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A comparative life cycle assessment of conventional hand dryer and roll paper towel as hand drying methods

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HIGHLIGHTS

- Comparative life cycle assessment of two prevalent hand drying methods was conducted.
- Two methods, warm air hand dryer use and paper towel use, assessed.
- Towel material and manufacturing and dryer electricity use major impact contributors.

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ABSTRACT

A comparative life cycle assessment, under a cradle to gate scope, was carried out between two hand drying methods namely conventional hand dryer use and dispenser issued roll paper towel use. The inventory analysis for this study was aided by the deconstruction of a hand dryer and dispenser unit besides additional data provided by the Physical Resources department, from the product system manufacturers and information from literature. The LCA software SimaPro, supported by the ecoinvent and US-EI databases, was used towards establishing the environmental impacts associated with the lifecycle stages of both the compared product systems. The Impact 2002+ method was used for classification and characterization of these environmental impacts. An uncertainty analysis addressing key input data and assumptions made, a sensitivity analysis covering the use intensity of the product systems and a scenario analysis looking at a US based use phase for the hand dryer were also conducted. Per functional unit, which is to achieve a pair of dried hands, the dispenser product system has a greater life cycle impact than the dryer product system across three of four endpoint impact categories. The use group of lifecycle stages for the dispenser product system, which represents the cradle to gate lifecycle stages associated with the paper towels, constitutes the major portion of this impact. For the dryer product system, the use group of lifecycle stages, which essentially covers the electricity consumption during dryer operation, constitutes the major stake in the impact categories. It is evident from the results of this study that per dry, for a use phase supplied by Ontario's grid (2010 grid mix scenario) and a United States based manufacturing scenario, the use of a conventional hand dryer (rated at 1800 W and under a 30 s use intensity) has a lesser environmental impact than with using two paper towels (100% recycled content, unbleached and weighing 4 g) issued from a roll dispenser.

1. Introduction

Since the middle of the 19th century, it has been identified that hand hygiene is very important in reducing the possibility of infection from disease causing microbes (Best and Neuhauser, 2004). Several scientific studies have been published since that time on hand hygiene and its effectiveness in curbing the spread of infectious diseases (Aiello et al., 2008; Das et al., 2008; Han and Hlaing, 1989). Bloomfield et al. (2007) suggested hands as the most significant entry point for microbial ingress to the human body and highlighted the relevance of hand hygiene procedures in controlling pathogen spread. The Centers for Disease Control and Prevention in the United States recommends drying hands after hand washing because wet hands can take in and transmit much more germs than if they were dry (Centers for Disease Control and Prevention, 2013). Therefore, in public settings in particular, hand drying is an important closing procedure after hand washing. In general, there are three different means of hand drying and these are through using paper towels, using cloth towels and using a hand dryer. All these three methods involve the manufacture, use and disposal or recycling of products which can ultimately affect the natural environment (Finnveden et al., 2009).

Growing public awareness on hygiene and rising hygiene standards is increasing the demand for hand dryers and tissue products for use in

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public restrooms and in institutional, commercial and industrial settings. The global tissue market, a significant percentage of that being paper towel products, registered a consumption of 31.5 million tonnes in 2012 (UUtela, 2013). As far as this global market, North America has the highest per capita consumption. On the other hand, around 2 million units of hand dryers were shipped out in 2013 (TMR, 2014). Market research forecasts continued growth in both the tissue and hand dryer segments. At the present time, paper towels dominate the hand drying market. According to a 2009 media report quoting a hand dryer manufacturer, the share of paper towels in the drying market was around 90% at that time (Sterrett, 2009). However, hand dryers are making an increasing foray into the drying market.

In order to assess the environmental impact of products and services, the most widely used tool is Life Cycle Analysis (LCA) otherwise known as Life Cycle Assessment (Guinée, 2001). Using LCA, all material demand, energy requirements and environmental emissions associated with the manufacture, use, transport and disposal phases of a product, through its life cycle, are identified (Guinee et al., 2010; Joshi, 1999). A LCA study can thus be used to compare products and processes so as to identify the better option in terms of environmental performance and thus make better informed decisions (Finnveden et al., 2009; Montalbo et al., 2011).

