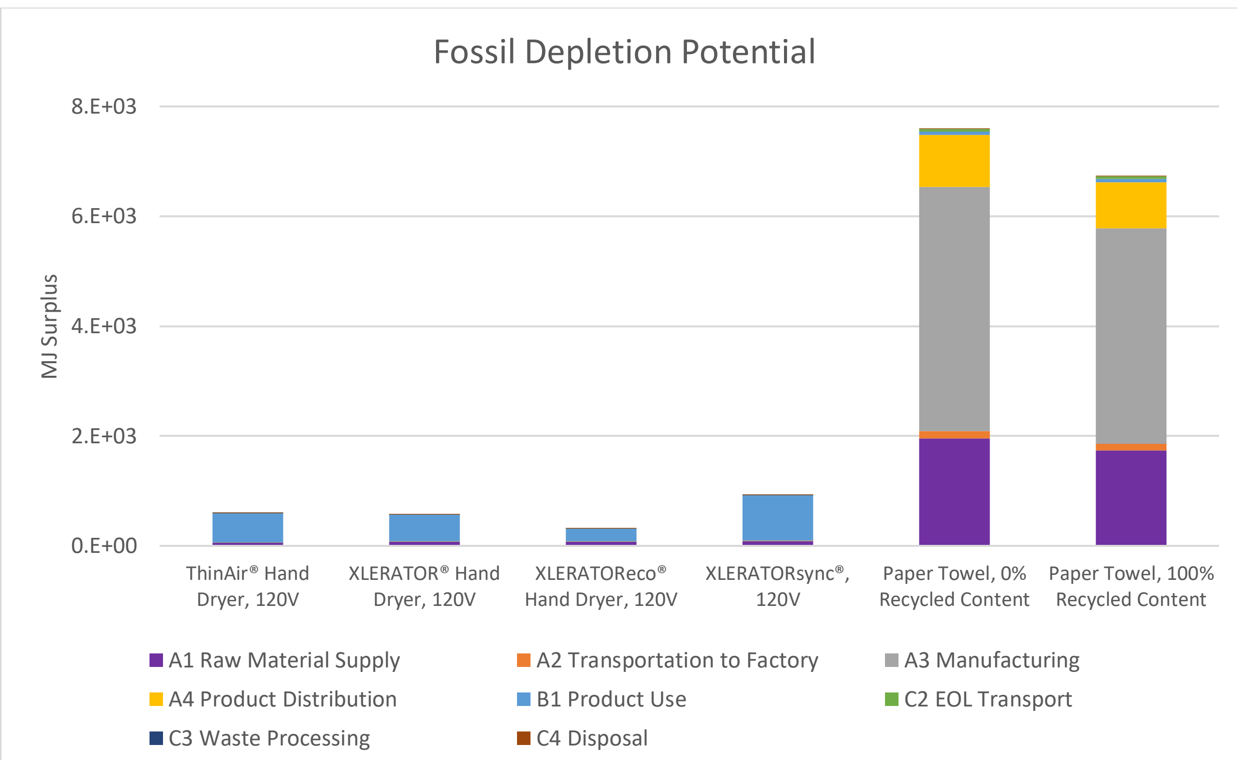



Figure 26: Comparative analysis – Fossil Depletion Potential, per functional unit: 260,000 hand drying Instances

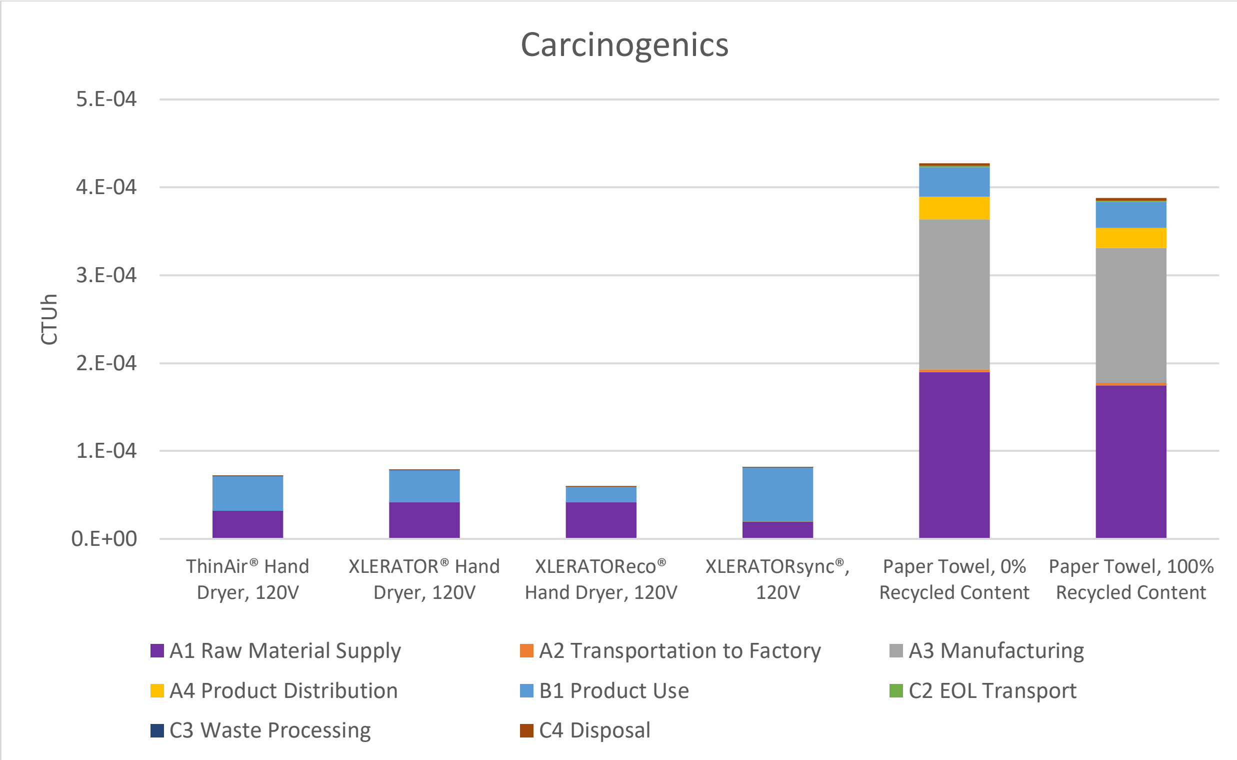



Figure 27: Comparative analysis – Carcinogenics, per functional unit: 260,000 hand drying Instances

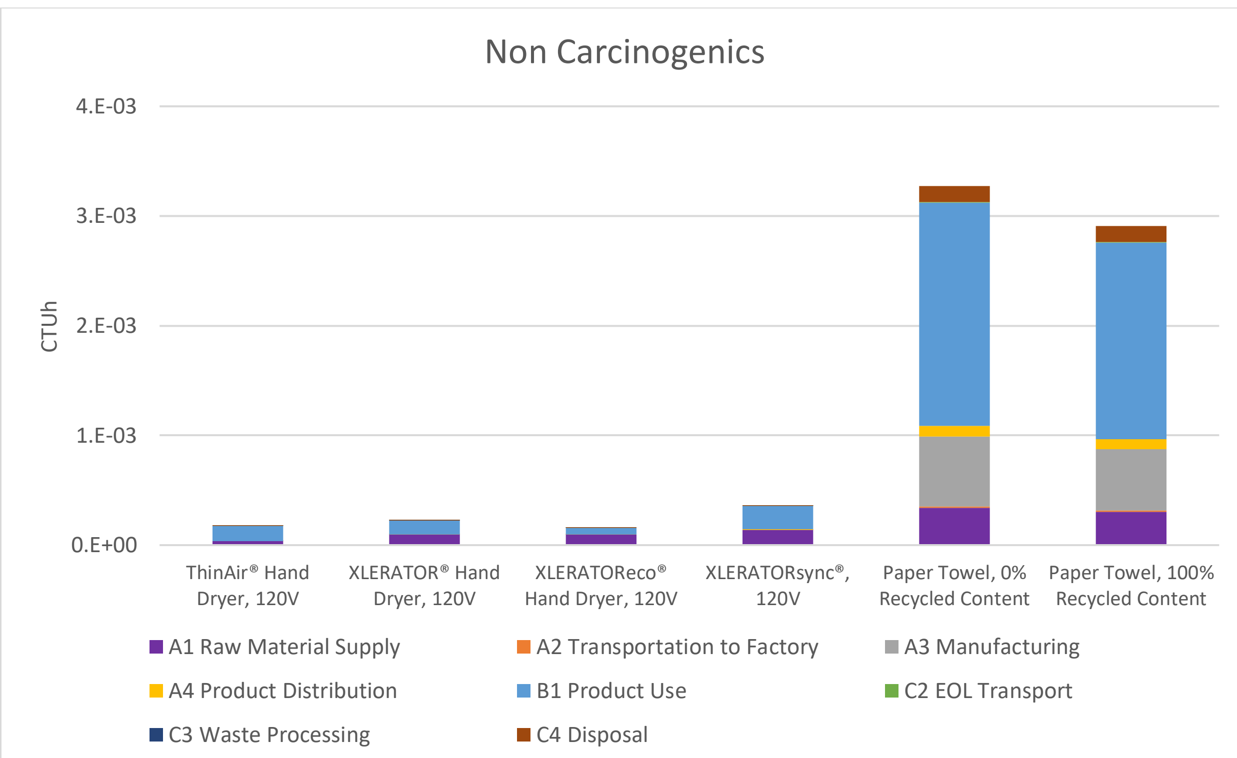



Figure 28: Comparative analysis – Non Carcinogenics, per functional unit: 260,000 hand drying Instances

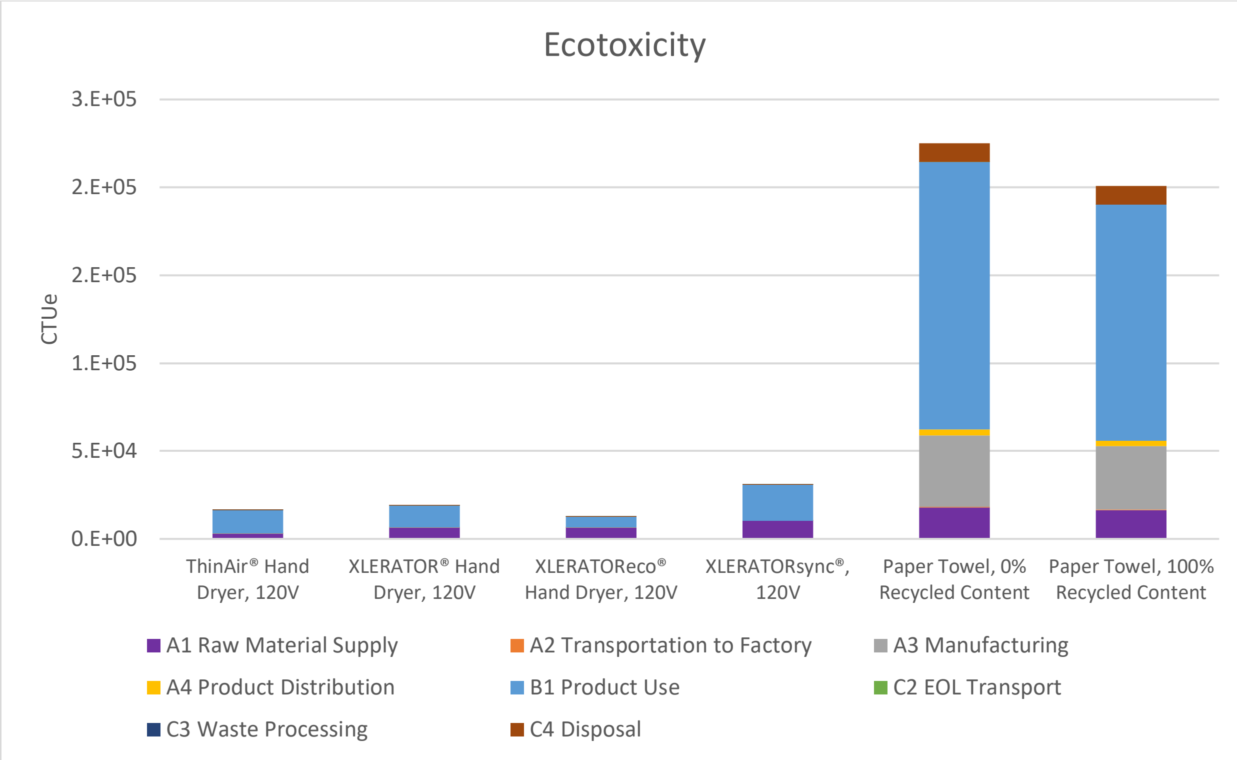



Figure 29: Comparative analysis – Ecotoxicity, per functional unit: 260,000 hand drying Instances

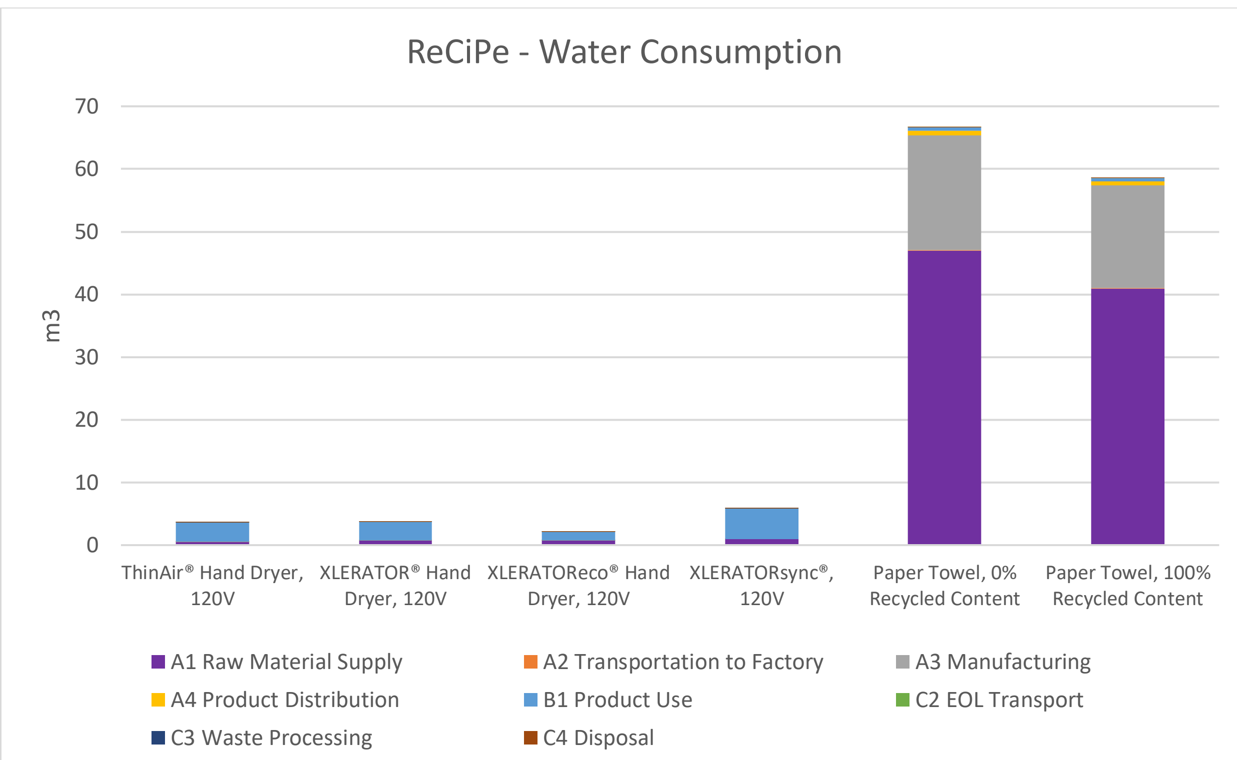



Figure 30: Comparative analysis – ReCiPe–Water Consumption, per functional unit: 260,000 hand drying Instances

Uncertainty analysis shown in **Figure 31** compares the XLERATORsync® Hand Dryer, which had the greatest environmental impacts compared to all the other Excel Dryers, and paper towel baseline containing 100% recycle content, had the least environmental impacts compared to the paper towel containing 0% recycle content. Besides the results for water consumption falling below the 95% confidence interval, the results indicate that for all the remaining impact categories, the impact between the Excel dryer and paper towel baseline are statistically significant (p > 0.05 for 100% of simulations).

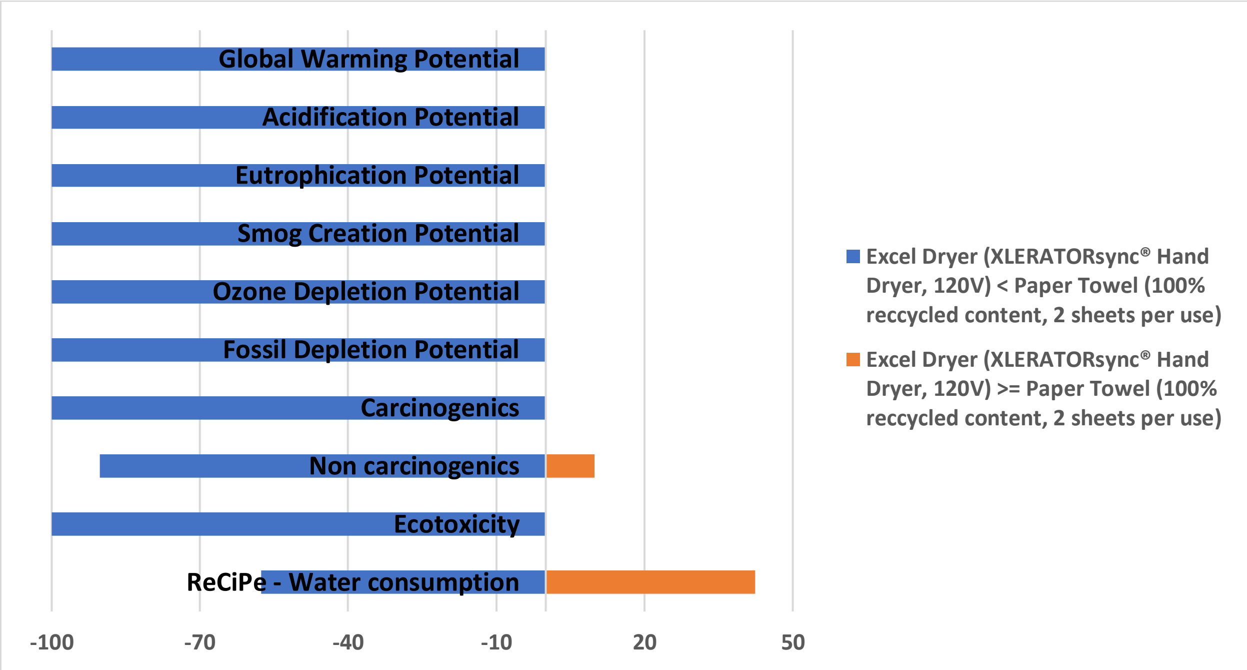



Figure 31: Uncertainty Analysis Results of Comparative Analysis, per functional unit: 260,000 hand drying Instances

## 5.2 Excel Dryer EPD Summary

**Figure** 32: EPD Results – Contribution Analysis of ThinAir® Hand Dryer, 120V, per functional unit: 100,000 hand drying to **Figure 35** below show the impact summary and contribution by life cycle stages of the four Excel Dryers with 120 voltages. Detailed tables for all model variations with different voltage can be found in **Appendix D**. Results of other indicators required by PCR can be found in **Appendix D** as well, which includes Resource Use, Output Flows and Waste Category Indicators.

