

Life Cycle Assessment of Hand Drying Systems

An LCA study with full sensitivity and uncertainty analysis, conducted in accordance with ISO standards 14040 and 14044, directly comparing the environmental impact of paper towels, cotton towels, standard warm air dryers, XLERATOR® and the Dyson Airblade™ hand dryer.

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Introduction

Life Cycle Assessment (LCA) is a scientific method of analysing the environmental impact of a product or range of products. Different products or technologies which have the same purpose can be directly compared (i.e. different hand drying solutions that all aim to dry hands).

A key strength of LCA is that it encompasses whole product systems, producing a detailed and balanced picture; including materials and manufacture, production, transport, use and disposal. It includes justified assumptions for a particular situation, looking at aspects such as manufacturing location, product usage and recyclability. It also takes a holistic approach to the environment, looking at a range of measures such as resource use, ecosystem quality, global warming potential, potential human health impacts and water system and land use, among others. In particular, global warming potential (g CO₂e) is a commonly used and well known metric that measures the amount of carbon dioxide equivalents produced.

Due to its wide scope a number of International Standards (including ISO 14040 and 14044 [1,2]) have been created to provide a standardized process for conducting LCAs. LCAs conducted following these standards all use a consistent basis and must fully justify methods and assumptions for quantifying total environmental impact. When a product is evaluated against the international standards key assumptions are made when setting the scope of the project, including the functional unit and the system boundaries.

However, even with ISO 14040 and 14044 in place, previous hand drying LCAs have used different assumptions and scopes which means that the results are not directly comparable with each other. In order to make any direct comparisons a justified functional unit and set of system boundaries needs to be set across all hand drying scenarios. Also other LCA studies often focus on one scenario and do not consider how changing key variables might affect the overall outcome. Different calculations need to be carried out to take into account different circumstances either now or in the future.

Dyson commissioned the Massachusetts Institute of Technology (MIT) to evaluate the environmental performance of the Dyson Airblade™ hand dryer. MIT conducted an LCA with an extended analysis which included:

1. All current and relevant research as data sources within the study—including LCAs commissioned by other manufacturers.
2. All possible product types within the hand drying category – so that all products could be directly compared.
3. An influential addition to the standard LCA format – a full and detailed sensitivity and uncertainty analysis – which included a wide range of scenarios, allowing conclusions to a statistical degree of certainty to be drawn.

Executive summary

This LCA is an analysis and comparison of the environmental impacts of hand-drying systems found in public washrooms. Carried out by MIT and commissioned by Dyson, this LCA report is the first to compare such a breadth of products. It also uses a justified baseline scenario, testing the robustness of comparative results through a comprehensive sensitivity and uncertainty analysis. All conclusions are fully justified to a statistical degree of certainty.

Aims and scope

The goal of this analysis is to evaluate and compare seven types of hand-drying systems including:

- 1) A Dyson Airblade™ hand dryer with an aluminum cover (a high-speed hands-in dryer)
- 2) A Dyson Airblade™ hand dryer with a plastic cover (a high-speed hands-in dryer)
- 3) An Excel XLERATOR® (a high-speed hands-under dryer)
- 4) A generic standard warm air dryer (a hands-under dryer)
- 5) Generic cotton roll towels
- 6) Generic paper towels manufactured from 100% virgin content
- 7) Generic paper towels manufactured from 100% recycled content

This LCA includes all life cycle stages, from cradle to grave (materials production, manufacturing, use and end-of-life) along with transport between each stage. Packaging for all systems, as well as dispensers, a waste bin, and bin liners for the towels, are also accounted for. For this LCA the following measures are used: global warming potential (GWP), cumulative energy demand (CED), and IMPACT 2002+ measures. This means the study looks at global warming potential as well as other measures including land use, water consumption, human health, ecosystem quality, climate change and resource use.

