

## **Sustainable Hand Drying Problem Statement**

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The purpose of this project is to compare the environmental impacts of paper towels versus those of hand dryers on a college campus via life cycle analyses. On a large college campus, paper towels are a significant source of solid waste. According to the United States Environmental Protection Agency<sup>1</sup>, 28.5% of municipal solid waste produced in the United States is paper waste. As a campus hosting over 30,000 individuals daily, the university has a significant impact on the carbon footprint associated with the use of paper towels. Each high traffic flow bathroom studied in this experiment uses approximately 22 rolls of paper towels per week (estimated from raw data collection). The campus evaluated comprises 67 buildings, all which contain bathrooms with paper towel dispensers. Our goal is to quantify the reductions in the university's carbon footprint and solid waste production caused by installing high-speed hand dryers, Dyson Airblades<sup>TM</sup>. The life cycle analyses account for the solid waste, CO<sub>2</sub> emissions, and energy inputs associated with the production, delivery, use, and disposal of paper towels and Dyson Airblade<sup>TM</sup> hand dryers.

## **Project Summary/Background**

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We investigated the environmental impacts of two hand drying systems in a high traffic flow building at the university. Dyson Airblade<sup>TM</sup> hand dryers were installed in one male and female bathroom that containing paper towels. The Dyson Airblade<sup>TM</sup> is an innovative hand dryer choice because of its application of new technologies. It dries more effectively than a standard warm air hand dryer because of the direction of two high speed air jets towards a set of hands inside the cavity of the dryer.

Life cycle analyses for both hand-drying options demonstrate that replacing paper towels with Dyson Airblade™ hand dryers will reduce solid waste and energy outputs associated with transporting the waste to an incineration plant. Life cycle analysis is a method used to analyze potential environmental impacts relative to the product being evaluated<sup>7</sup>. Our approach to conduct life cycle analysis was chosen to give perspective to the general consumer, as well as to compare the two hand-drying systems in the same units. Environmental impacts of production for paper towels and Dyson Airblade™ hand dryers are also considered.

The largest energy costs associated with the Dyson Airblade™ are associated with the power required to start up the hand dryer and keep it running for the duration of a drying period. While the materials in the hand dryers contribute to the carbon footprint of Dyson Airblade™ systems, their effects are minimal in the production and disposal phases of the life cycle<sup>2</sup>.

Inspiration for our study stemmed from previous research performed by Montalbo *et al*<sup>2</sup>. Their study compared seven different hand-drying methods by performing a life cycle analysis on each system. Ultimately, the research determined the Dyson Airblade™ to be the most sustainable mechanism amongst the seven hand drying methods: an aluminum-covered Dyson Airblade™ hand dryer, a plastic-covered Dyson Airblade™ hand dryer, an Excel XLERATOR™ hand dryer, a generic warm air hand dryer, generic cotton roll towels, generic paper towels manufactured from virgin content, and generic paper towels manufactured from 100% recycled content<sup>2</sup>. The MIT group assumed a drying time of 12 seconds at 1,400 watts based on manufacturer's information.

Our team's objective was to analyze the sustainability of the Dyson Airblade™ more practically through independent usage data obtained at our university. We also assessed user attitudes towards hand drying options. We benefited from the support of the university's

Facilities staff and their strong interest to assess feasibility of implementing high-speed hand dryers in high traffic flow bathrooms on campus.

## **Relationship to Sustainability**

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The Sustainable Hand Drying project contributes to the university's Climate Action Plan to reduce greenhouse gas emissions that the university contributes<sup>3</sup>. Prior to this study, Dyson Airblade™ hand dryers were installed only in a newly built, low traffic engineering building. This project influenced the university's Facilities staff to install the high-tech hand dryers in bathrooms on campus that experience high usage during the school week. Because students can use the Dyson Airblade™ on daily, they can become increasingly aware of simple lifestyle actions that will reduce negative environmental impacts. Most students are aware of the obvious proactive initiatives to reducing adverse impacts, including driving more fuel efficient cars and picking up trash in local neighborhoods. Our project creates mindfulness on how the carbon footprint of individuals at the university is influenced by everyday activities such as hand drying.