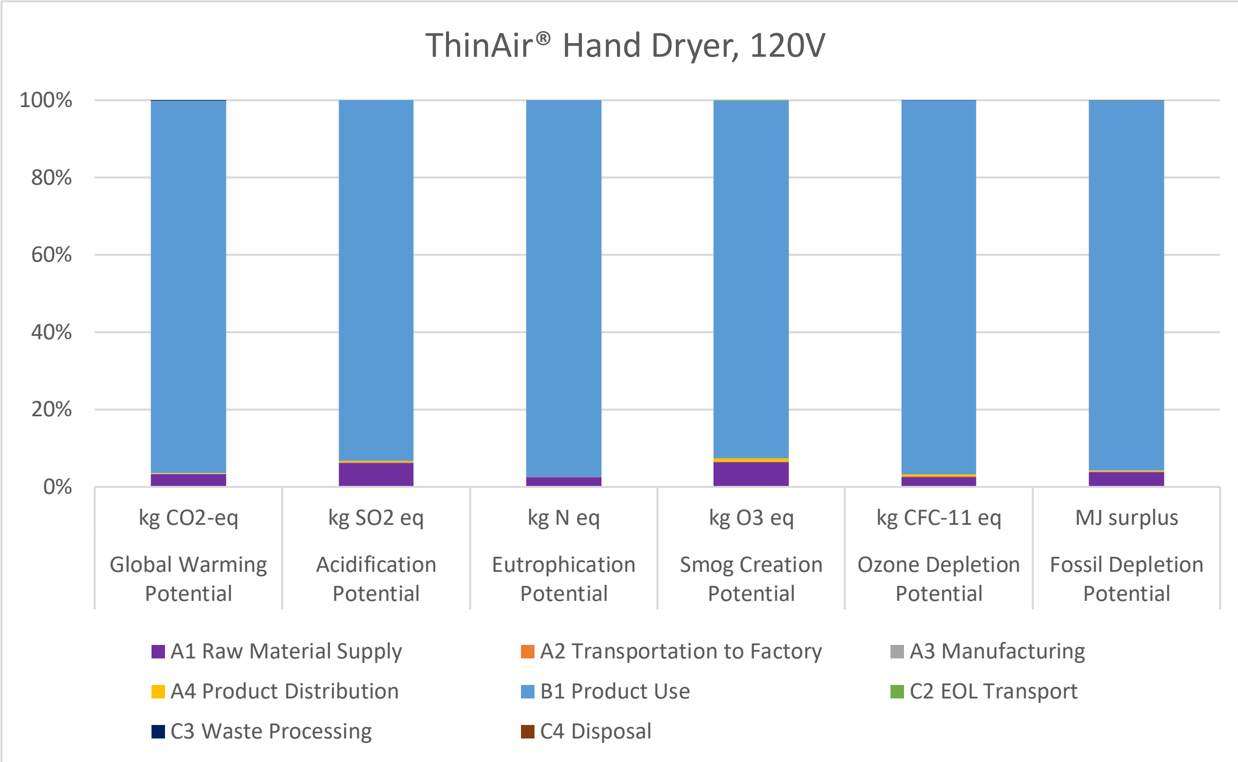



Figure 32: EPD Results – Contribution Analysis of ThinAir® Hand Dryer, 120V, per functional unit: 100,000 hand drying

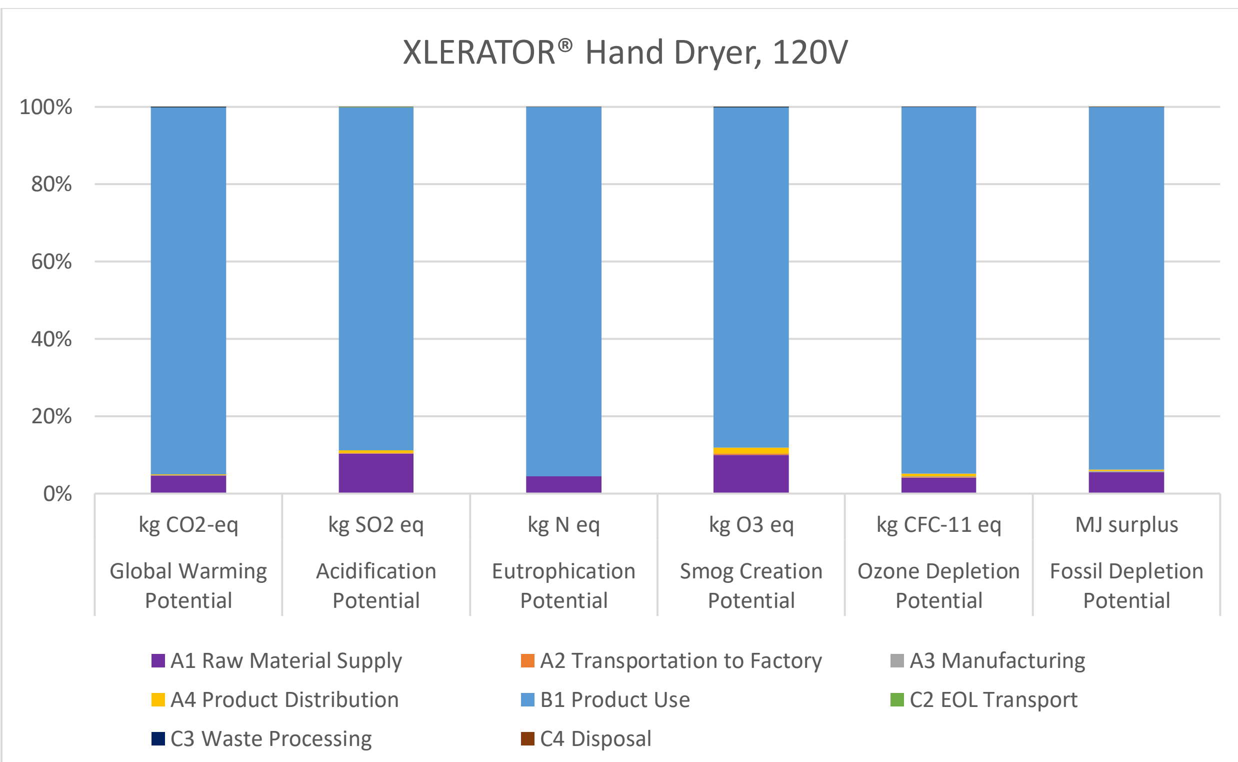



Figure 33: EPD Results – Contribution Analysis of XLERATOR® Hand Dryer, 120V, per functional unit: 100,000 hand drying Instances

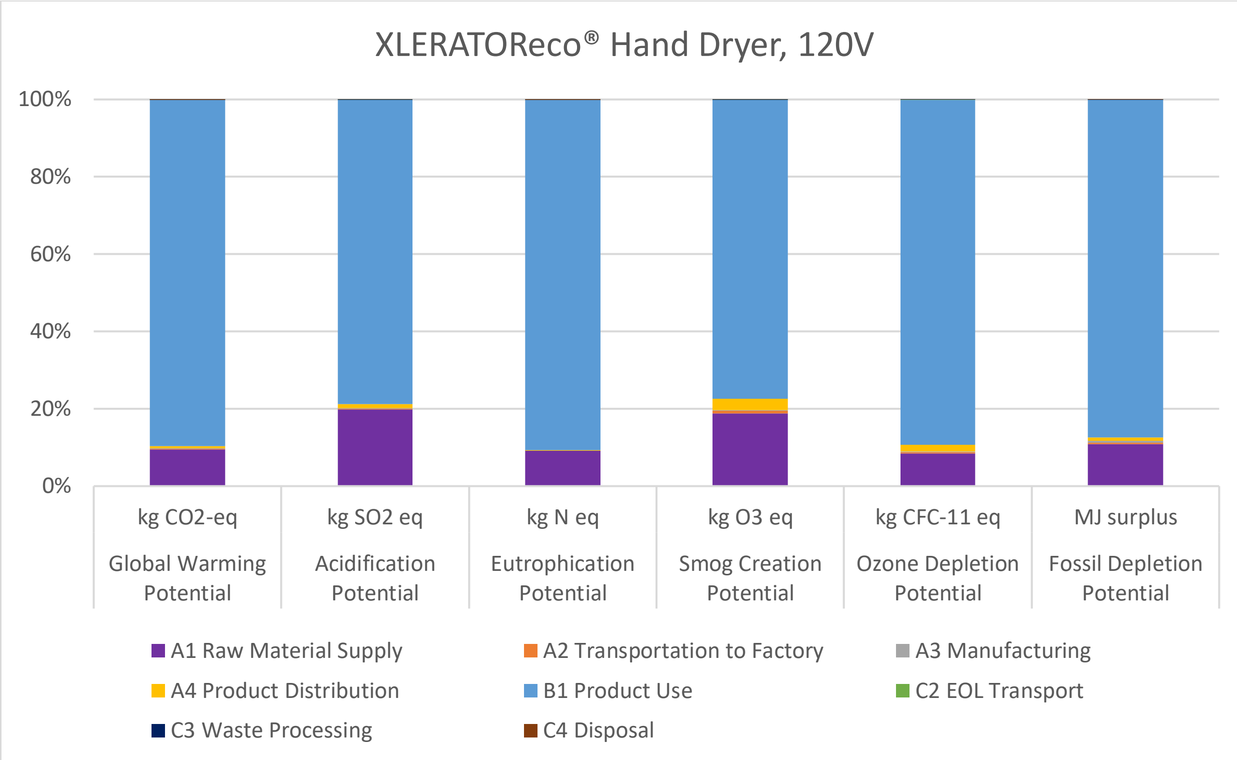



Figure 34: EPD Results – Contribution Analysis of XLERATOReco® Hand Dryer, 120V, per functional unit: 100,000 hand drying Instances

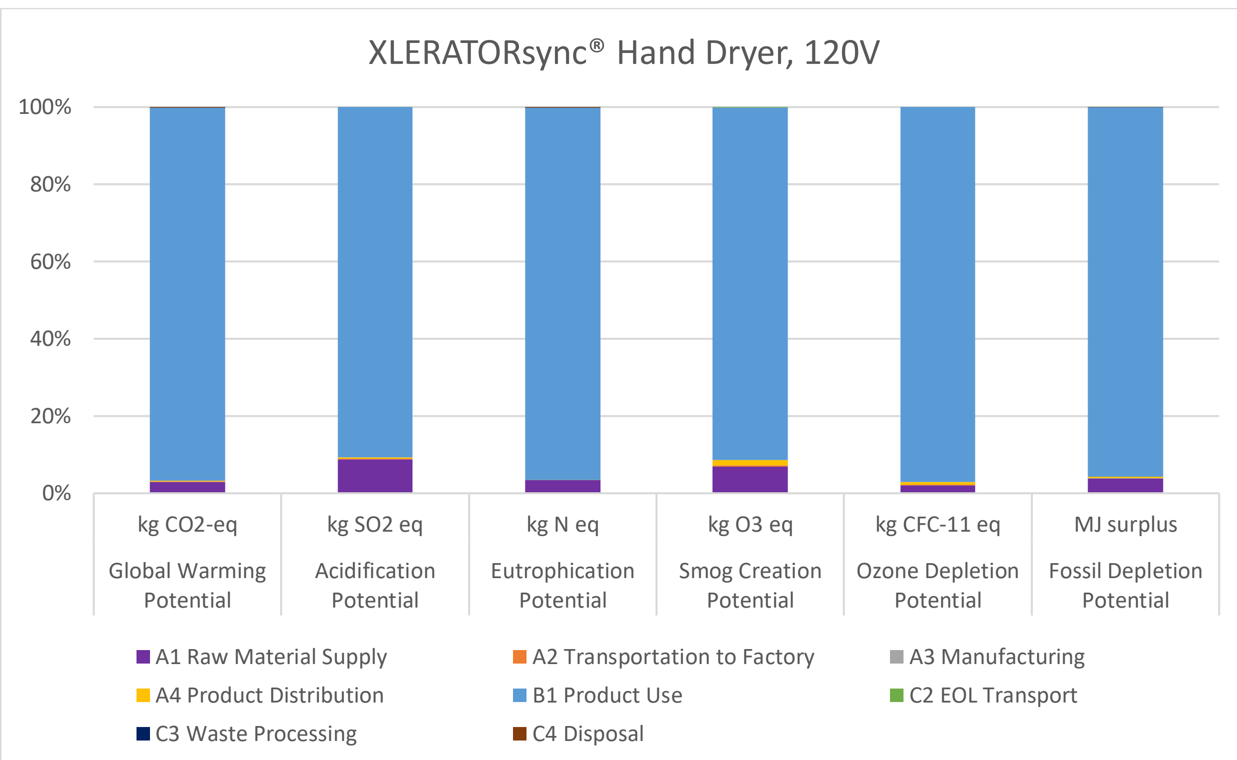



Figure 35: EPD Results – Contribution Analysis of XLERATORsync® Hand Dryer, 120V, per functional unit: 100,000 hand drying Instances

# 6. Life Cycle Interpretation

Interpretation is the last phase of an LCA, although it is typically done iteratively to inform and refine the goal and scope. In this section, the results are examined based on the data quality and consistency. Key assumptions are reviewed to ensure that conclusions and recommendations are consistent with the goal and scope. It should be noted that LCA results are based on a relative approach and indicate potential environmental effects therefore do not predict actual impacts on category impacts.

Based on the results and study assumptions, methods and data, the cradle-to-grave comparative analysis finds that the cradle-to-grave environmental impacts of all four Excel dryers are lower than the impacts of paper towel baselines across all ten impact categories. The life cycle impacts of the Excel dryers are driven by B1 use stage, while the paper towel baseline impacts are driven by the A1 raw materials stage and A3 manufacturing stage.

### 6.1 Findings

The analysis of the four different Excel dryers and paper towel baseline provides useful insights regarding the cradle-to-grave environmental impacts. The LCA results also identify where substantial impacts are occurring to allow further process and materials improvements to be implemented by Excel Dryers.

### 6.2 Completeness Check

Detailed information on the inputs and outputs of the four different Excel dryers and paper towel baseline were gathered with every effort made to perform a comprehensive analysis. An attempt was made to include as much detail as possible, even for processes that were found to be largely negligible in the environmental impact assessment. Processes were mass balanced before allocation to ensure all waste and emissions were captured. This was done to ensure completeness. Furthermore, all energy consumption that was understood as relevant for the comparison was included.

### 6.3 Consistency Check

The products were modeled in a consistent manner. System boundaries for all products were defined in a similar manner. Therefore, any differences in overall potential environmental impacts should not be due to inconsistent modeling or data.

### 6.4 Sensitivity Analysis

Sensitivity analysis is performed to understand the influence of variations in the assumptions, methods and data on the results. In other words, sensitivity analysis is used to understand the robustness of the conclusions and identify limitations to the results.

#### 6.4.1. Sensitivity Analysis 1 – Use Intensity

A sensitivity analysis on use intensity was conducted to evaluate the effect of number of cycles of running the hand dryers (increase from 1 cycle to 2 cycles), and the amount of paper towel used per hand drying (varies from 1 sheet to 4 sheets per use). The results are presented in **Figure 36** below. The discussion is based on the Global Warming Potential impact category, and similar trend can be observed in other impact categories. Detailed model results can be found in **Appendix E**: Life Cycle Assessment Results – Sensitivity Analysis.

Based on the use intensity sensitivity analysis, when comparing dryers to paper towel containing 0% recycled content, dryers have less environmental impacts no matter how many sheets of paper towel are used per hand drying, even when dryers run 2 cycles per use. This is also true when comparing dryers to paper towel containing 100% recycled content.

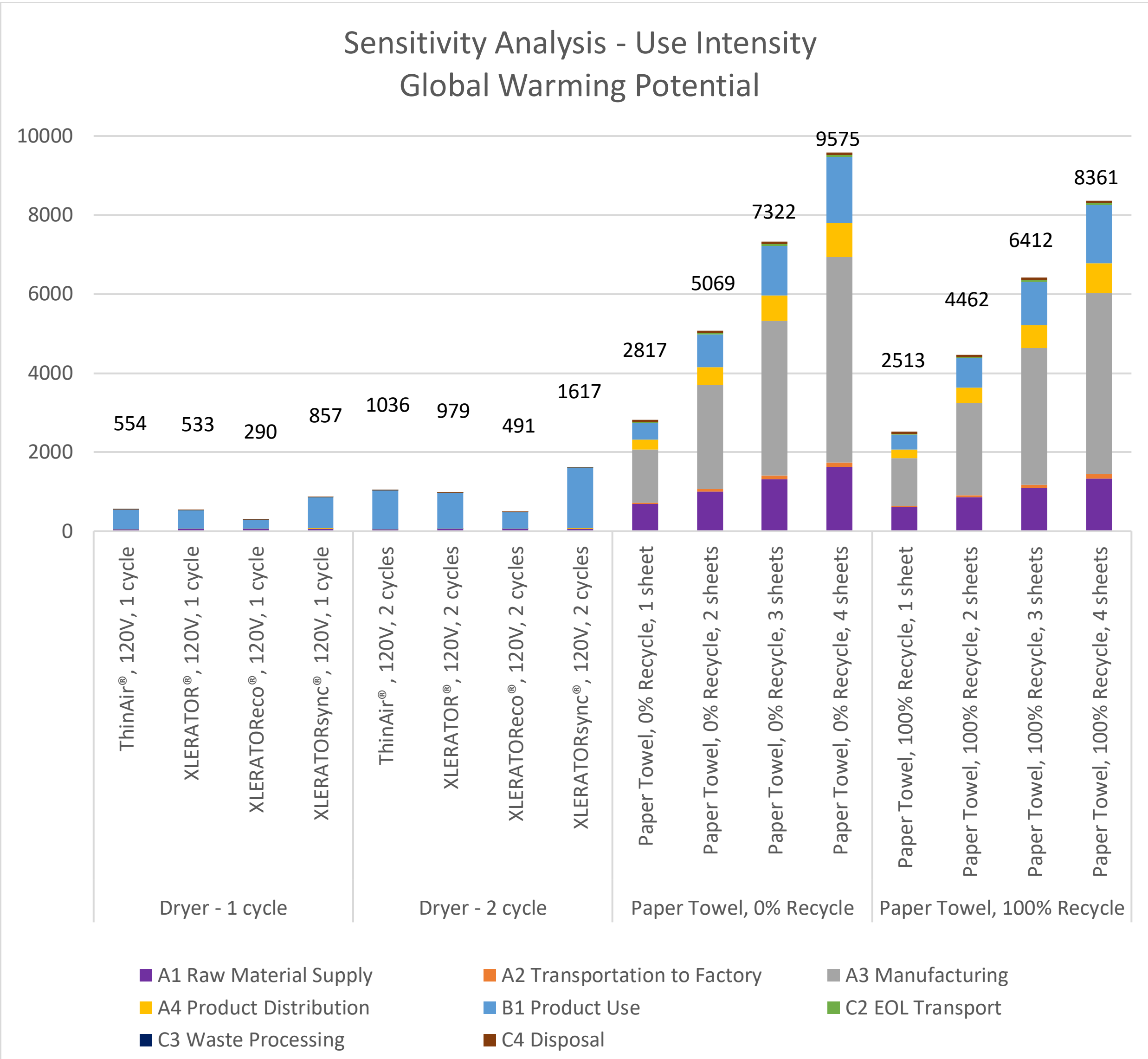



Figure 36: Use Intensity Sensitivity Analysis Results

### 6.4.2. Sensitivity Analysis 2 – Use Phase Electricity Grid Carbon Intensity

Another sensitivity analysis on use phase electricity grid carbon intensity was conducted to evaluate the effect of different electricity grid mix on running the hand dryers. The comparison was conducted on XLERATORsync® as it has the highest impact among all the dryers. The observed trend here between XLERATORsync® and the two paper towel scenarios can be applied to the other three dryers.