There are a number of LCA studies that are publicly available that study different hand drying methods. These LCA studies have been commissioned by a range of manufacturers including Airdri Ltd, Kimberley Clark and Excel XLERATOR® and all use different assumptions (see Section 1 in the Appendix). Between all these studies, there is not a single unified approach that can be used to examine all seven hand drying methods. Because of each of the studies' differing functional units, assumptions, data, and life cycle assessment outcomes, each product type cannot be easily compared.

This LCA study was commissioned as a means of addressing this gap. Data for this analysis were obtained from these existing LCA studies and assessed as necessary to ensure all hand-drying systems were compared using a consistent basis. In cases where the existing studies were inadequate as data sources, particularly for recycled paper towels, additional data sources were consulted and assumptions were made in order to develop a complete data set. The quality of the assumptions required to develop a complete set of data and put all of the systems on a consistent basis were tested through uncertainty and sensitivity analyses.

Method and results

The report results are first grounded around the baseline scenario. This is a set of justified assumptions that sets the "baseline" for the first stage of analysis (see Section 2 in the Appendix). A single pair of dry hands represents the functional unit in this study and each of the seven hand drying types is referenced to this unit. The same holds true for the towel dispensers, waste bin, bin liners, and packaging used by these products. For the hand dryers, "dry" is defined by the Protocol P335 [3], the Protocol for a hygienic commercial hand dryer as defined by the independent public health organization, NSF International. This provides a standard for hygienic hand drying in the commercial environment, thereby providing a consistent scientific basis for determining use times and the degree to which hands are dry.

From the baseline scenario it is concluded that the two Dyson Airblade™ hand dryers are associated with the lowest global warming potential (GWP) of all the hand-drying systems examined. Paper towels and standard warm air dryers were the two worst performing type of hand drying system in terms of environmental impact.

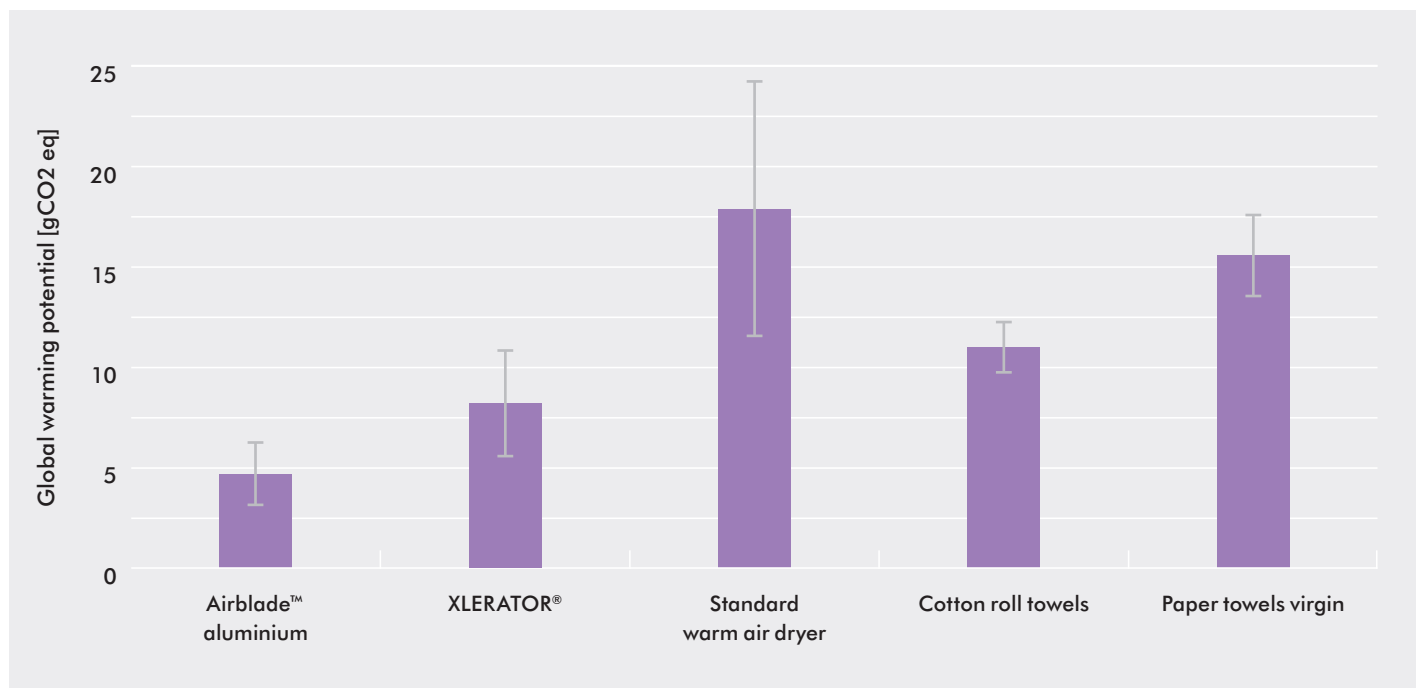
For paper towels the majority of the impact comes from the production of the paper towels themselves. The paper towel packaging, dispensers, waste bins, and bin liners account for less than 10% of the environmental burden. For standard warm air dryers, the majority of the impact comes from the use phase; with the longer dry time and higher rated power of the machine contributing to the majority of the GWP impact. A small part of the GWP impact of the standard warm air dryer (and XLERATOR®) also comes from motor spin-down time which uses energy.