The work presented here is the first phase of a longer term study. We anticipate collaboration with university staff on placement of signage in the high traffic volume bathrooms. We intend to assess whether signage about the positive environmental impacts we quantified here will influence bathroom patrons to choose the Dyson Airblade™ over paper towels when drying their hands. To date, the project has attracted the attention of students and staff. Quantification of the benefits of the Dyson Airblade™ dryers and their minimal environmental impact likely will result in the installation of more hand dryers on campus.

## Materials and Methods

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*Data collection.* The university's Facilities staff installed one plastic-coated Dyson Airblade™ hand dryer each in male and female bathrooms inside of a high-traffic classroom building (Figure 1). Each dryer was connected to a P4400 Kill A Watt™ power recording meter. The total power use over time for each bathroom was recorded by these meters. Data were collected by two Omron H7EC Backlit compact totalizers. The totalizers counted each time a hand dryer turned on.

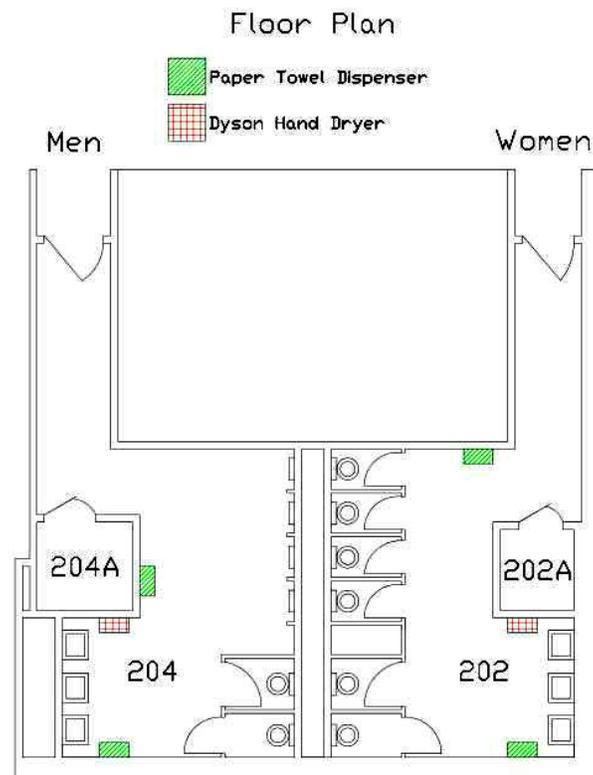
The male and female bathrooms in the high traffic building contain two paper towel dispensers each. One month of paper towel usage data after dryer installation were obtained through the university's Facilities staff and average weekly roll consumption was calculated. One academic year of paper towel use was calculated from this average.

*Design life and functional unit.* The design life of hand-drying options was set equal to five years, the design life of the Dyson Airblade™ hand dryer. The functional unit was a user. Therefore, hand-drying options were compared based on the impact from the number of users over five years. For the Dyson Airblade™ we estimated 205,500 users over five years (use based only on a 30-week academic year). This quantity of users was implemented in sustainableminds.com life cycle software for both hand dryers and paper towels to determine the amount of paper towels that would be used if the Dyson Airblade™ users had chosen paper towels instead. This quantifies helps to determine the reduction of environmental impact a user can have given that they use hand dryers instead of paper towels.

*Life cycle analysis.* Life cycle calculations were performed with the Sustainable Minds database. In this research, four negative environmental impacts were evaluated for each hand drying system: (1) equivalent carbon dioxide or CO<sub>2</sub>e (the global warming potential of

greenhouse gases relative to carbon dioxide<sup>4</sup>), (2) human carcinogens, (3) human toxicity (chemicals that have adverse effects on human health), and (4) millipoints (average environmental impact of the average European over one year is equal to 1,000,000 mPts<sup>5</sup>).