Besides the US average grid mix used in the base scenario, two customized electricity grid mixes of 100% wind and 100% coal are selected to represent a lower and higher carbon intensity of the electricity grid, as shown in **Table 26** below. The results of this sensitivity analysis are shown in **Figure 37** below. Since use phase dominates the life cycle impacts of the dryers, with a low carbon intensity grid, the overall global warming potential impacts of the dryer is 58% less than the same dryer in the base scenario and is 98% less than both of the paper towel scenarios with 0% or 100% recycled content. Similar trend applies to the high carbon intensity scenario as well. Although the impact of dryer is now 147% higher than the same dryer in the base scenario, it still achieves 58% or 52% reduction in global warming potential impacts, compared with paper towel scenarios with 0% or 100% recycled content, respectively. Overall, dryers show a significant advantage over the paper towels.

Table 26: Electricity Grid options

| Scenarios | Description |
|---|---|
| Base Scenario | US Average |
| Low Carbon Intensity Scenario | 100% Wind |
| High Carbon Intensity Scenario | 100% Coal |

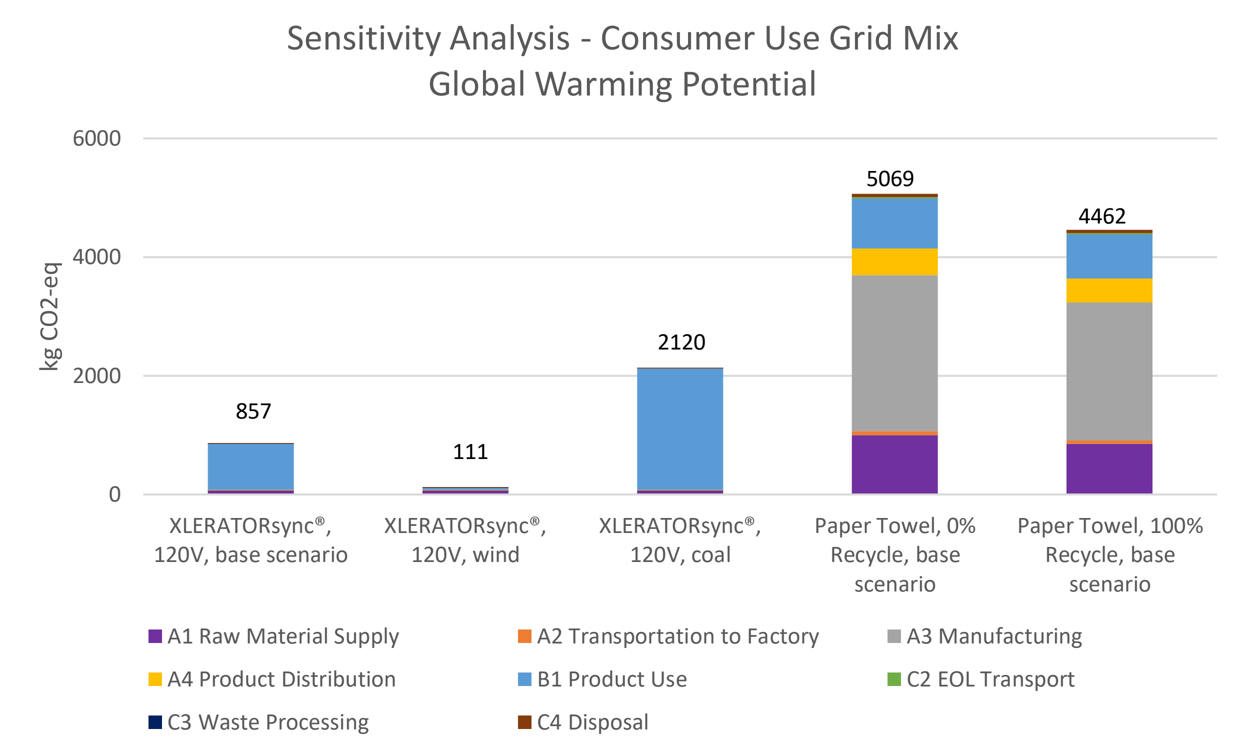



Figure 37: Use Grid Mix Sensitivity Analysis Results

### 6.4.3. Sensitivity Analysis 3 - Impact Assessment Method

ISO 14044 requires testing the sensitivity of the results to the selected method. This approach allows for the confirmation of general patterns in the results. ReCiPe 2016 v1.1 midpoint, Hierarchist perspective, V1.06 (ReCiPe Midpoint (H)) was used, along with CML-IA baseline V3.07 (CML).

**Table 27** below summarizes the impact assessment methods. As shown in **Figure 38** below, similar conclusions are reached that the paper towel baselines have more environmental impacts than the Excel dryers across all impact categories.

Table 27: Impact Assessment Method Sensitivity Analysis – Selected Methods

| Description | Unit | Selected Method |
|---|---|---|
| **Global Warming Potential** | kg CO2 eq. | ReCiPe 2016 v1.1 midpoint, Hierarchist perspective, V1.06 |
| **Stratospheric ozone depletion** | kg CFC-11 eq. | ReCiPe 2016 v1.1 midpoint, Hierarchist perspective, V1.06 |
| **Acidification** | kg SO2 eq. | CML-IA baseline V3.07 |
| **Eutrophication** | kg PO4--- eq | CML-IA baseline V3.07 |
| **Photochemical oxidation** | kg C2H4 eq | CML-IA baseline V3.07 |
| **Fossil resource scarcity** | kg oil eq | ReCiPe 2016 v1.1 midpoint, Hierarchist perspective, V1.06 |
| **Human carcinogenic toxicity** | kg 1,4-DCB | ReCiPe 2016 v1.1 midpoint, Hierarchist perspective, V1.06 |
| **Human non-carcinogenic toxicity** | kg 1,4-DCB | ReCiPe 2016 v1.1 midpoint, Hierarchist perspective, V1.06 |
| **Freshwater ecotoxicity** | kg 1,4-DCB | ReCiPe 2016 v1.1 midpoint, Hierarchist perspective, V1.06 |
| **Water use** | m3 | AWARE (Available WAter REmaining) V1.04 |

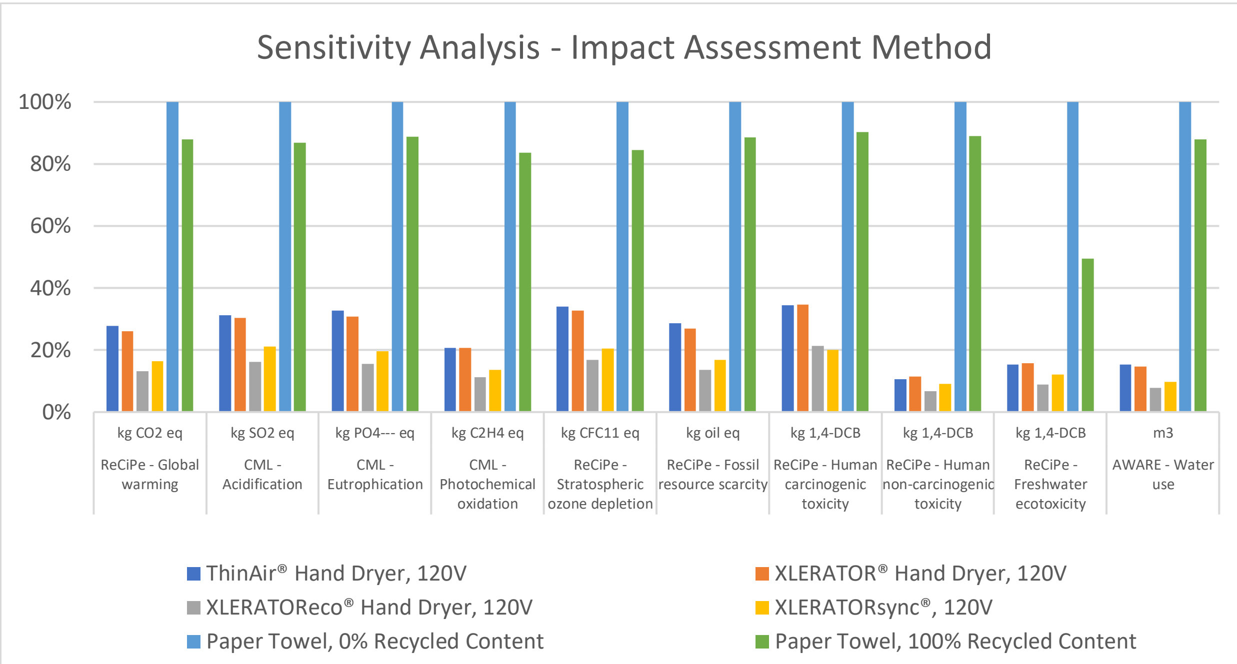



Figure 38: Sensitivity Analysis of Impact Assessment Method

Table 28: Comparative Results of Sensitivity Analysis of Impact Assessment Method - Comparative analysis of Excel dryers and Paper Towel Baseline, per functional unit: 260,000 hand drying Instances

| Impact Categories | ThinAir® Hand Dryer, 120V | XLERATOR® Hand Dryer, 120V | XLERATOReco® Hand Dryer, 120V | XLERATORsync®, 120V | Paper Towel, 0% Recycle Content | Paper Towel, 100% Recycle Content |
|---|---|---|---|---|---|---|
| **Global warming - ReCiPe Midpoint (H)** | 28% | 26% | 13% | 16% | 100% | 88% |
| **Acidification - CML** | 31% | 30% | 16% | 21% | 100% | 87% |
| **Eutrophication - CML** | 33% | 31% | 15% | 20% | 100% | 89% |
| **Photochemical oxidation - CML** | 21% | 21% | 11% | 14% | 100% | 84% |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Stratospheric ozone depletion - ReCiPe Midpoint (H)** | 34% | 33% | 17% | 20% | 100% | 84% |
| **Fossil resource scarcity - ReCiPe Midpoint (H)** | 29% | 27% | 14% | 17% | 100% | 88% |
| **Human carcinogenic toxicity - ReCiPe Midpoint (H)** | 34% | 35% | 21% | 20% | 100% | 90% |
| **Human non-carcinogenic toxicity - ReCiPe Midpoint (H)** | 11% | 11% | 7% | 9% | 100% | 89% |
| **Freshwater ecotoxicity - ReCiPe Midpoint (H)** | 15% | 16% | 9% | 12% | 100% | 49% |
| **Water use - AWARE** | 15% | 15% | 8% | 10% | 100% | 88% |

#### 6.4.4. Sensitivity Analysis 4 – Allocation of Recycled Content

When recycled content is used in a system, a methodological decision must be made regarding how to allocate the burdens from the production and/or disposal of that material among the several systems it may be part of. There are a number of approaches on how to allocate the impacts of the original production of materials that have been recycled. However, in this current study, the "cut-off" approach was utilized for the baseline scenarios. It is assumed that the impacts from the original production of the sulfate pulp have not been allocated to the paper towel system; therefore having 0% allocation. Thus, these impacts are allocated entirely to the prior systems that made use of the virgin content. Whereas production of the recycled sulfate pulp from the prior paper products has been allocated entirely to the system. Leading to 100% of the impact of disposing of the paper towels being allocated to the paper towel system.

Two additional allocation approaches were utilized to examine the effect of alternate methodological choices of allocating impacts of the original pulp production. One scenario was a scheme based on ISO/TR 14049 (ISO 14049, 2012) ("ISO-based method"), as shown in **Figure 39**. The other scenario was the waste treatment allocation method, which can be seen and **Figure 40**.

Both approaches were applied in the (Materials Systems Laboratory, 2011) study. Although the MIT study examined five different approaches, these two methods were chosen in this study because the ISO-based method had the high-end result while the waste treatment method had the low-end result when comparing the results of all five different approaches.

As shown in **Figure 39**, three product life cycles, L1, L2, and L3 were chosen, representing the average number of times paper is used and reused in the US before reaching the end-of-life stage (i.e. going to the landfill) (Materials Systems Laboratory, 2011). Similar to the cut off approach, both stages L2 and L3 bear the full environmental burden of their preceding repulping processes. Where L3 represents the final life cycle in the open loop system, since paper towels are always disposed of after use. The burden of the virgin pulp is allocated to L1, L2 and L3, which is calculated considering the production, disposal, and recycling losses that occur throughout each life cycle. Details of the ISO-based allocation method can be viewed in **Appendix H**: ISO-Based Allocation Method.

For the waste treatment allocation method, as shown in **Figure 40,** the waste management is only for the paper towel material stream that was discarded.

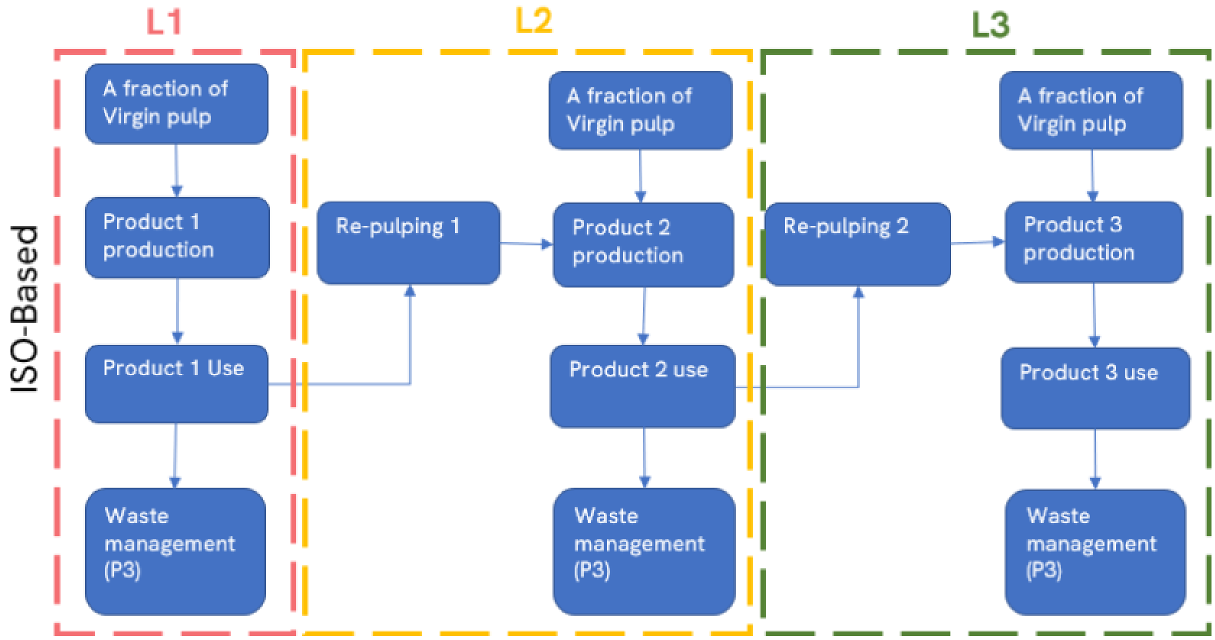



Figure 39: ISO-based allocation scheme for recycled content

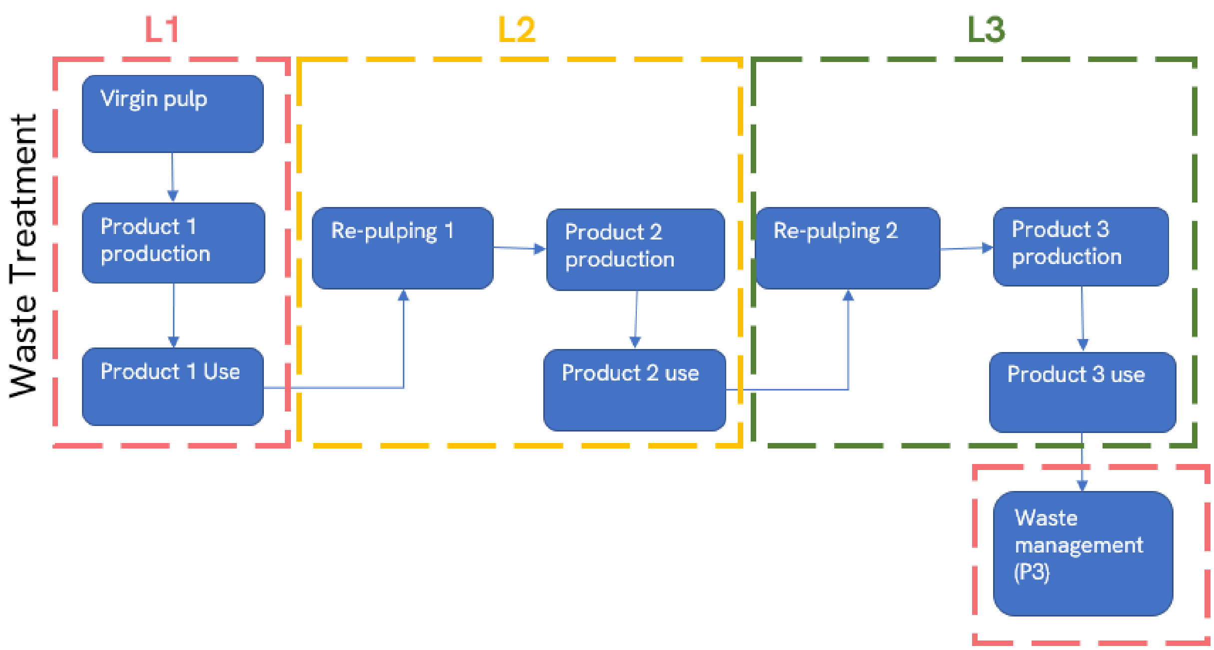



Figure 40: Waste treatment allocation scheme for recycled content.

Impacts of the two additional allocation methods (Waste treatment and ISO) are shown in **Figure 41** for paper towels manufactured with 100% recycled content. Depending on which allocation method is used, recycled paper towel can be either greater or less than the virgin paper towel. However, changing the allocation scheme does not change whether paper towels are preferred over the Excel dryers. The XLERATOReco®, has the least impact out of all dryers, is 95% and 92% less than the ISO and waste treatment method, respectively. While the XLERATORsync®, has the most impact out of all dryers, is 84% and 77% less than the ISO and waste treatment method, respectively This is due to the majority of paper towel burden coming from paper towel manufacturing, which is unaffected by either allocation choice.