For Dyson Airblade™ hand dryers, the majority of impact comes from the use phase; with its shorter dry time contributing to its lower impact over other high-speed hand dryers. There is also no spin-down due to the advanced technology in the Dyson digital motor. For other measures of environmental impact, including the IMPACT 2002+ damage assessments, water consumption and land occupation – all results indicate the plastic Dyson Airblade™ hand dryer has the lowest impact overall (see section 3 in the Appendix for graphed results).

The sensitivity and uncertainty analyses

This LCA report also included a detailed sensitivity and uncertainty analysis. The sensitivity analysis compares the GWP results for all seven of the hand drying systems under different scenarios. All the baseline assumptions are varied, one at a time, in order to test the robustness of the baseline scenario results and conclusions. The uncertainty analysis assesses the impact of simultaneously varying several baseline assumptions on the results and conclusions via statistical tests. A comparison between the results of existing studies is also carried out. Please refer to the sensitivity and uncertainty sections of the main report [4] to understand how these scenarios affect the probability and frequency of these impacts for the different hand drying solutions.

The uncertainty analysis showed that if users use drying systems until their hands are completely dry, the Dyson Airblade™ hand dryer’s GWP is lower than that of the XLERATOR® in 86% of the scenarios explored, and lower than that of the other drying systems in over 98% of the scenarios. Furthermore, the uncertainty analysis showed that the differences between the impacts of all products was statistically meaningful even when accounting for uncertainty in the data sets used to generate the results. The scenario and uncertainty analyses and the comparison with existing studies demonstrate that in spite of assumptions made to develop complete data sets (e.g., for recycled paper) and to compare all hand-drying systems on a complete basis the conclusions about the relative environmental impacts of the products are robust.



Error bars represent one standard deviation above and below the mean for a parameter uncertainty analysis of the baseline scenario.

Conclusions

This study clearly concludes that the Dyson Airblade™ hand dryer has the lowest environmental impact compared with all other possible hand drying systems – collectively scoring the lowest across all possible measures. This examination includes not only GWP but also potential human health impacts, ecosystem quality, energy demand, water consumption, and land occupation, and including all life cycle stages, from cradle to grave. See ranking table from the full MIT report [4] below (1 = lowest impact, 7 = highest impact; systems are assigned the same rank if the difference between their impacts is within 10% of the smaller of the two numbers).