There is concern that trees have to be felled to produce paper towels leading to a common perception that hand dryers are more eco-friendly. A review of literature shows that only a handful of LCA studies, comparing paper towel and electric hand dryer as hand drying methods, have been published to date (Budisulistiorini, 2007; Dettling and Margni, 2009; Environmental Resources Management, 2001; Montalbo et al., 2011). However, the results from these studies do not allow for a consistent conclusion to be derived as to whether dryer use or paper towel use has a greater life cycle environmental impact. Further, majority of these LCA studies were commissioned by dryer manufacturers and none looked at a product use scenario based in Canada. This paper seeks to add to the existing study base through a comparative LCA case study of two hand drying methods in a university campus setting in Canada and in process, providing an independent assessment of the better method solely from an environmental sustainability point of view.

2. Methodology

LCAs typically include a goal and scope definition, inventory analysis, life cycle impact assessment and an interpretation phase (ISO, 2006a,b). An LCA methodology, in line with ISO14040:2006 and ISO 14044:2006, is adopted in this study. This LCA is carried out using the proprietary LCA software SimaPro® 7 with database support from ecoinvent v2 & US-EI databases available in SimaPro.

2.1. Goal and scope

The goal of this LCA study is to assess and compare the life cycle environmental impact of using either paper towels or a warm air hand dryer which are two available hand drying methods at the University of Guelph (UoG) campus located in Ontario, Canada. For the purposes of this paper, the product system consisting of paper towels and its dispenser unit is termed the dispenser product system. The product system associated with the hand dryer is termed the dryer product system. The scope of this LCA is a cradle to gate system boundary and is applied to the different life cycle stages of the two product systems, right from material and manufacturing, transport of finished products and finally its use on campus at UoG. The end of life disposal and recycling scenarios are excluded under the scope of this study.

2.2. Case study scenario

A hands-under type warm air hand dryer, rated at 1800 watts (W), is compared to a controlled roll paper towel dispensing unit that issues paper towels made from 100% recycled paper. The case study is based on a United States (US) manufacturing scenario for the hand dryer unit, the paper towel dispensing unit, the paper towel rolls as well as for all associated packaging for both the product systems. The electricity grid source mix powering the hand dryer unit during its use phase is based on the 2012 grid scenario in Ontario.

2.3. System boundary

The system boundaries selected in this study are presented in Fig. 1. Under the framed system boundaries, the analysis covers raw material extraction & refining, manufacturing of semi-finished components for the hand dryer as well as for the dispenser unit, manufacturing of the paper product and corrugated board packaging, assembly of the components into the final finished product systems, transportation of product systems to the university campus and lastly, their use phase on campus.

2.4. List of assumptions

The following summarises the key assumptions and scenarios considered in this study:

- Washroom users will not avail of both hand drying methods at the same time.
- Paper towel use intensity is 2 sheets per dry and hand dryer usage is 30 s per dry.
- A five year product lifetime is considered for both the hand dryer and dispenser units during which time there is no deterioration in their operation or any requirement of maintenance.
- Over the considered lifetime of both the hand dryer and dispenser unit, the per annum washroom footfall remains a constant.
- Only one type (100% recycled content, unbleached) of roll paper towel is used as a dispenser consumable.
- Annual consumption of paper towel rolls at UoG translates to consumption with no carry-over inventory, no stub roll waste and no stock damage.
- A simple supply chain scenario is considered without distribution or warehousing hubs.
- Semi-finished products (e.g., machined aluminium die-castings, copper windings) manufactured by sub-suppliers using extracted and refined raw materials, are fed to two assembly plants (one assembly plant for the dispenser product system and another assembly plant for the dryer product system) where they are first converted to finished product components (e.g., electric motor) from which the final products (hand dryer, dispenser unit and paper towel rolls) are assembled and packaged for onward shipment. All the sub-suppliers are assumed to be located within a 250 km radius of the two main assembly plants.
- The entire hand dryer and dispenser installation demand on campus is met using only two delivery runs.
- A single shipment from the assembly factory to UoG provides for an entire five year paper towel demand.

2.5. Functional unit

The functional unit qualifies and quantifies the obligatory properties and performance output that should be associated with the product system under study and is also the central reference unit to which all the other data is normalised (Cooper, 2003; ISO, 2006a,b). The primary goal of both the hand drying systems under study here is to assist washroom users at UoG in achieving a pair of dry hands before leaving the restroom. On this basis, the functional unit for this study is defined as