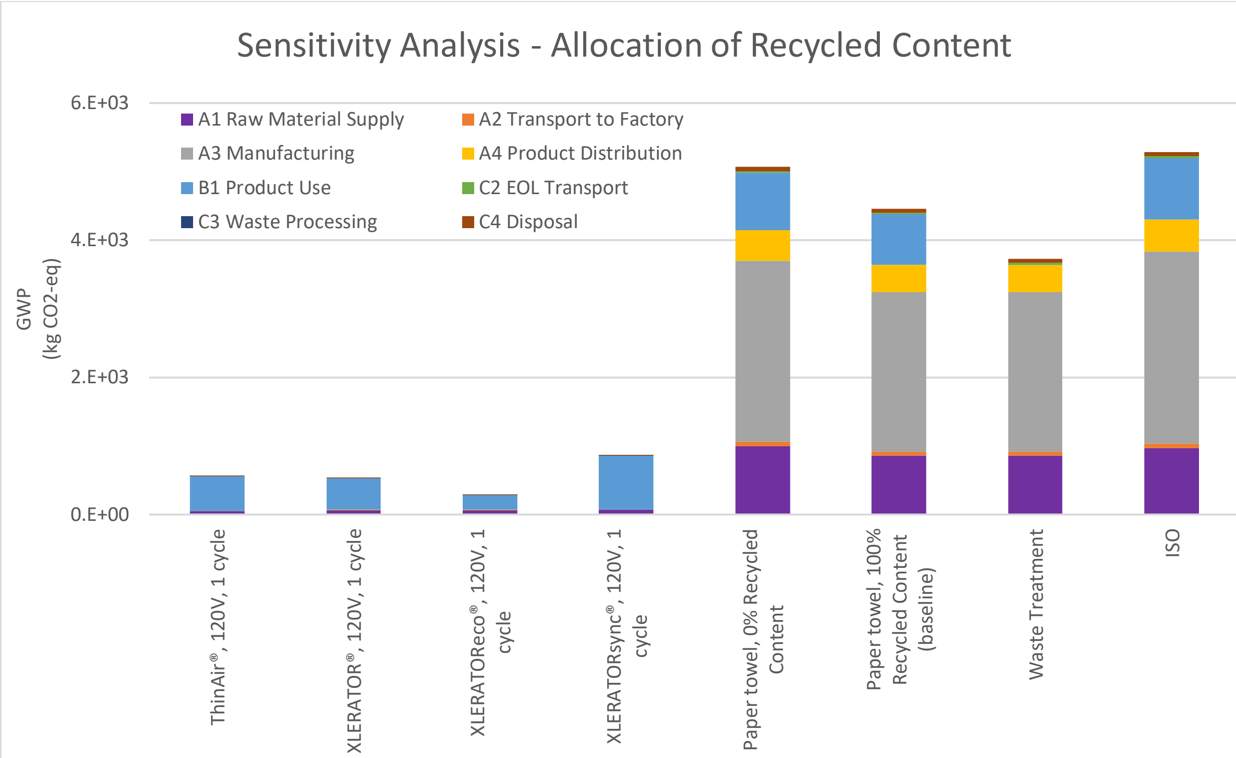


Figure 41: Sensitivity Analysis of Allocation of Recycled Content

### 6.5 Conclusions & Recommendations

The primary objectives of this report are to support the comparative assessment between paper towels and hand dryers as two methods of hand dryings for commercial application and to also provide the necessary background data to support the EPD for the four Excel hand dryer products.

Based on the results and study assumptions, methods and data for the comparative analysis base scenario portion of this study, **all four studied Excel dryers have fewer environmental impacts in all impact categories than paper towel scenarios.** The cradle-to-grave environmental impacts of the Excel dryers are dominated by the use stage, which is driven by power consumption and the amount of time it takes to dry one pair of hands. The cradle-to-grave environmental impacts of the paper towel baselines are driven by the manufacturing stage, specifically the electricity and natural gas that is used to manufacture the sulfate pulp to paper towels. It is also dominated by the raw materials, specifically the bleached sulfate pulp production from softwood and bleached sulfate pulp production from eucalyptus.

The energy efficiency of Excel dryers enables the dryers to have a great advantage when comparing with paper towel baselines, especially for the models that uses less energy per hand drying. XLERATOReco®, which is the no heat version of the standard XLERATOR® hand dryer, consumes less energy during consumer use and achieves a 46% impact reduction in global warming potential, compared to the standard XLERATOR® hand dryer. **The comparative analysis shows that the four Excel dryers have**

**between 80% to 87% fewer impacts than the paper towel baseline containing 0% recycled content and 81% to 96% fewer impacts than the paper towel baseline containing 100% recycled content.**

**Additional analysis on use intensity confirms the conclusion that Excel dryers have fewer environmental impacts no matter how many sheets of paper towel are used per hand drying, even when dryers run 2 cycles per use.**

**Further analysis results on the carbon intensity of use phase electricity grid again shows the great advantage of Excel dryers over paper towel baseline scenarios.** Represented by XLERATORsync®, which has the highest impacts among the four studied Excel dryers, it achieves from 58% to 98% reduction in global warming potential impacts, compared with paper towel baselines. The advantage of dryers will be more significant for the other three models with lower impacts than XLERATORsync®. By switching to a greener electricity grid (i.e., 100% wind) during consumer use phase, XLERATORsync®'s overall global warming potential impacts reduced by 87%, from 857 kg CO2eq to 111 kg CO2eq, and is 98% less than the impacts of the paper towel scenarios with 0% and 100% recycled content. And even with a high carbon intensity electricity grid (i.e., 100% coal) for consumer use phase, and the impacts of dryer increase by 147%, from 857 kg CO2eq to 2120 kg CO2eq, it still achieves a 58% or 52% reduction in global warming potential impacts, compared with paper towel scenarios with 0% or 100% recycled content, respectively. As the importance of decarbonizing the buildings sector is widely recognized now, and to achieve the Paris Agreement goals, the global buildings and construction sector must achieve net-zero emissions by 2050, and all new buildings must be net-zero carbon starting in 2030. The building sector is moving towards net zero buildings - achieving high energy efficient, using renewable energy directly, such as photovoltaics (PV), solar thermal hot water, and hydrogen, or using an energy supply that will be fully decarbonized by 2050. In addition, increasing the electrification of buildings using technologies available today, alongside a decarbonizing grid, is the primary solution for addressing building emissions from indirect sources. In both cases, Excel dryers can provide the building sector a better solution through the dryer's high energy efficiency, low maintenance needs and electrification of hand drying.

A final analysis on allocation of recycled content is conducted to evaluate the effect of different allocation of recycled content of the paper towel scenario containing 100% recycled content, **no matter which allocation method is used it does not change whether paper towels are preferred over the Excel dryers.** This is due to the majority of paper towel burden coming from paper towel manufacturing, which is unaffected by either allocation choice.

This comparative analysis and underlying LCA model are limited to the four Excel Dryer products and should not represent the overall sustainability position of electric hand dryers compared with a paper towel baseline. Overall, the comparative analysis results are favorable for the four studied Excel dryers. However, when comparing dryers with paper towels across all studied scenarios, as customers use less paper towels per hand drying, or if the paper towel manufacturers reduced the impact in producing the paper towels, electric dryers may start to lose its advantage over paper towel, especially if the running cycles are longer than what's designed, or when the grid has higher carbon intensity. Recommendations from this study include promoting and offering more products with high energy efficiency. Additionally, Excel can join the efforts to provide a greener grid for its customers.

To improve the LCA model, data quality and results accuracy, recommendations are made for future study. There is uncertainty of the paper towel baseline due to the data used for this study was sourced from LCA studies published in 2011 and 2009. Although some other secondary data was sourced from reports published in 2018 and 2023, it is recommended that Excel to further investigate of current paper towel baseline and collect data that is more recent and specific to the study region. Specifically, if more information about the manufacturing of the dispenser and the raw materials of the optical sensor become available, the data in the paper towel baseline can be fine-tuned.

# References

ACLCA. (2019). *ACLCA Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017.* ACLCA.

Bare, J., Gloria, T., & Norris, G. (2006). Development of the Method and U.S. Normalization Database for Life Cycle Impact Assessment and Sustainability Metrics. *Environmental Science & Technology*.

Bare, J., Norris, G., Pennington, D., & McKone, T. (2003). TRACI: The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts. *Journal of Industrial Ecology*.

Boulay A.M., B. J. (2018). The WULCA consensus characterization model for 108 water scarcity footprints: Assessing impacts of water consumption based on available water remaining (AWARE). . *The International Journal of Life Cycle Assessment*.

Carvalho, M., & Abrahao, R. (2017). Environmental and Economic Perspectives in the Analysis of Two Options for Hand Drying At an University Campus.

Frischknecht, R., Jungbluth, N., Althaus, H., Doka, G., Dones, R., Hischier, R., . . . Nemecek, T. (2007). *Implementation of Life Cycle Impact Assessment Methods: Data v2.0.* Dübendorf, Switzerland: ecoinvent report No. 3, Swiss centre for Life Cycle Inventories.

Georgia Pacific. (2023). Retrieved from https://www.gppro.com/gp/gppro/USD/GP-PRO-Categories/Commercial-Paper-Towels-and-Dispensers/ENMOTION%C2%AE-IMPULSE%C2%AE-8-1-ROLL-AUTOMATED-TOUCHLESS-PAPER-TOWEL-DISPENSER-BY-GP-PRO-GEORGIA-PACIFIC-BLACK-1-DISPENSER/p/59498A

IPCC, I. P. (2013). *IPCC Fith Assessment report. The PhysicalSceince Basis.* Retrieved from http://www.ipcc.ch/report/ar5/wg1/.

ISO 14025. (2006). *ISO 14025:2006: Environmental labels and declarations — Type III environmental declarations — Principles and procedures.* International Organization for Standardization.

ISO 14040. (2006). *ISO14040:2006/Amd 1:2020 -- Environmental management -- Life cycle assessment -- Principles and framework.* International Organization for Standardization.

ISO 14044. (2006). *ISO 14044:2006 Environmental management - Life cycle assessment - Requirements and guidelines.* International organization for Standardization (ISO).

ISO 14071. (2014). *ISO 14071: 2014 Environmental management — Life cycle assessment — Critical review processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006.* International organization for Standardization (ISO).

ISO. (2006). *ISO 14040:2006 Environmental management - Life cycle assessment - Principles and framework.* International Organization for Standardization (ISO).

ISO 21930. (2017). Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services.

Materials Systems Laboratory, M. I. (2011). Life Cycle Assessment of Hand Drying Systems.

Suresh, A., & Schultz, T. (2018). Life Cycle Impact Assessment Methodology for Envrionmental Paper Network Paper Calculator v4.0.

UL 10007, Version 1. (2016). For Preparing an Environmental Product Declaration (EPD) for the Product Category: Hand Dryers. UL.

UL. (2018). Product Category Rules for Building Related Products and Services, Part A: Life Cycle Assessment Calculation Rules and Report Requirements UL 10010, v3.2. UL.

UL. (2020). Product Category Rule (PCR) Guidance for Building-Related Products and Services Part B: Designated Steel Construction Product EPD Requirements, UL 10010–34, v.2. UL.

US, Q. (2009). *Comparative Environmental Life Cycle Assessment of Hand Drying Systems:The XLERATOR Hand Dryer, Conventional Hand Dryers and Paper Towel Systems.*

Weidema B P, B. C. (2013). *Overview and methodology. Data quality guideline for the ecoinvent database version 3.* St. Gallen: The ecoinvent Centre.

# Appendix A: Description of impact categories

Global Warming Potential (GWP): Aligned with the purpose of low carbon energy sources and high priority environmental issues, this impact category is deemed to be of high interest and relevance. Biogenic and non-biogenic carbon are assessed and included in estimating GWP values. In this study short-lived renewable or biogenic carbon dioxide uptake and release is considered to be neutral with respect to global warming emissions.

*Background:*

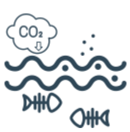
*Global warming occurs at both regional and global levels. When the short-wave radiation from the sun reaches the earth's surface, a portion of the radiation is absorbed, and the rest is reflected as infrared radiation. The reflected portion is absorbed by greenhouse gases, scattered in multiple direction, and contributes to the warming of the earth. Major greenhouse gases include carbon dioxide, carbon monoxide, methane and CFCs. The global warming potential is expressed in $CO_2$ equivalent meaning that contributing gases are measured and expressed in one harmonized unit. Common residence time of gases in the atmosphere is defined as 100 years.*

Ozone depletion potential and Smog formation: To include potential environmental impacts associated with stratospheric ozone depletion and atmospheric ozone creation, mentioned categories are added to the study.

*Background:*

*Ozone layer acts as a shield for life on earth. It traps ultraviolet radiations which can penetrate to organism protective layers and damage DNA. Release of certain chemicals can contribute to the depletion of ozone layer in stratosphere. Ozone depletion potential is defined as potential of a chemical in degrading ozone layer. Common contributors include Halons, Chlorofluorocarbons (CFCs) and Hydrofluorocarbons (HFCs). For this category, impacts are expressed based on kg CFC-11 equivalent.*

*Smog formation is a result of ozone creation in the troposphere. It can damage vegetation and materials, and in high concentrations, it can be toxic to humans as well. Nitrogen oxides, chlorin compounds and hydrocarbons can react at ground level and create ozone. High concentration of ozone arises in high temperature, low humidity and when air is static. Impacts of this category are measured and expressed in kg $O_3$ equivalent.*




Acidification and Eutrophication: These two categories are considered relevant to the study due to potential release of chemicals to air and water through processing and fuel combustion.

*Background:*

*Acidification of soil and water bodies is caused by transformation of air pollutants to acid molecules. In this situation, the PH-level of rainwater and fog, drops to the acidic range, and it can damage ecosystems, nutrient balance of the soil, and buildings. Ammonia, hydrogen sulfides and chlorides, $NO_x$ and $SO_x$ are common contributors to this impact category. Although, this effect can happen at global level, the regional impacts can vary significantly. The impacts of this category are measured and expressed in kg $SO_2$ equivalent.*

*Eutrophication refers to excess of nutrient in aquatic or terrestrial environments. It can cause algal growth which prevents sunlight from reaching the lower depth of water and depletes available oxygen needed for growth of aquatic organisms.  Air pollutants, wastewater and fertilization in agriculture can contribute to this impact. Phosphorus, ammonia and nitrogen compounds are considered as important pollutants. Impacts of this category as measured and expressed in kg Nitrogen equivalent.*


Fossil fuel depletion: Since the studied solution can replace nonrenewable sources of power generation, this category is deemed relevant and therefore, is added to the assessment.

*Background:*

*This impact category evaluates the reduction of the global amount of fossil fuels. The results are measured and expressed in MJ surplus, translating to the surplus energy needed for future mining and extraction of fossil fuels.*

# Appendix B: Life Cycle Inventory

Table 29: Life Cycle Inventory Summary for Excel Dryers

| Material | Unit | ThinAir® Hand Dryer Cover: ABS | ThinAir® Hand Dryer Cover: SS | XLERATOR® Hand Dryer White Thermoset Resin | XLERATOR® Hand Dryer Brushed Stainless Steel | XLERATOR® Hand Dryer White Epoxy Painted | XLERATORReco® Hand Dryer: White Thermoset Resin | XLERATORReco® Hand Dryer: Brushed Stainless Steel | XLERATORReco® Hand Dryer: White Epoxy Painted | XLERATORsync® |
|---|---|---|---|---|---|---|---|---|---|---|
| **ABS** | kg | 0.580 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.299 |
| **ABS_PC** | kg | 0.950 | 0.950 | 1.097 | 1.097 | 1.097 | 1.097 | 1.097 | 1.097 | 2.278 |
| **Acrylic** | kg | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.001 |
| **Carbon** | kg | 0.010 | 0.010 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 |
| **Glass reinforced resin** | kg | 0.072 | 0.072 | 2.412 | 0.301 | 0.301 | 2.412 | 0.301 | 0.301 | 0.301 |
| **Phenolic** | kg | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 |
| **LDPE** | kg | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **Mica** | kg | 0.015 | 0.015 | 0.024 | 0.024 | 0.024 | 0.000 | 0.000 | 0.000 | 0.024 |
| **Rubber** | kg | 0.052 | 0.052 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | 0.070 | 0.138 |
| **Vinyl** | kg | 0.004 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **Polyurethane foam** | kg | 0.007 | 0.007 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.019 |
| **Stainless steel** | kg | 0.000 | 1.346 | 0.000 | 2.263 | 0.000 | 0.000 | 2.263 | 0.000 | 0.131 |
| **Nichrome** | kg | 0.009 | 0.009 | 0.007 | 0.007 | 0.007 | 0.000 | 0.000 | 0.000 | 0.007 |
| **Aluminum** | kg | 0.150 | 0.150 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.071 | 0.170 |
| **Steel** | kg | 0.304 | 0.304 | 1.018 | 1.018 | 1.018 | 1.016 | 1.016 | 1.016 | 0.973 |
| **Copper** | kg | 0.129 | 0.129 | 0.333 | 0.333 | 0.333 | 0.333 | 0.333 | 0.333 | 0.499 |
| **Brass** | kg | 0.021 | 0.021 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.023 |
| **Paper** | kg | 0.001 | 0.001 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.087 |
| **PCB** | kg | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.000 |
| **Electronics (Non-PCB/IC)** | kg | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.099 |
| **Electronics (IC)** | kg | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **Polyethylene** | kg | 0.000 | 0.000 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.000 |
| **Phenolic thermoset resin** | kg | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **Zinc** | kg | 0.000 | 0.000 | 0.000 | 0.000 | 4.118 | 0.000 | 0.000 | 4.118 | 1.659 |
| **Nylon** | kg | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.036 |
| **Cardboard** | kg | 0.727 | 0.727 | 0.678 | 0.678 | 0.678 | 0.678 | 0.678 | 0.678 | 2.014 |
| **Molded Pulp** | kg | 0.184 | 0.184 | 0.185 | 0.185 | 0.185 | 0.185 | 0.185 | 0.185 | 0.000 |
| **Plastic bag** | kg | 0.019 | 0.019 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.038 |
| **Paper** | kg | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 |
| **Foam** | kg | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.370 |

Table 30: Life Cycle Inventory Summary for Paper Towel Baseline

| Material | Unit | Paper Towel, 0% Recycle Content (2 Sheets) | Paper Towel, 100% Recycle Content (2 Sheets) |
|---|---|---|---|
| **A1 Battery RM** | kg | 0.72 | 0.72 |
| **A1 Dispenser RM** | kg | 1.540 | 1.540 |
| **A1 IR Sensor RM** | kg | 0.2346 | 0.2346 |
| **A1 Paper Towel RM (0% Recycled)** | kg | 1,330.54 | 0.000 |
| **A1 Paper Towel RM (100% Recycled)** | kg | 0.000 | 1,171.17 |
| **A1 Waste Bin RM** | kg | 6.3 | 6.2 |
| **A1 Waste Liner RM** | kg | 85.8 | 85.8 |
| **A1 Cardboard RM** | kg | 53.3 | 53.3 |
| **B1 Battery** | kg | 1.08 | 1.08 |

# Appendix C:  Life Cycle Assessment Results – Comparative Analysis Base Scenario

## C1. Excel Dryers Life Cycle Assessment Results

Table 31: ThinAir® Hand Dryer, 120V - Base Scenario, 1 cycle per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 5.54E+02 | 46.90628 | 0.220656 | 1.846258 | 1.694109 | 502.3646 | 0.0320812 | 0.13778 | 0.42307 |
| **Acidification Potential** | kg SO2 eq | 1.72E+00 | 0.26378 | 0.001694 | 0.002614 | 0.012443 | 1.434072 | 0.0001977 | 0.00066 | 0.000108 |
| **Eutrophication Potential** | kg N eq | 3.14E+00 | 0.207725 | 0.000225 | 0.001264 | 0.002318 | 2.928714 | 3.838E-05 | 0.000556 | 0.002153 |
| **Smog Creation Potential** | kg O3 eq | 1.70E+01 | 2.619758 | 0.042705 | 0.029629 | 0.348708 | 13.93948 | 0.0053288 | 0.007793 | 0.001781 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 3.62E-05 | 2.5E-06 | 4.37E-08 | 7.42E-08 | 3.75E-07 | 3.32E-05 | 7.593E-09 | 5.87E-09 | 1.45E-09 |
| **Fossil Depletion Potential** | MJ surplus | 5.90E+02 | 57.71255 | 0.456488 | 3.889569 | 3.359374 | 524.1476 | 0.0678121 | 0.10462 | 0.018683 |
| **Carcinogenics** | CTUh | 7.18E-05 | 3.2E-05 | 1.11E-08 | 4.88E-08 | 1.66E-07 | 3.95E-05 | 1.861E-09 | 1.17E-08 | 2.34E-09 |
| **Non-Carcinogenics** | CTUh | 1.79E-04 | 3.87E-05 | 3E-08 | 2.15E-07 | 3.14E-07 | 0.000139 | 6.98E-09 | 1.14E-07 | 4.97E-08 |
| **Ecotoxicity** | CTUe | 1.64E+04 | 3175.097 | 0.71584 | 4.399268 | 13.4143 | 13197.72 | 0.2431062 | 2.832578 | 1.976017 |
| **ReCiPe-Water Consumption** | m3 | 3.63E+00 | 0.484357 | 0.001415 | 0.016432 | 0.003267 | 3.11956 | 5.328E-05 | 0.001039 | 0.000299 |