Ranking

Product	Global Warming Potential	Human Health	Ecosystem Quality	Cumulative Energy Demand	Water Consumption	Land Occupation
Airblade™ aluminum	1	1	1	1	3	1
Airblade™ plastic	1	1	1	1	1	1
XLERATOR®	3	3	3	3	4	3
Standard warm air dryer	7	7	4	6	7	4
Cotton roll towels	4	3	6	4	1	6
Paper towels, virgin	5	5	7	7	5	7
100% recycled	5	5	4	5	5	5

Appendix

Section 1

There are a number of LCA studies that are publicly available that study some hand drying methods. These include:

- A streamlined life cycle assessment conducted for Airdri Ltd. and Bobrick Washroom Equipment that compares a standard warm air dryer to paper towels. [5]
- A hand dryer-towel comparison produced by MyClimate, previously commissioned by Dyson in Switzerland. [6]
- A comparison between cotton roll towels and paper towels commissioned by Vendor. [7]
- Some calculations made by the Climate Conservancy for Salon. [8]

More comprehensive life cycle assessments that comply with the ISO 14040 and 14044 life cycle assessment standards include:

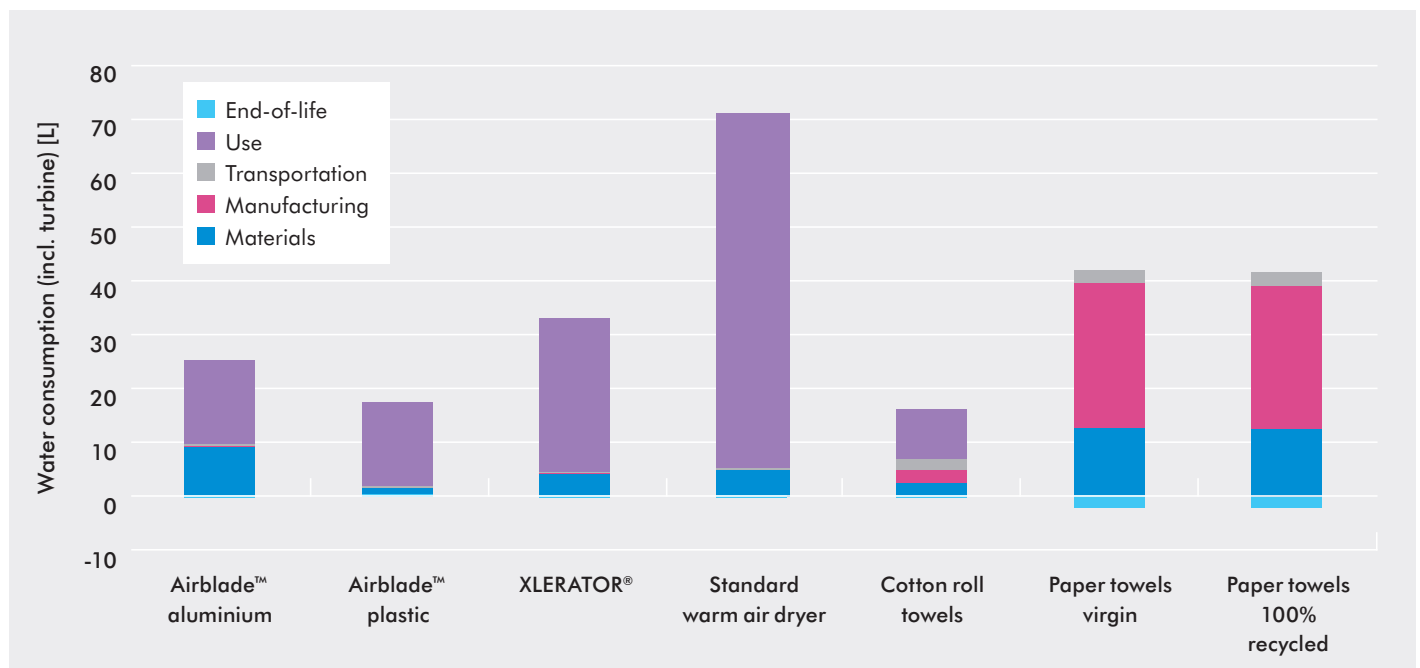
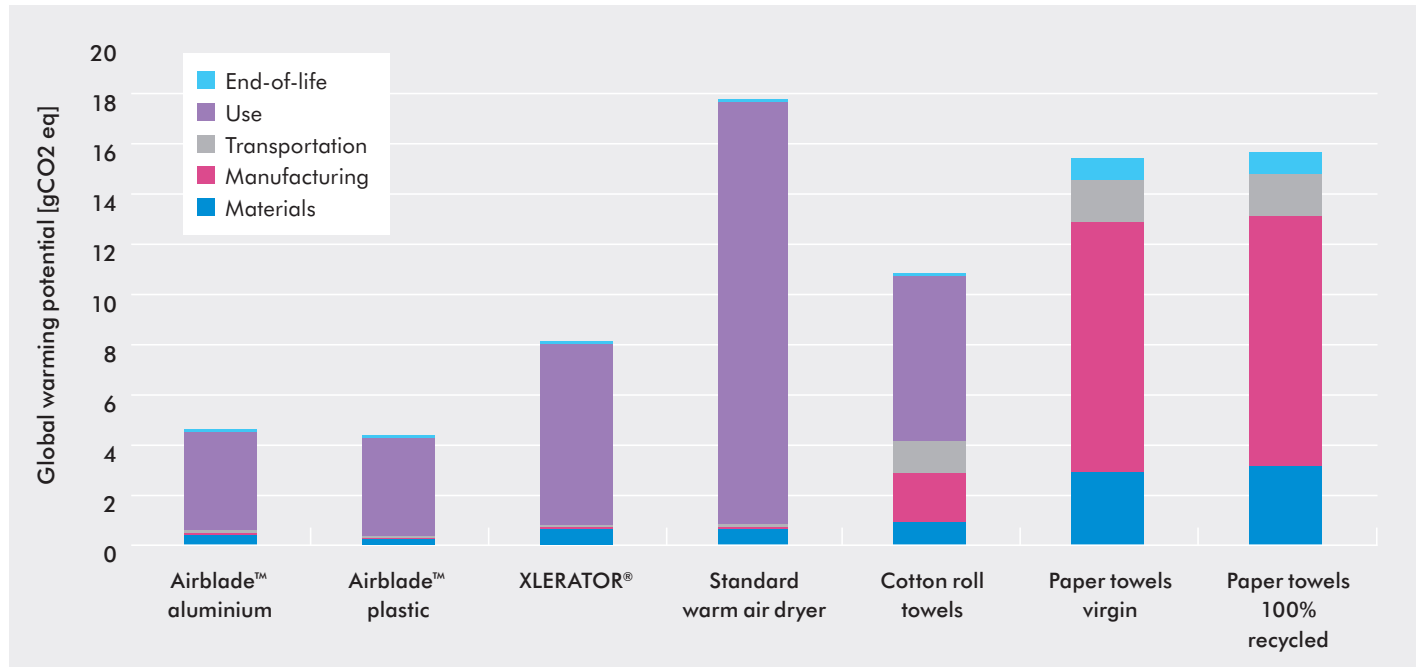
- A study for the European Textile Services Association (ETSA) that also compares cotton roll towels to paper towels. [9]
- An investigation into multiple types of tissue products commissioned by Kimberly-Clark. [10]
- A study comparing XLERATOR® hand dryer to a standard warm air dryer and paper towels, commissioned by Excel Dryer. [11]
- Dyson has also conducted a life cycle assessment of Dyson Airblade™ hand dryers in accordance with the PAS 2050 standard [12] in order to obtain a Carbon Reduction Label from the Carbon Trust [13]