Table 32: XLERATOR® Hand Dryer, 120V - Base Scenario, 1 cycle per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 5.33E+02 | 61.98241 | 0.809649 | 1.846258 | 3.101179 | 464.8418 | 0.0587268 | 0.292886 | 0.398919 |
| **Acidification Potential** | kg SO2 eq | 1.78E+00 | 0.424536 | 0.004782 | 0.002614 | 0.022778 | 1.326958 | 0.000362 | 0.001402 | 0.000102 |
| **Eutrophication Potential** | kg N eq | 3.06E+00 | 0.342303 | 0.000798 | 0.001264 | 0.004243 | 2.709961 | 7.026E-05 | 0.001183 | 0.00204 |
| **Smog Creation Potential** | kg O3 eq | 1.77E+01 | 3.980224 | 0.137601 | 0.029629 | 0.638334 | 12.89831 | 0.0097547 | 0.016567 | 0.001675 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 3.54E-05 | 3.69E-06 | 1.6E-07 | 7.42E-08 | 6.87E-07 | 3.07E-05 | 1.39E-08 | 1.25E-08 | 1.36E-09 |
| **Fossil Depletion Potential** | MJ surplus | 5.74E+02 | 76.69137 | 1.691045 | 3.889569 | 6.149557 | 484.9977 | 0.1241345 | 0.222397 | 0.017552 |
| **Carcinogenics** | CTUh | 7.86E-05 | 4.16E-05 | 3.86E-08 | 4.88E-08 | 3.03E-07 | 3.65E-05 | 3.408E-09 | 2.49E-08 | 2.18E-09 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Non-Carcinogenics** | CTUh | 2.26E-04 | 9.56E-05 | 1.17E-07 | 2.15E-07 | 5.74E-07 | 0.000129 | 1.278E-08 | 2.43E-07 | 4.62E-08 |
| **Ecotoxicity** | CTUe | 1.89E+04 | 6608.783 | 2.53848 | 4.399268 | 24.55577 | 12211.95 | 0.4450221 | 6.02137 | 1.81601 |
| **ReCiPe-Water Consumption** | m3 | 3.68E+00 | 0.761897 | 0.005663 | 0.016432 | 0.00598 | 2.886553 | 9.754E-05 | 0.002209 | 0.000281 |

Table 33: XLERATOReco® Hand Dryer, 120V - Base Scenario, 1 cycle per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 2.90E+02 | 61.89994 | 0.805701 | 1.846258 | 3.085721 | 221.2314 | 0.058434 | 0.291211 | 0.398919 |
| **Acidification Potential** | kg SO2 eq | 1.08E+00 | 0.420706 | 0.004759 | 0.002614 | 0.022664 | 0.631537 | 0.0003602 | 0.001394 | 0.000102 |
| **Eutrophication Potential** | kg N eq | 1.64E+00 | 0.341887 | 0.000794 | 0.001264 | 0.004222 | 1.289748 | 6.991E-05 | 0.001176 | 0.00204 |
| **Smog Creation Potential** | kg O3 eq | 1.09E+01 | 3.97352 | 0.13693 | 0.029629 | 0.635152 | 6.13867 | 0.0097061 | 0.016472 | 0.001675 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 1.93E-05 | 3.68E-06 | 1.59E-07 | 7.42E-08 | 6.83E-07 | 1.46E-05 | 1.383E-08 | 1.24E-08 | 1.36E-09 |
| **Fossil Depletion Potential** | MJ surplus | 3.19E+02 | 76.61036 | 1.682799 | 3.889569 | 6.118905 | 230.8242 | 0.1235157 | 0.221125 | 0.017552 |
| **Carcinogenics** | CTUh | 5.93E-05 | 4.15E-05 | 3.84E-08 | 4.88E-08 | 3.01E-07 | 1.74E-05 | 3.391E-09 | 2.47E-08 | 2.18E-09 |
| **Non-Carcinogenics** | CTUh | 1.58E-04 | 9.55E-05 | 1.16E-07 | 2.15E-07 | 5.71E-07 | 6.13E-05 | 1.271E-08 | 2.42E-07 | 4.62E-08 |
| **Ecotoxicity** | CTUe | 1.25E+04 | 6600.078 | 2.526102 | 4.399268 | 24.43337 | 5812.015 | 0.4428038 | 5.986928 | 1.81601 |
| **ReCiPe-Water Consumption** | m3 | 2.16E+00 | 0.757393 | 0.005635 | 0.016432 | 0.00595 | 1.373793 | 9.705E-05 | 0.002197 | 0.000281 |

Table 34: XLERATORsync® Hand Dryer, 120V - Base Scenario, 1 cycle per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 8.57E+02 | 66.21088 | 1.051968 | 1.846906 | 4.170067 | 782.1241 | 0.0789682 | 0.332382 | 1.530978 |
| **Acidification Potential** | kg SO2 eq | 2.87E+00 | 0.597116 | 0.006746 | 0.002615 | 0.030628 | 2.232685 | 0.0004868 | 0.001591 | 0.000455 |
| **Eutrophication Potential** | kg N eq | 5.03E+00 | 0.44242 | 0.001046 | 0.001264 | 0.005705 | 4.559672 | 9.448E-05 | 0.001342 | 0.014693 |
| **Smog Creation Potential** | kg O3 eq | 2.74E+01 | 4.54101 | 0.185865 | 0.029639 | 0.858349 | 21.70217 | 0.0131169 | 0.018801 | 0.009265 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 5.61E-05 | 3.09E-06 | 2.08E-07 | 7.43E-08 | 9.24E-07 | 5.17E-05 | 1.869E-08 | 1.42E-08 | 8.05E-09 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Fossil Depletion Potential** | MJ surplus | 9.19E+02 | 87.73309 | 2.1912 | 3.890933 | 8.269136 | 816.0377 | 0.1669201 | 0.252388 | 0.090761 |
| **Carcinogenics** | CTUh | 8.15E-05 | 1.95E-05 | 5.09E-08 | 4.88E-08 | 4.07E-07 | 6.15E-05 | 4.582E-09 | 2.82E-08 | 2.29E-08 |
| **Non-Carcinogenics** | CTUh | 3.61E-04 | 0.000142 | 1.49E-07 | 2.15E-07 | 7.72E-07 | 0.000217 | 1.718E-08 | 2.76E-07 | 8.26E-07 |
| **Ecotoxicity** | CTUe | 3.09E+04 | 10291.28 | 3.330905 | 4.400811 | 33.01945 | 20547.34 | 0.5984086 | 6.833354 | 51.64945 |
| **ReCiPe-Water Consumption** | m3 | 5.80E+00 | 0.906368 | 0.007183 | 0.016438 | 0.008041 | 4.856798 | 0.0001312 | 0.002507 | 0.001667 |

## C2. Paper Towel Life Cycle Assessment Results

Table 35: Paper Towel, 0% Recycled Content - Base Scenario, 2 Sheet per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C4 |
|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 5.07E+03 | 998.4273 | 63.63861 | 2632.654 | 448.0158 | 839.1377 | 25.455446 | 62.1673 |
| **Acidification Potential** | kg SO2 eq | 1.52E+01 | 5.907156 | 0.392265 | 5.639127 | 2.761544 | 0.365163 | 0.1569059 | 0.020341 |
| **Eutrophication Potential** | kg N eq | 2.56E+01 | 4.58179 | 0.076141 | 10.66519 | 0.536032 | 9.114739 | 0.0304564 | 0.576973 |
| **Smog Creation Potential** | kg O3 eq | 2.66E+02 | 111.7441 | 10.57056 | 60.24549 | 74.41675 | 4.264115 | 4.2282244 | 0.379274 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 4.67E-04 | 0.000105 | 1.51E-05 | 0.000229 | 0.000106 | 5.44E-06 | 6.025E-06 | 3.8E-07 |
| **Fossil Depletion Potential** | MJ surplus | 7.60E+03 | 1956.464 | 134.517 | 4443.429 | 946.9993 | 60.13552 | 53.806779 | 4.006542 |
| **Carcinogenics** | CTUh | 4.27E-04 | 0.000189 | 3.69E-06 | 0.000171 | 2.6E-05 | 3.33E-05 | 1.477E-06 | 2.87E-06 |
| **Non-Carcinogenics** | CTUh | 3.27E-03 | 0.000341 | 1.38E-05 | 0.000635 | 9.75E-05 | 0.002036 | 5.539E-06 | 0.000142 |
| **Ecotoxicity** | CTUe | 2.25E+05 | 17735.51 | 482.2432 | 40510.88 | 3394.992 | 152159 | 192.8973 | 10762.07 |
| **ReCiPe-Water Consumption** | m3 | 6.67E+01 | 46.95896 | 0.105696 | 18.28162 | 0.744097 | 0.530747 | 0.0422782 | 0.048733 |

Table 36: Paper Towel, 100% Recycled Content - Base Scenario, 4 Sheet per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C4 |
|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 4.46E+03 | 8.56E+02 | 5.68E+01 | 2.33E+03 | 4.00E+02 | 7.39E+02 | 2.27E+01 | 6.22E+01 |
| **Acidification Potential** | kg SO2 eq | 1.32E+01 | 4.899084 | 0.349977 | 4.996586 | 2.463836 | 0.337175 | 0.1399907 | 0.020341 |
| **Eutrophication Potential** | kg N eq | 2.28E+01 | 4.237292 | 0.067933 | 9.424031 | 0.478245 | 8.034738 | 0.027173 | 0.576973 |
| **Smog Creation Potential** | kg O3 eq | 2.26E+02 | 88.46243 | 9.431004 | 53.4401 | 66.39427 | 3.838492 | 3.7724018 | 0.379274 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 4.05E-04 | 8.43E-05 | 1.34E-05 | 0.000202 | 9.46E-05 | 4.85E-06 | 5.376E-06 | 3.8E-07 |
| **Fossil Depletion Potential** | MJ surplus | 6.73E+03 | 1740.235 | 120.0154 | 3918.558 | 844.9083 | 53.85044 | 48.006153 | 4.006542 |
| **Carcinogenics** | CTUh | 3.88E-04 | 0.000175 | 3.29E-06 | 0.000153 | 2.32E-05 | 2.95E-05 | 1.318E-06 | 2.87E-06 |
| **Non-Carcinogenics** | CTUh | 2.91E-03 | 0.000303 | 1.24E-05 | 0.000561 | 8.7E-05 | 0.001796 | 4.942E-06 | 0.000142 |
| **Ecotoxicity** | CTUe | 2.01E+05 | 16485.32 | 430.2551 | 35785.18 | 3028.996 | 134278.6 | 172.10205 | 10762.07 |
| **ReCiPe-Water Consumption** | m3 | 5.86E+01 | 40.96107 | 0.094301 | 16.32986 | 0.66388 | 0.480807 | 0.0377205 | 0.048733 |

# Appendix D: Life Cycle Assessment Results - EPD

## D1. ThinAir® Hand Dryer EPD results – Environmental Impact

Table 37: LCA Results – Environmental Impact – ThinAir® Hand Dryer, 120V, per use for 100,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 1.95E+02 | 6.43E+00 | 3.02E-02 | 2.61E-01 | 2.32E-01 | 1.88E+02 | 4.39E-03 | 1.89E-02 | 5.80E-02 |
| **Acidification Potential** | kg SO2 eq | 5.76E-01 | 3.61E-02 | 2.32E-04 | 3.64E-04 | 1.70E-03 | 5.38E-01 | 2.71E-05 | 9.04E-05 | 1.48E-05 |
| **Eutrophication Potential** | kg N eq | 1.13E+00 | 2.85E-02 | 3.08E-05 | 1.32E-04 | 3.18E-04 | 1.10E+00 | 5.26E-06 | 7.62E-05 | 2.95E-04 |
| **Smog Creation Potential** | kg O3 eq | 5.65E+00 | 3.59E-01 | 5.85E-03 | 4.28E-03 | 4.78E-02 | 5.23E+00 | 7.30E-04 | 1.07E-03 | 2.44E-04 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 1.29E-05 | 3.42E-07 | 5.99E-09 | 7.96E-09 | 5.14E-08 | 1.25E-05 | 1.04E-09 | 8.04E-10 | 1.99E-10 |
| **Fossil Depletion Potential** | MJ surplus | 2.06E+02 | 7.91E+00 | 6.25E-02 | 5.54E-01 | 4.60E-01 | 1.97E+02 | 9.29E-03 | 1.43E-02 | 2.56E-03 |

Table 38: LCA Results – Environmental Impact – ThinAir® Hand Dryer, 208V, per use for 100,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 1.62E+02 | 6.43E+00 | 3.02E-02 | 2.61E-01 | 2.32E-01 | 1.55E+02 | 4.39E-03 | 1.89E-02 | 5.80E-02 |
| **Acidification Potential** | kg SO2 eq | 4.82E-01 | 3.61E-02 | 2.32E-04 | 3.64E-04 | 1.70E-03 | 4.43E-01 | 2.71E-05 | 9.04E-05 | 1.48E-05 |
| **Eutrophication Potential** | kg N eq | 9.34E-01 | 2.85E-02 | 3.08E-05 | 1.32E-04 | 3.18E-04 | 9.05E-01 | 5.26E-06 | 7.62E-05 | 2.95E-04 |
| **Smog Creation Potential** | kg O3 eq | 4.73E+00 | 3.59E-01 | 5.85E-03 | 4.28E-03 | 4.78E-02 | 4.31E+00 | 7.30E-04 | 1.07E-03 | 2.44E-04 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 1.07E-05 | 3.42E-07 | 5.99E-09 | 7.96E-09 | 5.14E-08 | 1.03E-05 | 1.04E-09 | 8.04E-10 | 1.99E-10 |
| **Fossil Depletion Potential** | MJ surplus | 1.71E+02 | 7.91E+00 | 6.25E-02 | 5.54E-01 | 4.60E-01 | 1.62E+02 | 9.29E-03 | 1.43E-02 | 2.56E-03 |

Table 39: LCA Results – Environmental Impact – ThinAir® Hand Dryer, 230V, per use for 100,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 1.81E+03 | 7.70E+01 | 4.27E-01 | 3.40E+00 | 3.28E+00 | 1.73E+03 | 6.51E-02 | 2.05E-01 | 1.88E-02 |
| **Acidification Potential** | kg SO2 eq | 8.58E+02 | 8.30E+00 | 1.37E-02 | 2.42E-01 | 5.34E-02 | 8.50E+02 | 7.86E-04 | 4.16E-02 | 2.74E-03 |
| **Eutrophication Potential** | kg N eq | 2.31E-02 | 6.99E-03 | 4.46E-06 | 4.38E-06 | 2.82E-04 | 1.58E-02 | 2.78E-06 | 1.26E-05 | 1.50E-07 |
| **Smog Creation Potential** | kg O3 eq | 6.33E+01 | 2.27E+00 | 1.25E-03 | 1.26E-01 | 1.71E-02 | 6.09E+01 | 2.20E-04 | 7.24E-03 | 1.93E-04 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 1.30E+02 | 9.83E-01 | 1.41E-03 | 1.40E+00 | 7.29E-03 | 1.27E+02 | 1.10E-04 | 5.60E-03 | 2.89E-04 |
| **Fossil Depletion Potential** | MJ surplus | 1.01E+02 | 5.98E+00 | 1.81E-03 | 4.66E-02 | 2.89E-02 | 9.51E+01 | 4.24E-04 | 1.85E-02 | 2.63E-04 |

## D2. ThinAir® Hand Dryer EPD results – Resource Use, Waste Categories and Output Flows

Table 40: LCA Results – Environmental Impact – Resource Use, ThinAir® Hand Dryer, 120V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **RPRE** | MJ, LHV | 3.62E+02 | 9.24E+00 | 4.47E-03 | 1.57E+00 | 5.33E-02 | 3.51E+02 | 7.54E-04 | 3.14E-02 | 7.46E-04 |
| **RPRM** | MJ, LHV | 2.75E-03 | 2.75E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **RPRT** | MJ | 3.62E+02 | 9.24E+00 | 4.47E-03 | 1.57E+00 | 5.33E-02 | 3.51E+02 | 7.54E-04 | 3.14E-02 | 7.46E-04 |
| **NRPRE** | MJ | 3.28E+03 | 7.87E+01 | 4.41E-01 | 3.64E+00 | 3.34E+00 | 3.19E+03 | 6.59E-02 | 2.46E-01 | 2.16E-02 |
| **NRPRM** | MJ | 6.64E+00 | 6.64E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NRPRT** | MJ | 3.29E+03 | 8.53E+01 | 4.41E-01 | 3.64E+00 | 3.34E+00 | 3.19E+03 | 6.59E-02 | 2.46E-01 | 2.16E-02 |
| **SM** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NRSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RE** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **FW** | m3 | 1.24E+00 | 6.64E-02 | 1.94E-04 | 1.98E-03 | 4.48E-04 | 1.17E+00 | 7.30E-06 | 1.42E-04 | 4.10E-05 |

Table 41: LCA Results – Environmental Impact – Waste Categories and Output Flows, ThinAir® Hand Dryer, 120V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **HWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NHWD** | kg | 4.25E-02 | x | x | 2.24E-04 | x | x | x | x | 4.23E-02 |
| **HRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **LRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **CRU** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **MR** | kg | 8.51E-02 | x | x | x | x | x | x | x | 8.51E-02 |
| **MER** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, electrical** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, thermal** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |

Table 42: LCA Results – Environmental Impact – Resource Use, ThinAir® Hand Dryer, 208V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **RPRE** | MJ, LHV | 3.00E+02 | 9.24E+00 | 4.47E-03 | 1.57E+00 | 5.33E-02 | 2.89E+02 | 7.54E-04 | 3.14E-02 | 7.46E-04 |
| **RPRM** | MJ, LHV | 2.75E-03 | 2.75E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **RPRT** | MJ | 3.00E+02 | 9.24E+00 | 4.47E-03 | 1.57E+00 | 5.33E-02 | 2.89E+02 | 7.54E-04 | 3.14E-02 | 7.46E-04 |
| **NRPRE** | MJ | 2.72E+03 | 7.87E+01 | 4.41E-01 | 3.64E+00 | 3.34E+00 | 2.63E+03 | 6.59E-02 | 2.46E-01 | 2.16E-02 |
| **NRPRM** | MJ | 6.64E+00 | 6.64E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NRPRT** | MJ | 2.72E+03 | 8.53E+01 | 4.41E-01 | 3.64E+00 | 3.34E+00 | 2.63E+03 | 6.59E-02 | 2.46E-01 | 2.16E-02 |
| **SM** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NRSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RE** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **FW** | m3 | 1.03E+00 | 6.64E-02 | 1.94E-04 | 1.98E-03 | 4.48E-04 | 9.64E-01 | 7.30E-06 | 1.42E-04 | 4.10E-05 |

Table 43: LCA Results – Environmental Impact – Waste Categories and Output Flows, ThinAir® Hand Dryer, 208V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **HWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NHWD** | kg | 4.25E-02 | x | x | 2.24E-04 | x | x | x | x | 4.23E-02 |
| **HRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **LRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **CRU** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **MR** | kg | 8.51E-02 | x | x | x | x | x | x | x | 8.51E-02 |
| **MER** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, electrical** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, thermal** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |

Table 44: LCA Results – Environmental Impact – Resource Use, ThinAir® Hand Dryer, 230V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **RPRE** | MJ, LHV | 3.53E+02 | 9.24E+00 | 4.47E-03 | 1.57E+00 | 5.33E-02 | 3.42E+02 | 7.54E-04 | 3.14E-02 | 7.46E-04 |
| **RPRM** | MJ, LHV | 2.75E-03 | 2.75E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **RPRT** | MJ | 3.53E+02 | 9.24E+00 | 4.47E-03 | 1.57E+00 | 5.33E-02 | 3.42E+02 | 7.54E-04 | 3.14E-02 | 7.46E-04 |
| **NRPRE** | MJ | 3.20E+03 | 7.87E+01 | 4.41E-01 | 3.64E+00 | 3.34E+00 | 3.12E+03 | 6.59E-02 | 2.46E-01 | 2.16E-02 |
| **NRPRM** | MJ | 6.64E+00 | 6.64E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NRPRT** | MJ | 3.21E+03 | 8.53E+01 | 4.41E-01 | 3.64E+00 | 3.34E+00 | 3.12E+03 | 6.59E-02 | 2.46E-01 | 2.16E-02 |
| **SM** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NRSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RE** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **FW** | m3 | 1.21E+00 | 6.64E-02 | 1.94E-04 | 1.98E-03 | 4.48E-04 | 1.14E+00 | 7.30E-06 | 1.42E-04 | 4.10E-05 |

Table 45: LCA Results – Environmental Impact – Waste Categories and Output Flows, ThinAir® Hand Dryer, 230V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **HWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NHWD** | kg | 4.25E-02 | x | x | 2.24E-04 | x | x | x | x | 4.23E-02 |
| **HRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **LRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **CRU** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **MR** | kg | 8.51E-02 | x | x | x | x | x | x | x | 8.51E-02 |
| **MER** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, electrical** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, thermal** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |

## D3. XLERATOR® Hand Dryer EPD results – Environmental Impact

Table 46: LCA Results – Environmental Impact – XLERATOR® Hand Dryer, 120V, per use for 100,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 1.83E+02 | 8.49E+00 | 1.11E-01 | 2.61E-01 | 4.25E-01 | 1.74E+02 | 8.04E-03 | 4.01E-02 | 5.46E-02 |
| **Acidification Potential** | kg SO2 eq | 5.59E-01 | 5.82E-02 | 6.55E-04 | 3.64E-04 | 3.12E-03 | 4.96E-01 | 4.96E-05 | 1.92E-04 | 1.40E-05 |
| **Eutrophication Potential** | kg N eq | 1.06E+00 | 4.69E-02 | 1.09E-04 | 1.32E-04 | 5.81E-04 | 1.01E+00 | 9.63E-06 | 1.62E-04 | 2.79E-04 |
| **Smog Creation Potential** | kg O3 eq | 5.49E+00 | 5.45E-01 | 1.88E-02 | 4.28E-03 | 8.74E-02 | 4.83E+00 | 1.34E-03 | 2.27E-03 | 2.30E-04 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 1.21E-05 | 5.05E-07 | 2.19E-08 | 7.96E-09 | 9.41E-08 | 1.15E-05 | 1.90E-09 | 1.71E-09 | 1.86E-10 |
| **Fossil Depletion Potential** | MJ surplus | 1.94E+02 | 1.05E+01 | 2.32E-01 | 5.54E-01 | 8.42E-01 | 1.81E+02 | 1.70E-02 | 3.05E-02 | 2.40E-03 |

Table 47: LCA Results – Environmental Impact – XLERATOR® Hand Dryer, 208V, per use for 100,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 1.49E+02 | 8.49E+00 | 1.11E-01 | 2.61E-01 | 4.25E-01 | 1.40E+02 | 8.04E-03 | 4.01E-02 | 5.46E-02 |
| **Acidification Potential** | kg SO2 eq | 4.62E-01 | 5.82E-02 | 6.55E-04 | 3.64E-04 | 3.12E-03 | 4.00E-01 | 4.96E-05 | 1.92E-04 | 1.40E-05 |
| **Eutrophication Potential** | kg N eq | 8.64E-01 | 4.69E-02 | 1.09E-04 | 1.32E-04 | 5.81E-04 | 8.16E-01 | 9.63E-06 | 1.62E-04 | 2.79E-04 |
| **Smog Creation Potential** | kg O3 eq | 4.55E+00 | 5.45E-01 | 1.88E-02 | 4.28E-03 | 8.74E-02 | 3.89E+00 | 1.34E-03 | 2.27E-03 | 2.30E-04 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 9.89E-06 | 5.05E-07 | 2.19E-08 | 7.96E-09 | 9.41E-08 | 9.26E-06 | 1.90E-09 | 1.71E-09 | 1.86E-10 |
| **Fossil Depletion Potential** | MJ surplus | 1.58E+02 | 1.05E+01 | 2.32E-01 | 5.54E-01 | 8.42E-01 | 1.46E+02 | 1.70E-02 | 3.05E-02 | 2.40E-03 |

Table 48: LCA Results – Environmental Impact – XLERATOR® Hand Dryer, 230V, per use for 100,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 1.79E+02 | 8.49E+00 | 1.11E-01 | 2.61E-01 | 4.25E-01 | 1.70E+02 | 8.04E-03 | 4.01E-02 | 5.46E-02 |
| **Acidification Potential** | kg SO2 eq | 5.47E-01 | 5.82E-02 | 6.55E-04 | 3.64E-04 | 3.12E-03 | 4.85E-01 | 4.96E-05 | 1.92E-04 | 1.40E-05 |
| **Eutrophication Potential** | kg N eq | 1.04E+00 | 4.69E-02 | 1.09E-04 | 1.32E-04 | 5.81E-04 | 9.90E-01 | 9.63E-06 | 1.62E-04 | 2.79E-04 |
| **Smog Creation Potential** | kg O3 eq | 5.37E+00 | 5.45E-01 | 1.88E-02 | 4.28E-03 | 8.74E-02 | 4.71E+00 | 1.34E-03 | 2.27E-03 | 2.30E-04 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 1.19E-05 | 5.05E-07 | 2.19E-08 | 7.96E-09 | 9.41E-08 | 1.12E-05 | 1.90E-09 | 1.71E-09 | 1.86E-10 |
| **Fossil Depletion Potential** | MJ surplus | 1.89E+02 | 1.05E+01 | 2.32E-01 | 5.54E-01 | 8.42E-01 | 1.77E+02 | 1.70E-02 | 3.05E-02 | 2.40E-03 |

## D4. XLERATOR® Hand Dryer EPD results – Resource Use, Waste Categories and Output Flows

Table 49: LCA Results – Environmental Impact – Resource Use, XLERATOR® Hand Dryer, 120V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **RPRE** | MJ, LHV | 3.38E+02 | 1.29E+01 | 1.69E-02 | 1.57E+00 | 9.76E-02 | 3.24E+02 | 1.38E-03 | 6.67E-02 | 7.03E-04 |
| **RPRM** | MJ, LHV | 6.65E-03 | 6.65E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **RPRT** | MJ | 3.38E+02 | 1.29E+01 | 1.69E-02 | 1.57E+00 | 9.76E-02 | 3.24E+02 | 1.38E-03 | 6.67E-02 | 7.03E-04 |
| **NRPRE** | MJ | 3.07E+03 | 1.07E+02 | 1.64E+00 | 3.64E+00 | 6.11E+00 | 2.95E+03 | 1.21E-01 | 5.24E-01 | 2.03E-02 |
| **NRPRM** | MJ | 8.19E+00 | 8.19E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NRPRT** | MJ | 3.08E+03 | 1.15E+02 | 1.64E+00 | 3.64E+00 | 6.11E+00 | 2.95E+03 | 1.21E-01 | 5.24E-01 | 2.03E-02 |
| **SM** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NRSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RE** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **FW** | m3 | 1.19E+00 | 1.04E-01 | 7.76E-04 | 1.98E-03 | 8.19E-04 | 1.08E+00 | 1.34E-05 | 3.03E-04 | 3.85E-05 |

Table 50: LCA Results – Environmental Impact – Waste Categories and Output Flows, XLERATOR® Hand Dryer, 120V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **HWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NHWD** | kg | 3.97E-02 | x | x | 2.24E-04 | x | x | x | x | 3.95E-02 |
| **HRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **LRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **CRU** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **MR** | kg | 8.06E-02 | x | x | x | x | x | x | x | 8.06E-02 |
| **MER** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, electrical** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, thermal** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |

Table 51: LCA Results – Environmental Impact – Resource Use, XLERATOR® Hand Dryer, 208V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **RPRE** | MJ, LHV | 2.75E+02 | 1.29E+01 | 1.69E-02 | 1.57E+00 | 9.76E-02 | 2.61E+02 | 1.38E-03 | 6.67E-02 | 7.03E-04 |
| **RPRM** | MJ, LHV | 6.65E-03 | 6.65E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **RPRT** | MJ | 2.75E+02 | 1.29E+01 | 1.69E-02 | 1.57E+00 | 9.76E-02 | 2.61E+02 | 1.38E-03 | 6.67E-02 | 7.03E-04 |
| **NRPRE** | MJ | 2.49E+03 | 1.07E+02 | 1.64E+00 | 3.64E+00 | 6.11E+00 | 2.37E+03 | 1.21E-01 | 5.24E-01 | 2.03E-02 |
| **NRPRM** | MJ | 8.19E+00 | 8.19E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NRPRT** | MJ | 2.50E+03 | 1.15E+02 | 1.64E+00 | 3.64E+00 | 6.11E+00 | 2.37E+03 | 1.21E-01 | 5.24E-01 | 2.03E-02 |
| **SM** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NRSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RE** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **FW** | m3 | 9.78E-01 | 1.04E-01 | 7.76E-04 | 1.98E-03 | 8.19E-04 | 8.70E-01 | 1.34E-05 | 3.03E-04 | 3.85E-05 |

Table 52: LCA Results – Environmental Impact – Waste Categories and Output Flows, XLERATOR® Hand Dryer, 208V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **HWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NHWD** | kg | 3.97E-02 | x | x | 2.24E-04 | x | x | x | x | 3.95E-02 |
| **HRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **LRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **CRU** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **MR** | kg | 8.06E-02 | x | x | x | x | x | x | x | 8.06E-02 |
| **MER** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, electrical** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, thermal** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |

Table 53: LCA Results – Environmental Impact – Resource Use, XLERATOR® Hand Dryer, 230V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **RPRE** | MJ, LHV | 3.31E+02 | 1.29E+01 | 1.69E-02 | 1.57E+00 | 9.76E-02 | 3.16E+02 | 1.38E-03 | 6.67E-02 | 7.03E-04 |
| **RPRM** | MJ, LHV | 6.65E-03 | 6.65E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **RPRT** | MJ | 3.31E+02 | 1.29E+01 | 1.69E-02 | 1.57E+00 | 9.76E-02 | 3.16E+02 | 1.38E-03 | 6.67E-02 | 7.03E-04 |
| **NRPRE** | MJ | 3.00E+03 | 1.07E+02 | 1.64E+00 | 3.64E+00 | 6.11E+00 | 2.88E+03 | 1.21E-01 | 5.24E-01 | 2.03E-02 |
| **NRPRM** | MJ | 8.19E+00 | 8.19E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NRPRT** | MJ | 3.01E+03 | 1.15E+02 | 1.64E+00 | 3.64E+00 | 6.11E+00 | 2.88E+03 | 1.21E-01 | 5.24E-01 | 2.03E-02 |
| **SM** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NRSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RE** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **FW** | m3 | 1.16E+00 | 1.04E-01 | 7.76E-04 | 1.98E-03 | 8.19E-04 | 1.05E+00 | 1.34E-05 | 3.03E-04 | 3.85E-05 |

Table 54: LCA Results – Environmental Impact – Waste Categories and Output Flows, XLERATOR® Hand Dryer, 230V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **HWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NHWD** | kg | 3.97E-02 | x | x | 2.24E-04 | x | x | x | x | 3.95E-02 |
| **HRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **LRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **CRU** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **MR** | kg | 8.06E-02 | x | x | x | x | x | x | x | 8.06E-02 |
| **MER** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, electrical** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, thermal** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |

## D5. XLERATOReco® Hand Dryer EPD results – Environmental Impact

Table 55: LCA Results – Environmental Impact – XLERATOReco® Hand Dryer, 120V, per use for 100,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 8.96E+01 | 8.48E+00 | 1.10E-01 | 2.61E-01 | 4.23E-01 | 8.02E+01 | 8.00E-03 | 3.99E-02 | 5.46E-02 |
| **Acidification Potential** | kg SO2 eq | 2.91E-01 | 5.76E-02 | 6.52E-04 | 3.64E-04 | 3.10E-03 | 2.29E-01 | 4.93E-05 | 1.91E-04 | 1.40E-05 |
| **Eutrophication Potential** | kg N eq | 5.16E-01 | 4.68E-02 | 1.09E-04 | 1.32E-04 | 5.78E-04 | 4.68E-01 | 9.58E-06 | 1.61E-04 | 2.79E-04 |
| **Smog Creation Potential** | kg O3 eq | 2.88E+00 | 5.44E-01 | 1.88E-02 | 4.28E-03 | 8.70E-02 | 2.23E+00 | 1.33E-03 | 2.26E-03 | 2.30E-04 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 5.94E-06 | 5.04E-07 | 2.18E-08 | 7.96E-09 | 9.36E-08 | 5.31E-06 | 1.89E-09 | 1.70E-09 | 1.86E-10 |
| **Fossil Depletion Potential** | MJ surplus | 9.59E+01 | 1.05E+01 | 2.31E-01 | 5.54E-01 | 8.38E-01 | 8.37E+01 | 1.69E-02 | 3.03E-02 | 2.40E-03 |

Table 56: LCA Results – Environmental Impact – XLERATOReco® Hand Dryer, 208V, per use for 100,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 7.46E+01 | 8.48E+00 | 1.10E-01 | 2.61E-01 | 4.23E-01 | 6.52E+01 | 8.00E-03 | 3.99E-02 | 5.46E-02 |
| **Acidification Potential** | kg SO2 eq | 2.48E-01 | 5.76E-02 | 6.52E-04 | 3.64E-04 | 3.10E-03 | 1.86E-01 | 4.93E-05 | 1.91E-04 | 1.40E-05 |
| **Eutrophication Potential** | kg N eq | 4.28E-01 | 4.68E-02 | 1.09E-04 | 1.32E-04 | 5.78E-04 | 3.80E-01 | 9.58E-06 | 1.61E-04 | 2.79E-04 |
| **Smog Creation Potential** | kg O3 eq | 2.47E+00 | 5.44E-01 | 1.88E-02 | 4.28E-03 | 8.70E-02 | 1.81E+00 | 1.33E-03 | 2.26E-03 | 2.30E-04 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 4.94E-06 | 5.04E-07 | 2.18E-08 | 7.96E-09 | 9.36E-08 | 4.31E-06 | 1.89E-09 | 1.70E-09 | 1.86E-10 |
| **Fossil Depletion Potential** | MJ surplus | 8.02E+01 | 1.05E+01 | 2.31E-01 | 5.54E-01 | 8.38E-01 | 6.80E+01 | 1.69E-02 | 3.03E-02 | 2.40E-03 |

Table 57: LCA Results – Environmental Impact – XLERATOReco® Hand Dryer, 230V, per use for 100,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 8.58E+01 | 8.48E+00 | 1.10E-01 | 2.61E-01 | 4.23E-01 | 7.64E+01 | 8.00E-03 | 3.99E-02 | 5.46E-02 |
| **Acidification Potential** | kg SO2 eq | 2.80E-01 | 5.76E-02 | 6.52E-04 | 3.64E-04 | 3.10E-03 | 2.18E-01 | 4.93E-05 | 1.91E-04 | 1.40E-05 |
| **Eutrophication Potential** | kg N eq | 4.94E-01 | 4.68E-02 | 1.09E-04 | 1.32E-04 | 5.78E-04 | 4.46E-01 | 9.58E-06 | 1.61E-04 | 2.79E-04 |
| **Smog Creation Potential** | kg O3 eq | 2.78E+00 | 5.44E-01 | 1.88E-02 | 4.28E-03 | 8.70E-02 | 2.12E+00 | 1.33E-03 | 2.26E-03 | 2.30E-04 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 5.69E-06 | 5.04E-07 | 2.18E-08 | 7.96E-09 | 9.36E-08 | 5.05E-06 | 1.89E-09 | 1.70E-09 | 1.86E-10 |
| **Fossil Depletion Potential** | MJ surplus | 9.19E+01 | 1.05E+01 | 2.31E-01 | 5.54E-01 | 8.38E-01 | 7.97E+01 | 1.69E-02 | 3.03E-02 | 2.40E-03 |

## D6. XLERATOReco® Hand Dryer EPD results – Resource Use, Waste Categories and Output Flows

Table 58: LCA Results – Environmental Impact – Resource Use, XLERATOReco® Hand Dryer, 120V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **RPRE** | MJ, LHV | 1.64E+02 | 1.28E+01 | 1.69E-02 | 1.57E+00 | 9.71E-02 | 1.49E+02 | 1.37E-03 | 6.63E-02 | 7.03E-04 |
| **RPRM** | MJ, LHV | 6.65E-03 | 6.65E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **RPRT** | MJ | 1.64E+02 | 1.28E+01 | 1.69E-02 | 1.57E+00 | 9.71E-02 | 1.49E+02 | 1.37E-03 | 6.63E-02 | 7.03E-04 |
| **NRPRE** | MJ | 1.48E+03 | 1.07E+02 | 1.63E+00 | 3.64E+00 | 6.08E+00 | 1.36E+03 | 1.20E-01 | 5.21E-01 | 2.03E-02 |
| **NRPRM** | MJ | 8.17E+00 | 8.17E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NRPRT** | MJ | 1.49E+03 | 1.15E+02 | 1.63E+00 | 3.64E+00 | 6.08E+00 | 1.36E+03 | 1.20E-01 | 5.21E-01 | 2.03E-02 |
| **SM** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NRSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RE** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **FW** | m3 | 6.06E-01 | 1.04E-01 | 7.72E-04 | 1.98E-03 | 8.15E-04 | 4.98E-01 | 1.33E-05 | 3.01E-04 | 3.85E-05 |

Table 59: LCA Results – Environmental Impact – Waste Categories and Output Flows, XLERATOReco® Hand Dryer, 120V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **HWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NHWD** | kg | 3.97E-02 | x | x | 2.24E-04 | x | x | x | x | 3.95E-02 |
| **HRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **LRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **CRU** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **MR** | kg | 8.06E-02 | x | x | x | x | x | x | x | 8.06E-02 |
| **MER** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, electrical** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, thermal** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |