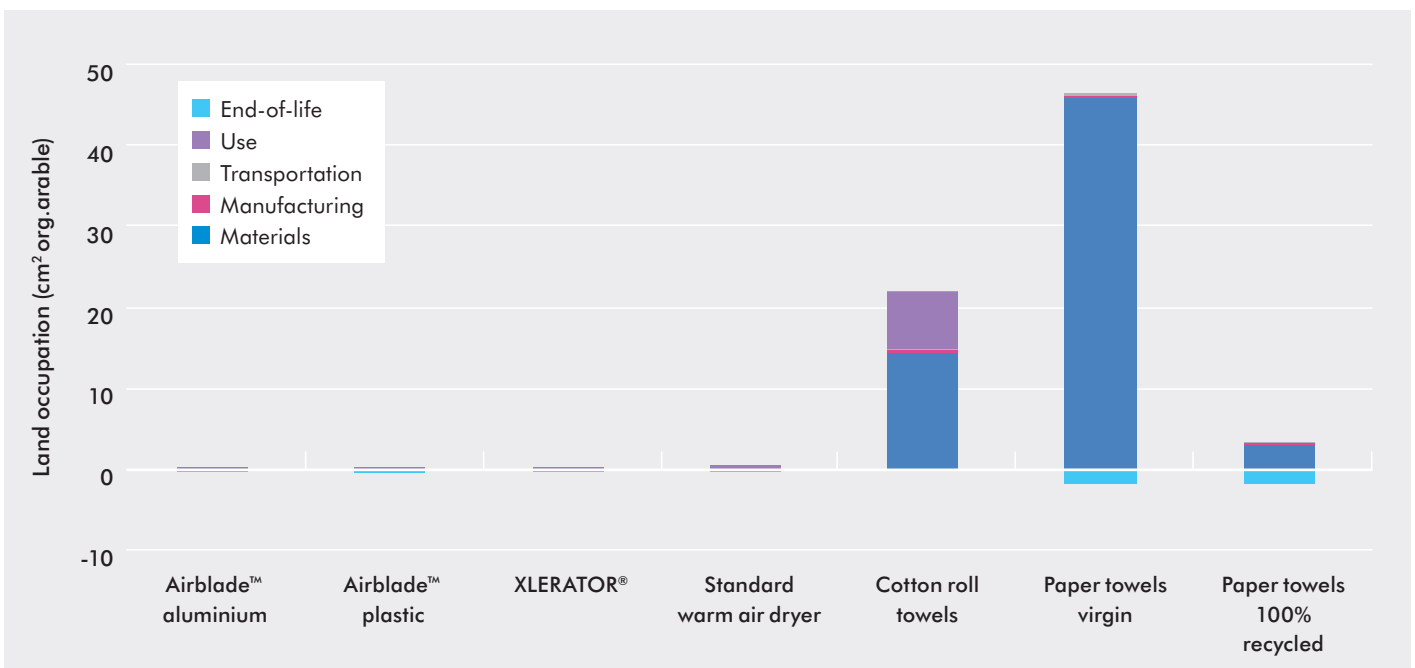
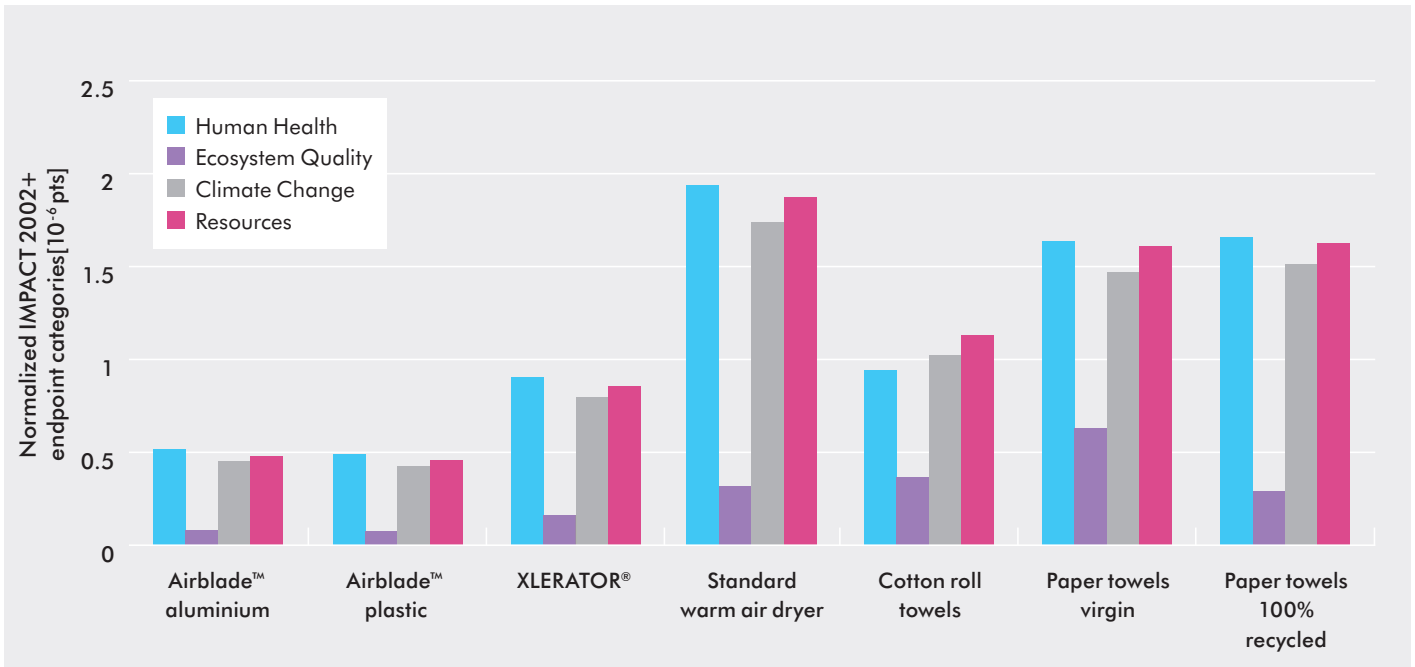
Section 2