Table 60: LCA Results – Environmental Impact – Resource Use, XLERATOReco® Hand Dryer, 208V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **RPRE** | MJ, LHV | 1.36E+02 | 1.28E+01 | 1.69E-02 | 1.57E+00 | 9.71E-02 | 1.21E+02 | 1.37E-03 | 6.63E-02 | 7.03E-04 |
| **RPRM** | MJ, LHV | 6.65E-03 | 6.65E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **RPRT** | MJ | 1.36E+02 | 1.28E+01 | 1.69E-02 | 1.57E+00 | 9.71E-02 | 1.21E+02 | 1.37E-03 | 6.63E-02 | 7.03E-04 |
| **NRPRE** | MJ | 1.22E+03 | 1.07E+02 | 1.63E+00 | 3.64E+00 | 6.08E+00 | 1.11E+03 | 1.20E-01 | 5.21E-01 | 2.03E-02 |
| **NRPRM** | MJ | 8.17E+00 | 8.17E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NRPRT** | MJ | 1.23E+03 | 1.15E+02 | 1.63E+00 | 3.64E+00 | 6.08E+00 | 1.11E+03 | 1.20E-01 | 5.21E-01 | 2.03E-02 |
| **SM** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NRSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RE** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **FW** | m3 | 5.13E-01 | 1.04E-01 | 7.72E-04 | 1.98E-03 | 8.15E-04 | 4.05E-01 | 1.33E-05 | 3.01E-04 | 3.85E-05 |

Table 61: LCA Results – Environmental Impact – Waste Categories and Output Flows, XLERATOReco® Hand Dryer, 208V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **HWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NHWD** | kg | 3.97E-02 | x | x | 2.24E-04 | x | x | x | x | 3.95E-02 |
| **HRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **LRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **CRU** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **MR** | kg | 8.06E-02 | x | x | x | x | x | x | x | 8.06E-02 |
| **MER** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, electrical** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, thermal** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |

Table 62: LCA Results – Environmental Impact – Resource Use, XLERATOReco® Hand Dryer, 230V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **RPRE** | MJ, LHV | 1.57E+02 | 1.28E+01 | 1.69E-02 | 1.57E+00 | 9.71E-02 | 1.42E+02 | 1.37E-03 | 6.63E-02 | 7.03E-04 |
| **RPRM** | MJ, LHV | 6.65E-03 | 6.65E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **RPRT** | MJ | 1.57E+02 | 1.28E+01 | 1.69E-02 | 1.57E+00 | 9.71E-02 | 1.42E+02 | 1.37E-03 | 6.63E-02 | 7.03E-04 |
| **NRPRE** | MJ | 1.41E+03 | 1.07E+02 | 1.63E+00 | 3.64E+00 | 6.08E+00 | 1.30E+03 | 1.20E-01 | 5.21E-01 | 2.03E-02 |
| **NRPRM** | MJ | 8.17E+00 | 8.17E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NRPRT** | MJ | 1.42E+03 | 1.15E+02 | 1.63E+00 | 3.64E+00 | 6.08E+00 | 1.30E+03 | 1.20E-01 | 5.21E-01 | 2.03E-02 |
| **SM** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NRSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RE** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **FW** | m3 | 5.82E-01 | 1.04E-01 | 7.72E-04 | 1.98E-03 | 8.15E-04 | 4.75E-01 | 1.33E-05 | 3.01E-04 | 3.85E-05 |

Table 63: LCA Results – Environmental Impact – Waste Categories and Output Flows, XLERATOReco® Hand Dryer, 230V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **HWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NHWD** | kg | 3.97E-02 | x | x | 2.24E-04 | x | x | x | x | 3.95E-02 |
| **HRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **LRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **CRU** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **MR** | kg | 8.06E-02 | x | x | x | x | x | x | x | 8.06E-02 |
| **MER** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, electrical** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, thermal** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |

## D5. XLERATORsync® Hand Dryer EPD results – Environmental Impact

Table 64: LCA Results – Environmental Impact – XLERATORsync® Hand Dryer, 120V, per use for 100,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 3.06E+02 | 9.07E+00 | 1.44E-01 | 2.61E-01 | 5.71E-01 | 2.95E+02 | 1.08E-02 | 4.55E-02 | 2.10E-01 |
| **Acidification Potential** | kg SO2 eq | 9.31E-01 | 8.18E-02 | 9.24E-04 | 3.64E-04 | 4.20E-03 | 8.43E-01 | 6.67E-05 | 2.18E-04 | 6.23E-05 |
| **Eutrophication Potential** | kg N eq | 1.79E+00 | 6.06E-02 | 1.43E-04 | 1.32E-04 | 7.82E-04 | 1.72E+00 | 1.29E-05 | 1.84E-04 | 2.01E-03 |
| **Smog Creation Potential** | kg O3 eq | 8.97E+00 | 6.22E-01 | 2.55E-02 | 4.28E-03 | 1.18E-01 | 8.19E+00 | 1.80E-03 | 2.58E-03 | 1.27E-03 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 2.01E-05 | 4.23E-07 | 2.84E-08 | 7.96E-09 | 1.27E-07 | 1.95E-05 | 2.56E-09 | 1.94E-09 | 1.10E-09 |
| **Fossil Depletion Potential** | MJ surplus | 3.22E+02 | 1.20E+01 | 3.00E-01 | 5.54E-01 | 1.13E+00 | 3.08E+02 | 2.29E-02 | 3.46E-02 | 1.24E-02 |

## D6. XLERATORsync® Hand Dryer EPD results – Resource Use, Waste Categories and Output Flows

Table 65: LCA Results – Resource Use – XLERATORsync® Hand Dryer, 120V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **RPRE** | MJ, LHV | 5.65E+02 | 1.34E+01 | 2.18E-02 | 1.57E+00 | 1.31E-01 | 5.50E+02 | 1.86E-03 | 7.57E-02 | 2.90E-03 |
| **RPRM** | MJ, LHV | 1.99E-01 | 1.99E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **RPRT** | MJ | 5.65E+02 | 1.36E+01 | 2.18E-02 | 1.57E+00 | 1.31E-01 | 5.50E+02 | 1.86E-03 | 7.57E-02 | 2.90E-03 |
| **NRPRE** | MJ | 5.13E+03 | 1.12E+02 | 2.12E+00 | 3.64E+00 | 8.21E+00 | 5.01E+03 | 1.62E-01 | 5.94E-01 | 9.84E-02 |
| **NRPRM** | MJ | 1.36E+01 | 1.36E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NRPRT** | MJ | 5.15E+03 | 1.26E+02 | 2.12E+00 | 3.64E+00 | 8.21E+00 | 5.01E+03 | 1.62E-01 | 5.94E-01 | 9.84E-02 |
| **SM** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NRSF** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **RE** | MJ | 0.00E+00 | x | x | x | x | x | x | x | x |
| **FW** | m3 | 1.96E+00 | 1.24E-01 | 9.84E-04 | 1.98E-03 | 1.10E-03 | 1.83E+00 | 1.80E-05 | 3.43E-04 | 2.28E-04 |

Table 66: LCA Results – Waste Categories and Output Flows – XLERATORsync® Hand Dryer, 120V, per use for 100,000 hand dryings

| Indicators | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **HWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **NHWD** | kg | 2.84E-01 | x | x | 2.24E-04 | x | x | x | x | 2.84E-01 |
| **HRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **LRWD** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **CRU** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **MR** | kg | 1.89E-01 | x | x | x | x | x | x | x | 1.89E-01 |
| **MER** | kg | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, electrical** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |
| **EE, thermal** | MJ, LHV | 0.00E+00 | x | x | x | x | x | x | x | x |

# Appendix E: Life Cycle Assessment Results – Sensitivity Analysis

## E1. Excel Dryers Life Cycle Assessment Results – High Use Intensity - 2 cycles per use

Table 67: LCA Results –Environmental Impact – ThinAir® Hand Dryer, 120V, 2 cycles per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 1.04E+03 | 4.69E+01 | 2.21E-01 | 1.90E+00 | 1.69E+00 | 9.85E+02 | 3.21E-02 | 1.38E-01 | 4.23E-01 |
| **Acidification Potential** | kg SO2 eq | 3.09E+00 | 2.64E-01 | 1.69E-03 | 2.65E-03 | 1.24E-02 | 2.81E+00 | 1.98E-04 | 6.60E-04 | 1.08E-04 |
| **Eutrophication Potential** | kg N eq | 5.96E+00 | 2.08E-01 | 2.25E-04 | 9.63E-04 | 2.32E-03 | 5.74E+00 | 3.84E-05 | 5.56E-04 | 2.15E-03 |
| **Smog Creation Potential** | kg O3 eq | 3.04E+01 | 2.62E+00 | 4.27E-02 | 3.12E-02 | 3.49E-01 | 2.73E+01 | 5.33E-03 | 7.79E-03 | 1.78E-03 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 6.81E-05 | 2.50E-06 | 4.37E-08 | 5.81E-08 | 3.75E-07 | 6.51E-05 | 7.59E-09 | 5.87E-09 | 1.45E-09 |
| **Fossil Depletion Potential** | MJ surplus | 1.09E+03 | 5.77E+01 | 4.56E-01 | 4.04E+00 | 3.36E+00 | 1.03E+03 | 6.78E-02 | 1.05E-01 | 1.87E-02 |

Table 68: LCA Results – Resource Use – XLERATOR® Hand Dryer, 120V, 2 cycles per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 9.79E+02 | 6.20E+01 | 8.10E-01 | 1.90E+00 | 3.10E+00 | 9.10E+02 | 5.87E-02 | 2.93E-01 | 3.99E-01 |
| **Acidification Potential** | kg SO2 eq | 3.05E+00 | 4.25E-01 | 4.78E-03 | 2.65E-03 | 2.28E-02 | 2.60E+00 | 3.62E-04 | 1.40E-03 | 1.02E-04 |
| **Eutrophication Potential** | kg N eq | 5.66E+00 | 3.42E-01 | 7.98E-04 | 9.63E-04 | 4.24E-03 | 5.31E+00 | 7.03E-05 | 1.18E-03 | 2.04E-03 |
| **Smog Creation Potential** | kg O3 eq | 3.01E+01 | 3.98E+00 | 1.38E-01 | 3.12E-02 | 6.38E-01 | 2.53E+01 | 9.75E-03 | 1.66E-02 | 1.68E-03 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 6.48E-05 | 3.69E-06 | 1.60E-07 | 5.81E-08 | 6.87E-07 | 6.02E-05 | 1.39E-08 | 1.25E-08 | 1.36E-09 |
| **Fossil Depletion Potential** | MJ surplus | 1.04E+03 | 7.67E+01 | 1.69E+00 | 4.04E+00 | 6.15E+00 | 9.50E+02 | 1.24E-01 | 2.22E-01 | 1.76E-02 |

Table 69: LCA Results – Resource Use – XLERATOReco® Hand Dryer, 120V, 2 cycles per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 4.91E+02 | 6.19E+01 | 8.06E-01 | 1.90E+00 | 3.09E+00 | 4.23E+02 | 5.84E-02 | 2.91E-01 | 3.99E-01 |
| **Acidification Potential** | kg SO2 eq | 1.66E+00 | 4.21E-01 | 4.76E-03 | 2.65E-03 | 2.27E-02 | 1.21E+00 | 3.60E-04 | 1.39E-03 | 1.02E-04 |
| **Eutrophication Potential** | kg N eq | 2.82E+00 | 3.42E-01 | 7.94E-04 | 9.63E-04 | 4.22E-03 | 2.47E+00 | 6.99E-05 | 1.18E-03 | 2.04E-03 |
| **Smog Creation Potential** | kg O3 eq | 1.65E+01 | 3.97E+00 | 1.37E-01 | 3.12E-02 | 6.35E-01 | 1.17E+01 | 9.71E-03 | 1.65E-02 | 1.68E-03 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 3.26E-05 | 3.68E-06 | 1.59E-07 | 5.81E-08 | 6.83E-07 | 2.80E-05 | 1.38E-08 | 1.24E-08 | 1.36E-09 |
| **Fossil Depletion Potential** | MJ surplus | 5.30E+02 | 7.66E+01 | 1.68E+00 | 4.04E+00 | 6.12E+00 | 4.41E+02 | 1.24E-01 | 2.21E-01 | 1.76E-02 |

Table 70: LCA Results – Resource Use – XLERATORsync® Hand Dryer, 120V, 2 cycles per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 1.62E+03 | 6.62E+01 | 1.05E+00 | 1.90E+00 | 4.17E+00 | 1.54E+03 | 7.90E-02 | 3.32E-01 | 1.53E+00 |
| **Acidification Potential** | kg SO2 eq | 5.04E+00 | 5.97E-01 | 6.75E-03 | 2.65E-03 | 3.06E-02 | 4.40E+00 | 4.87E-04 | 1.59E-03 | 4.55E-04 |
| **Eutrophication Potential** | kg N eq | 9.46E+00 | 4.42E-01 | 1.05E-03 | 9.63E-04 | 5.71E-03 | 8.99E+00 | 9.45E-05 | 1.34E-03 | 1.47E-02 |
| **Smog Creation Potential** | kg O3 eq | 4.84E+01 | 4.54E+00 | 1.86E-01 | 3.12E-02 | 8.58E-01 | 4.28E+01 | 1.31E-02 | 1.88E-02 | 9.27E-03 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 1.06E-04 | 3.09E-06 | 2.08E-07 | 5.81E-08 | 9.24E-07 | 1.02E-04 | 1.87E-08 | 1.42E-08 | 8.05E-09 |
| **Fossil Depletion Potential** | MJ surplus | 1.71E+03 | 8.77E+01 | 2.19E+00 | 4.04E+00 | 8.27E+00 | 1.61E+03 | 1.67E-01 | 2.52E-01 | 9.08E-02 |

## E2. Paper Towel Life Cycle Assessment Results – 1 to 4 sheets per use

Table 71: Paper Towel, 0% Recycled Content – 1 Sheet per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C4 |
|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 2816.584 | 687.0893 | 35.0004 | 1348.864 | 246.4028 | 423.06 | 14.00016 | 62.1673 |
| **Acidification Potential** | kg SO2 eq | 8.799182 | 3.752714 | 0.21574 | 2.956944 | 1.518813 | 0.248335 | 0.086296 | 0.020341 |
| **Eutrophication Potential** | kg N eq | 13.92755 | 2.906521 | 0.041877 | 5.484163 | 0.294811 | 4.606455 | 0.016751 | 0.576973 |
| **Smog Creation Potential** | kg O3 eq | 150.4293 | 66.65773 | 5.81367 | 31.83752 | 40.92823 | 2.487424 | 2.325468 | 0.379274 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 0.00025 | 6.05E-05 | 8.28E-06 | 0.000116 | 5.83E-05 | 2.98E-06 | 3.31E-06 | 3.8E-07 |
| **Fossil Depletion Potential** | MJ surplus | 4433.291 | 1518.531 | 73.98255 | 2252.441 | 520.8372 | 33.89949 | 29.59302 | 4.006542 |

Table 72: Paper Towel, 0% Recycled Content – 2 Sheets per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C4 |
|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 5069.496 | 998.4273 | 63.63861 | 2632.654 | 448.0158 | 839.1377 | 25.45545 | 62.1673 |
| **Acidification Potential** | kg SO2 eq | 15.2425 | 5.907156 | 0.392265 | 5.639127 | 2.761544 | 0.365163 | 0.156906 | 0.020341 |
| **Eutrophication Potential** | kg N eq | 25.58133 | 4.58179 | 0.076141 | 10.66519 | 0.536032 | 9.114739 | 0.030456 | 0.576973 |
| **Smog Creation Potential** | kg O3 eq | 265.8486 | 111.7441 | 10.57056 | 60.24549 | 74.41675 | 4.264115 | 4.228224 | 0.379274 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 0.000467 | 0.000105 | 1.51E-05 | 0.000229 | 0.000106 | 5.44E-06 | 6.03E-06 | 3.8E-07 |
| **Fossil Depletion Potential** | MJ surplus | 7599.358 | 1956.464 | 134.517 | 4443.429 | 946.9993 | 60.13552 | 53.80678 | 4.006542 |

Table 73: Paper Towel, 0% Recycled Content – 3 Sheets per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C4 |
|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 7322.408 | 1309.765 | 92.27683 | 3916.444 | 649.6289 | 1255.215 | 36.91073 | 62.1673 |
| **Acidification Potential** | kg SO2 eq | 21.68582 | 8.061598 | 0.568789 | 8.321311 | 4.004275 | 0.481991 | 0.227516 | 0.020341 |
| **Eutrophication Potential** | kg N eq | 37.2351 | 6.25706 | 0.110405 | 15.84623 | 0.777254 | 13.62302 | 0.044162 | 0.576973 |
| **Smog Creation Potential** | kg O3 eq | 381.2678 | 156.8306 | 15.32745 | 88.65346 | 107.9053 | 6.040805 | 6.130981 | 0.379274 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 0.000683 | 0.000149 | 2.18E-05 | 0.000342 | 0.000154 | 7.9E-06 | 8.74E-06 | 3.8E-07 |
| **Fossil Depletion Potential** | MJ surplus | 10765.43 | 2394.397 | 195.0513 | 6634.418 | 1373.162 | 86.37155 | 78.02054 | 4.006542 |

Table 74: Paper Towel, 0% Recycled Content – 4 Sheets per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C4 |
|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 9575.32 | 1621.103 | 120.915 | 5200.234 | 851.2419 | 1671.293 | 48.36602 | 62.1673 |
| **Acidification Potential** | kg SO2 eq | 28.12914 | 10.21604 | 0.745313 | 11.00349 | 5.247006 | 0.598819 | 0.298125 | 0.020341 |
| **Eutrophication Potential** | kg N eq | 48.88888 | 7.93233 | 0.14467 | 21.02726 | 1.018475 | 18.13131 | 0.057868 | 0.576973 |
| **Smog Creation Potential** | kg O3 eq | 496.687 | 201.917 | 20.08434 | 117.0614 | 141.3938 | 7.817495 | 8.033738 | 0.379274 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 0.0009 | 0.000193 | 2.86E-05 | 0.000454 | 0.000201 | 1.04E-05 | 1.14E-05 | 3.8E-07 |
| **Fossil Depletion Potential** | MJ surplus | 13931.49 | 2832.33 | 255.5857 | 8825.406 | 1799.324 | 112.6076 | 102.2343 | 4.006542 |

Table 75: Paper Towel, 100% Recycled Content – 1 Sheet per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C4 |
|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 2513.026 | 616.0916 | 31.57013 | 1195.092 | 222.2537 | 373.2224 | 12.62805 | 62.1673 |
| **Acidification Potential** | kg SO2 eq | 7.781427 | 3.248678 | 0.194596 | 2.635673 | 1.369959 | 0.234341 | 0.077839 | 0.020341 |
| **Eutrophication Potential** | kg N eq | 12.56008 | 2.734271 | 0.037772 | 4.863582 | 0.265917 | 4.066455 | 0.015109 | 0.576973 |
| **Smog Creation Potential** | kg O3 eq | 130.364 | 55.01688 | 5.243891 | 28.43483 | 36.91699 | 2.274613 | 2.097557 | 0.379274 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 0.000219 | 5.02E-05 | 7.47E-06 | 0.000103 | 5.26E-05 | 2.68E-06 | 2.99E-06 | 3.8E-07 |
| **Fossil Depletion Potential** | MJ surplus | 3998.401 | 1410.416 | 66.73177 | 1990.005 | 469.7917 | 30.75695 | 26.69271 | 4.006542 |

Table 76: Paper Towel, 100% Recycled Content – 2 Sheets per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C4 |
|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 4462.379 | 856.4318 | 56.77807 | 2325.111 | 399.7176 | 739.4625 | 22.71123 | 62.1673 |
| **Acidification Potential** | kg SO2 eq | 13.20699 | 4.899084 | 0.349977 | 4.996586 | 2.463836 | 0.337175 | 0.139991 | 0.020341 |
| **Eutrophication Potential** | kg N eq | 22.84638 | 4.237292 | 0.067933 | 9.424031 | 0.478245 | 8.034738 | 0.027173 | 0.576973 |
| **Smog Creation Potential** | kg O3 eq | 225.718 | 88.46243 | 9.431004 | 53.4401 | 66.39427 | 3.838492 | 3.772402 | 0.379274 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 0.000405 | 8.43E-05 | 1.34E-05 | 0.000202 | 9.46E-05 | 4.85E-06 | 5.38E-06 | 3.8E-07 |
| **Fossil Depletion Potential** | MJ surplus | 6729.58 | 1740.235 | 120.0154 | 3918.558 | 844.9083 | 53.85044 | 48.00615 | 4.006542 |

Table 77: Paper Towel, 100% Recycled Content – 3 Sheets per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C4 |
|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 6411.732 | 1096.772 | 81.98601 | 3455.129 | 577.1815 | 1105.703 | 32.7944 | 62.1673 |
| **Acidification Potential** | kg SO2 eq | 18.63255 | 6.549491 | 0.505357 | 7.357499 | 3.557714 | 0.44001 | 0.202143 | 0.020341 |
| **Eutrophication Potential** | kg N eq | 33.13269 | 5.740312 | 0.098093 | 13.98448 | 0.690573 | 12.00302 | 0.039237 | 0.576973 |
| **Smog Creation Potential** | kg O3 eq | 321.0719 | 121.908 | 13.61812 | 78.44538 | 95.87155 | 5.402372 | 5.447247 | 0.379274 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 0.000591 | 0.000118 | 1.94E-05 | 0.000301 | 0.000137 | 7.02E-06 | 7.76E-06 | 3.8E-07 |
| **Fossil Depletion Potential** | MJ surplus | 9460.758 | 2070.053 | 173.299 | 5847.111 | 1220.025 | 76.94393 | 69.3196 | 4.006542 |

Table 78: Paper Towel, 100% Recycled Content – 4 Sheets per use for 260,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C4 |
|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 8361.086 | 1337.112 | 107.194 | 4585.147 | 754.6454 | 1471.943 | 42.87758 | 62.1673 |
| **Acidification Potential** | kg SO2 eq | 24.05812 | 8.199897 | 0.660737 | 9.718412 | 4.651591 | 0.542844 | 0.264295 | 0.020341 |
| **Eutrophication Potential** | kg N eq | 43.419 | 7.243333 | 0.128253 | 18.54493 | 0.902901 | 15.97131 | 0.051301 | 0.576973 |
| **Smog Creation Potential** | kg O3 eq | 416.4259 | 155.3535 | 17.80523 | 103.4507 | 125.3488 | 6.966251 | 7.122092 | 0.379274 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 0.000776 | 0.000152 | 2.54E-05 | 0.0004 | 0.000179 | 9.18E-06 | 1.01E-05 | 3.8E-07 |
| **Fossil Depletion Potential** | MJ surplus | 12191.94 | 2399.872 | 226.5826 | 7775.664 | 1595.142 | 100.0374 | 90.63304 | 4.006542 |

## E3. Excel Dryers Life Cycle Assessment Results – high carbon use phase electricity grid (coal)

Table 79: LCA Results – Environmental Impact – XLERATORsync® Hand Dryer, 120V, high carbon use phase electricity grid, per use for 26,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 2.12E+03 | 6.62E+01 | 1.05E+00 | 1.90E+00 | 4.17E+00 | 2.05E+03 | 7.90E-02 | 3.32E-01 | 1.53E+00 |
| **Acidification Potential** | kg SO2 eq | 1.34E+01 | 5.97E-01 | 6.75E-03 | 2.65E-03 | 3.06E-02 | 1.28E+01 | 4.87E-04 | 1.59E-03 | 4.55E-04 |
| **Eutrophication Potential** | kg N eq | 8.79E+00 | 4.42E-01 | 1.05E-03 | 9.63E-04 | 5.71E-03 | 8.33E+00 | 9.45E-05 | 1.34E-03 | 1.47E-02 |
| **Smog Creation Potential** | kg O3 eq | 1.13E+02 | 4.54E+00 | 1.86E-01 | 3.12E-02 | 8.58E-01 | 1.08E+02 | 1.31E-02 | 1.88E-02 | 9.27E-03 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 5.66E-05 | 3.09E-06 | 2.08E-07 | 5.81E-08 | 9.24E-07 | 5.23E-05 | 1.87E-08 | 1.42E-08 | 8.05E-09 |
| **Fossil Depletion Potential** | MJ surplus | 4.67E+02 | 8.77E+01 | 2.19E+00 | 4.04E+00 | 8.27E+00 | 3.64E+02 | 1.67E-01 | 2.52E-01 | 9.08E-02 |

## E4. Excel Dryers Life Cycle Assessment Results – low carbon use phase electricity grid (wind)

Table 80: LCA Results – Environmental Impact – XLERATORsync® Hand Dryer, 120V, low carbon use phase electricity grid, per use for 26,000 hand dryings

| Impact category | Unit | Total | A1 | A2 | A3 | A4 | B1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global Warming Potential** | kg CO2-eq | 1.11E+02 | 6.62E+01 | 1.05E+00 | 1.90E+00 | 4.17E+00 | 3.56E+01 | 7.90E-02 | 3.32E-01 | 1.53E+00 |
| **Acidification Potential** | kg SO2 eq | 8.69E-01 | 5.97E-01 | 6.75E-03 | 2.65E-03 | 3.06E-02 | 2.29E-01 | 4.87E-04 | 1.59E-03 | 4.55E-04 |
| **Eutrophication Potential** | kg N eq | 9.33E-01 | 4.42E-01 | 1.05E-03 | 9.63E-04 | 5.71E-03 | 4.66E-01 | 9.45E-05 | 1.34E-03 | 1.47E-02 |
| **Smog Creation Potential** | kg O3 eq | 7.45E+00 | 4.54E+00 | 1.86E-01 | 3.12E-02 | 8.58E-01 | 1.79E+00 | 1.31E-02 | 1.88E-02 | 9.27E-03 |
| **Ozone Depletion Potential** | kg CFC-11 eq | 5.75E-06 | 3.09E-06 | 2.08E-07 | 5.81E-08 | 9.24E-07 | 1.43E-06 | 1.87E-08 | 1.42E-08 | 8.05E-09 |
| **Fossil Depletion Potential** | MJ surplus | 1.37E+02 | 8.77E+01 | 2.19E+00 | 4.04E+00 | 8.27E+00 | 3.38E+01 | 1.67E-01 | 2.52E-01 | 9.08E-02 |

# Appendix F: Additional Calculations for Paper Towel Scenarios

## F1. Calculation of Per Sheet for Paper Towel Scenarios

Table 81: Sources and calculations of per sheet for paper towel baseline

| | Calculation | 0% Recycle Content Paper Towel | 100% Recycle Content Paper Towel | Comment |
|---|---|---|---|---|
| **Weight per roll (g/in$^2$)** | | 0.026 | 0.026 | From (Suresh & Schultz, 2018) report. This is the average grammage values for tissue products. |
| **Area of roll (in$^2$)** | | 68889 | 69300 | From (Georgia Pacific, 2023). Area of 1 roll that's typically purchased with the dispenser used in this. No reason was given on why the 100% recycled paper towel has greater dimensions. However, in this study it is assumed this is due to the lower quality/thinner of paper being used. |
| **Weight per roll (g)** | Weight per roll*area of roll | 1791.114 | 1801.8 | |
| **Sheets per roll** | | 700 | 800 | From (Georgia Pacific, 2023). The typical amount of sheets included per roll. |
| **Weight per Sheet (g)** | Weight per roll/sheets per roll | 2.56 | 2.25 | |
| **Sheets used** | | 2 | 2 | From (Suresh & Schultz, 2018) and (Materials Systems Laboratory, 2011) |
| **Overall weight (baseline)** | Weight per sheet*sheets used*functional unit (260,000) | 1,330.54 | 1,171.17 | |

## F2. Calculation of Waste Liners

It is assumed the liners are used 5 times a week, with 52 weeks in a year. A liner itself weighs 0.033 kg and after 10 years, the system will use 85.5 kg of liners, which is allocated to the raw materials and then disposed of at the end-of-life stage. The assumption of the weight of the liners and use of liners come from the 2009 Excel report (US, 2009).

# Appendix G: Life Cycle Inventory for Paper Towel Scenarios – A3 Manufacturing Stage (Sulfate Pulp to Paper Towels)

Table 82: LCI for Paper Towel scenarios – A3 manufacturing stage (sulfate pulp to paper towels)

| Material | Utility Type | Library Process | Amount | Unit |
|---|---|---|---|---|
| **A3_Paper Towel Manufacturing** [6] | Water | Water, unspecified natural origin, US | 0.212 | L |
| | Electricity | Electricity, low voltage {US}\| market group for \| Cut-off, U | 29.4 | KJ |
| | Natural Gas | Heat, central or small-scale, natural gas {RER}\| market group for \| Cut-off, U | 48.7 | KJ |
| | Wastewater | Wastewater, average {RoW}\| market for wastewater, average \| Cut-off, U | 0.212 | L |

[6] When modelling A3_Paper Towel Manufacturing, data is based on (Materials Systems Laboratory, 2011) study. Therefore, A3_Paper Towel Manufacturing was modelled per 0.004112 kg, rather than per 1 kg.

# Appendix H: ISO-Based Allocation Method

### H1. ISO-Based Allocation Method

According to ISO/TR 14049 (ISO 14049, 2012), there are several steps to open loop recycling, which can be seen in **Figure 42.** Following these steps, **Figure 43** illustrates the allocation basis, which reflects the loadings associated with the primary product system, until the end of the product life (ISO 14049, 2012). The next step is the determination of uses of the recycled material. There are two major different uses of the virgin pulp in this scenario – one is the discarded paper towel and the other is recycled paper products. The difference is, once the paper towel is used, it is discarded. While the other recycled paper products are open to further recovery and recycling. Moreover, for this method it was considered 44.5% of the virgin pulp is directed to municipal solid waste and 55.5% enters into recovering and recycling paper product systems. This assumption is based off the assumptions made within the MIT study; where there was a 44.5% disposal loss assumed (Materials Systems Laboratory, 2011).

The third step was the calculation of uses. In order to calculate the total number of uses, the formula and variables below were used (ISO 14049, 2012):

$$u = 1+z_1 \cdot [(u_{12} \cdot y_2) + (u_{13} \cdot y_3) \cdot (1/1-(z_3 \cdot y_3)))]$$

Table 83: Explanation of variables used for ISO-based allocation method calculations.

| Variable | Description | Value | Explanation |
|---|---|---|---|
| $z_1$ | Fraction of primary product which is recovered after a first use and then recycled | 0.555 | 100%-44.5%=55.5%=0.555. Assumption is based off the assumptions made within the MIT study; where there was a 44.5% disposal loss assumed (Materials Systems Laboratory, 2011). |
| $u_{12}$ | Fraction of $z_1$ fibres which are recycled into paper towel | 0.25 | Due to the lack of data, this value was taken from the example used in ISO 14049. |
| $u_{13}$ | Fraction of $z_1$ fibres which are recycled into recycled products | 0.75 | Due to the lack of data, this value was taken from the example used in ISO 14049. |
| $y_2$ | Yield of repulped fibres for paper towel products | 0.631 | 1-(0.33+0.039) =0.631. Using the same assumptions as the MIT study, there is a 3.9% production loss and a 33.3% recycling loss (Materials Systems Laboratory, 2011). Therefore, the yield is the remaining product after losses from re-pulping and production. |
| $y_3$ | Yield of repulped fibres for recycled products | 0.631 | 1-(0.33+0.039) =0.631. Using the same assumptions as the MIT study, there is a 3.9% production loss and a 33.3% recycling loss (Materials Systems Laboratory, 2011). Therefore, the yield is the remaining product after losses from re-pulping and production. |

| | | | |
|---|---|---|---|
| **$z_3$** | The fraction of recycled product which is recycled again. Assumes no open loop recycling of post consumer fibres. | 0.555 | The fraction of product that is being sent to re-pulping after the use phase. Therefore, it's the percentage of product not going into waste management. |

After calculating u, which evaluated to 1.492, calculating the allocation factor was next. In this scneario, the allocation factor calculated was for the totality of the recycled product uses receives, which is equal to: $z_1 \cdot (u-1)/u$. After plugging in the numbers, the allocation factor resulted to 0.1830. For the final step the allocation factor was multiplied to the mass of the product used in our study, 1,330.54 kg, which resulted to 243.43 kg.

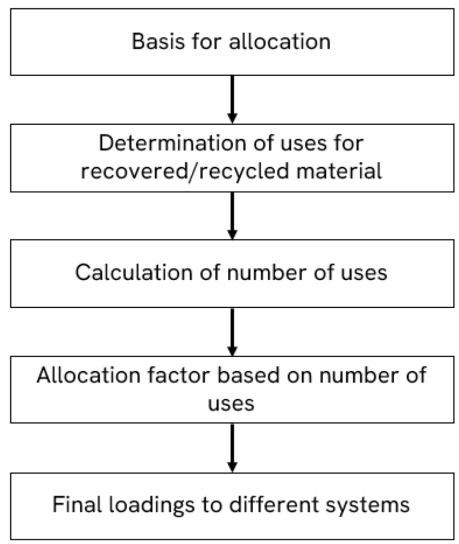



Figure 42: ISO-based allocation method steps.

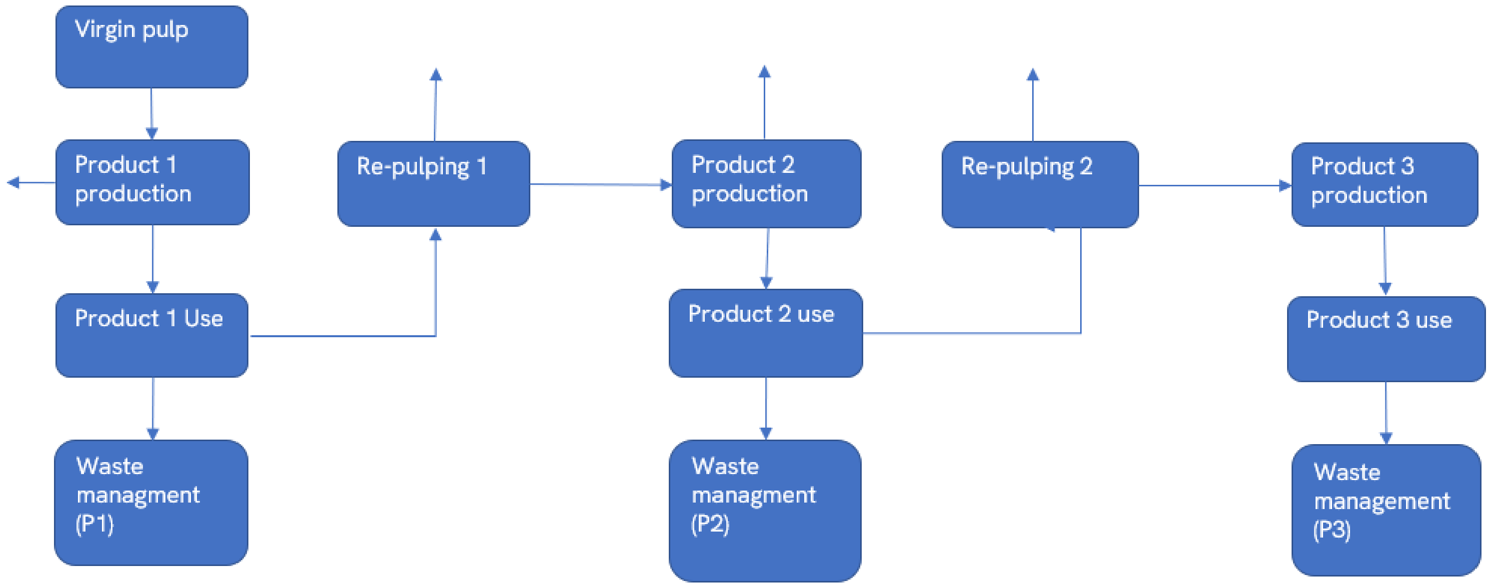



Figure 43: ISO-based Allocation basis

# Appendix I: Critical Review Statement

585 Grove St., Ste. 145 PMB 966,
Herndon, VA 20170, USA

+1.571.225.0518
www.smartepd.com
info@smartepd.com

June 19, 2023

**Verification Report: Comparative Life Cycle Assessment of Hand Drying Systems**

Excel Dryer Inc commissioned a panel of experts to perform an external independent verification of the **Comparative Life Cycle Assessment of Hand Drying Systems: Excel Hand Dryers and Paper Towel Systems (May 2023)** report created by **True North Collective Sustainability Consulting.**

**The review of the study was performed to demonstrate conformance** with the following standards:

> International Organization for Standardization. (2006). *Environmental management -- Life cycle assessment – Principles and framework* (ISO 14040:2006).
>
> International Organization for Standardization. (2006). *Environmental management -- Life cycle assessment -- Requirements and guidelines* (ISO 14044:2006).
>
> International Organization for Standardization. (2014). *Environmental management -- Life cycle assessment -- Critical review processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006.* (ISO/TS 14071:2014).
>
> Product Category Rules for Hand Dryers – For preparing and Environmental Product Declaration (EPD) for the Product Category: Hand Dryers. UL 10007, Version 1, 2016.

The independent third-party verification was conducted by the following panel of experts per ISO 14044:2006 Section 6.2: Critical review as well as the referenced Product Category Rules (PCR):

> Anna N. Lasso, LCACP
> Founder/CEO
> Smart EPD
>
> Thomas P. Gloria, Ph.D., LCACP
> Founder, Chief Sustainability Engineer
> Industrial Ecology Consultants
>
> Alison Conroy, LCACP
> Independent Contractor

**REVIEW SCOPE**

The intent of this review was to provide an independent third-party external verification of a LCA study report in conformance with the previously listed ISO standards and PCR. This review did not include an assessment of the Life Cycle Inventory (LCI) model, however, it did include a detailed analysis of the individual datasets used to complete the study.

**REVIEW PROCESS**

The review process involved the verification of all requirements set forth by the applicable ISO standards and PCR cataloged in comprehensive review table along with editorial comments. There were three rounds of comments by the reviewers submitted to the LCA practitioner. Responses by the LCA practitioner to each issue raised were resolved and acknowledged by the review panel to have been satisfactorily addressed.

**VERIFICATION STATEMENT**

Based on the independent verification objectives, the **Comparative Life Cycle Assessment of Hand Drying Systems: Excel Hand Dryers and Paper Towel Systems (May 2023)** was determined to be ***in conformance*** with the applicable ISO standards and Product Category Rules. The plausibility, quality, and accuracy of the LCA-based data and supporting information are confirmed.

As the Chair of the External Independent Third-Party Review Panel, I confirm that the members of the panel have sufficient scientific knowledge and experience of energy and fuel pellet systems and the applicable ISO standards to carry out this verification.

Anna Lasso
Smart EPD Founder/CEO
anna.lasso@smartepd.com
571-225-0518

# About TrueNorth Collective

TrueNorth Collective
Sustainable Design makes for Better Business
Info@truenorthcollective.net
https://www.truenorthcollective.net