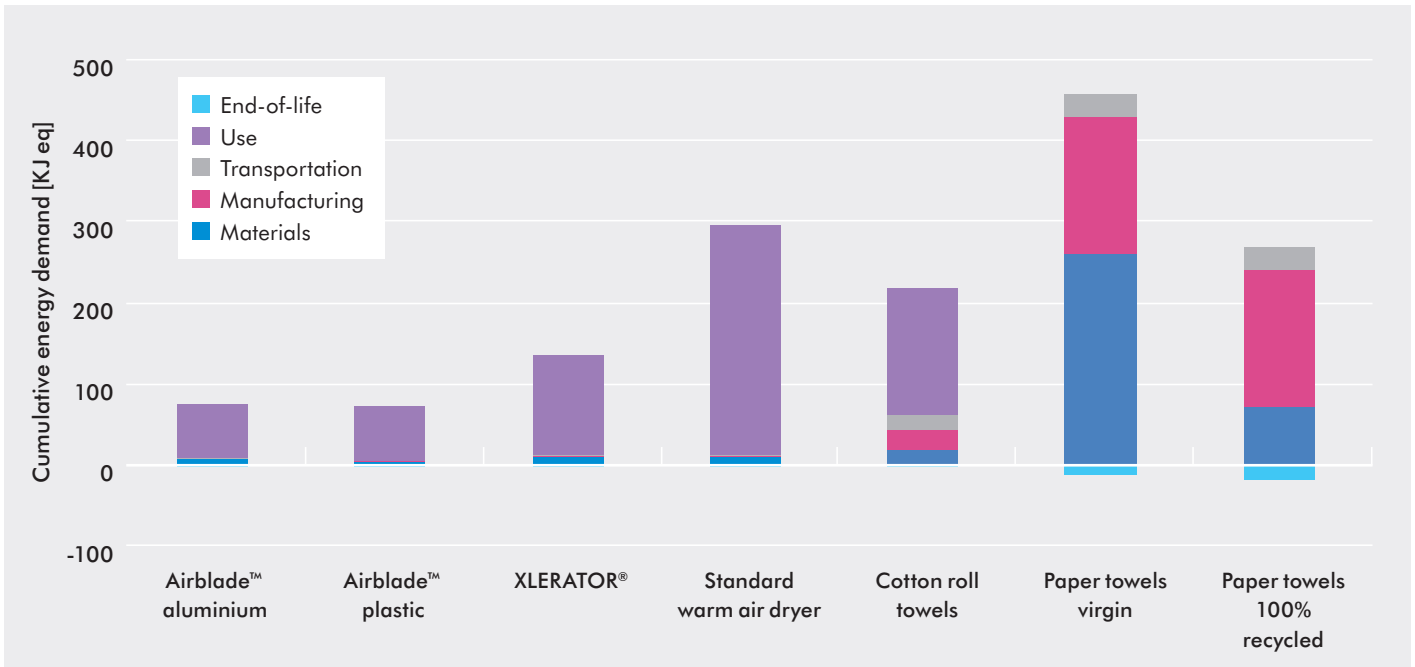
Baseline scenario assumptions (all are justified and varied in the sensitivity and uncertainty analysis):

- Lifetime usage (350,000) – number of pairs of hands dried over the 5-year product life span.
- Manufacturing phase electric grid mix (China or US average mix).
- Use phase electric grid mix (US average mix).
- Use intensity (varies by product) – length of dry time for dryers, or number of paper towels or cotton roll towel pulls required to dry hands.
- End-of-life scenario (19% incinerated, 81% landfilled with energy recovery) – fraction of waste incinerated, landfilled, recycled, or composted; energy recovery assumption is maintained throughout.
- Dryer electronics unit process (Electronic component, active, unspecified) – unit process inventory chosen to represent the control and optics assemblies in the XLERATOR® and standard warm air dryer.
- Cotton roll towel reuses (103 cycles) – number of times cotton roll towels can be laundered and reused before disposal.
- Paper towel mass (1.98g) – mass of virgin and recycled content paper towels
- Paper pulping process (ECF-bleached sulfate) – manufacturing process of pulp used by virgin paper towels.
- End-of-life allocation methodology for recycled content in paper towels (cut-off) – allocation of the burden of primary material production, recycling, and end-of-life processes.
- Manufacturing location (China or US) – where the products are manufactured; affects production electric grid mix and transportation distances
- Use location (US) – where the products are used; affects transportation distances, electric grid mix, and end-of-life scenario

Section 3







References

1. International Organization for Standardization: Environmental management – Life cycle assessment – Principles and framework. (2006).
2. International Organization for Standardization: Environmental management – Life cycle assessment – Requirements and guidelines. (2006).
3. NSF International: NSF Protocol P335 Hygienic Commercial Hand Dryers, http://www.nsf.org/business/engineering_and_research/protocols.asp?program=EngineeringSer, (2007).
4. T. Montalbo, J. Gregory, R. Kirchain. Life Cycle Assessment of Hand Drying Systems. Materials Systems Laboratory. Massachusetts Institute of Technology. (2011)
5. Environmental Resources Management: Streamlined Life Cycle Assessment Study. (2001).
6. MyClimate: Dyson Hand Dryer Fact Sheet, http://www.climatop.ch/downloads/E-Fact_Sheet_Dyson_Hand_dryer_v3.pdf, (2008).
7. de Schryver, A., Vieira, M. LCA of two different hand drying systems, http://www.vendorinternational.com/upload/Engelse%20plaatjes/VendorReport_shortversion.pdf, (2008).
8. Paper towels vs. electric hand dryers, <http://www.climateconservancy.org/salon.php>.
9. Eberle, U., Möller, M. Life Cycle Analysis of Hand-Drying Systems: A comparison of cotton towels and paper towels. Öko-Institut (2006).
10. Madsen, J. Life Cycle Assessment of Tissue Products. Environmental Resources Management (2007).
11. Dettling, J., Margni, M. Comparative Environmental Life Cycle Assessment of Hand Drying Systems: The XLERATOR® Hand Dryer, Conventional Hand Dryers and Paper Towel Systems. Quantis (2009).
12. BSI Group: PAS 2050:2008 Specification for the assessment of the life cycle greenhouse gas emissions of goods and services, <http://www.bsigroup.com/upload/Standards%20&%20Publications/Energy/PAS2050.pdf>, (2008).
13. Dyson: The Dyson Airblade hand dryer receives industry first Carbon Reduction Label, <http://www.dysonairblade.com/news/newsArticle.asp?newsID=116>, (2010).