Manufacturing impacts were determined by the material makeup of the plastic-coated Dyson Airblade™ unit as reported by Montalbo *et al.*<sup>2</sup>. The paper towels were assumed to be made up entirely of molded pulp material in calculations.



**Figure 1: Floor plan of high traffic bathrooms post dryer implementation.**

Transportation impacts were calculated using the assumption that a 20 ton truck carries shipments from the paper mill headquarters to the distributor location. An assumption was made that the distributor transported paper towel shipments to the university with a 3.5-7.5 ton truck. The amount of shipments needed over a five year time period was calculated based on paper towel consumption data collected from the university's Facilities staff.

*Disposal.* For this life cycle stage, two scenarios were calculated for the Dyson Airblade™. In the first scenario, all of its components are recycled. In the second scenario, all of its components are disposed of in landfill.

Paper towels were assumed to be incinerated (following the practice in our town). Transportation to the incineration plant was neglected because the relatively small mass fraction contribution of paper towels to the municipal solid waste.

Information obtained from each stage of life was entered into the sustainableminds.com life cycle analysis software to calculate the carbon footprint.

*Cost Analysis.* A comparative cost analysis was calculated in dollars per functional unit for each hand-drying system. The average kWh use per person was calculated from data collection and analyzed with the average cost per kWh at the university<sup>6</sup> to calculate dollars per functional unit for the Dyson Airblade™. The number of paper towel rolls per use was found by assuming that 18 inches of paper towel were utilized per person. This calculation was used with the unit cost of one roll of paper towels to estimate the cost per functional unit for paper towels.

*User attitudes.* We conducted an anonymous survey over two days of users of bathroom facilities in the newly built, low traffic engineering building. It was anticipated that the users were mainly people who worked in the building. Dyson Airblade™ dryers have been an option in the bathrooms since the building was opened in the fall of 2011. The survey asked if the users used paper towels or the Dyson Airblade™.

## Results, Evaluation, and Demonstration

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*User survey.* Approximately 64.6% of the users stated that they chose paper towels over hand dryers. This was a remarkable result. Recall that the survey was thought to include mostly people who had almost two year's experience with the hand dryers. The results of the survey indicate that user acceptance of the high-velocity hand dryers cannot be assumed.

*Life cycle analysis.* Using the Sustainable Minds software, the main environmental impacts of the hand dryer and paper towels were calculated in terms of millipoints (mPts) and kilograms of carbon dioxide equivalents (CO<sub>2</sub> eq kg).

The environmental impact of a Dyson Airblade™ hand dryer, when assumed to be completely disposed of in a landfill, was calculated to be 0.016 mPts per use (i.e., per pair of dry hands). The major impact categories were ecotoxicity (contributing 64.2% of total impacts), human carcinogens (contributing 26.5%), and human toxicity (contributing 8.7%). The carbon footprint was calculated to be 0.0043 CO<sub>2</sub> eq kg per use.

The environmental impact of a Dyson Airblade™, when assumed to be completely recycled at the end of its life, was calculated to be 0.015 mPts per use. The major impact categories were ecotoxicity (contributing 63.0%), human carcinogens (contributing 27.6%), and human toxicity (contributing 8.8%). The carbon footprint was calculated to be 0.0041 CO<sub>2</sub> eq kg per use.

The comparison between the Airblade™ disposed of by landfill and the Airblade™ with recycling shows that recycling slightly decreases the environmental impacts of the machine. If the impacts were extrapolated to the total impacts over the five-year life span, the impacts of the landfilled Airblade™ and the Airblade™ with recycling would be 3,288 mPts and 3,083 mPts,

respectively. The carbon footprint of the Airblade™ disposed of by landfill and the Airblade™ with recycling would be 884 CO<sub>2</sub> eq kg and 843 CO<sub>2</sub> eq kg, respectively. Figure 2 shows the scorecards generated by Sustainable Minds for the two Airblade™ scenarios.

The environmental impact of paper towels was calculated to be 0.079 mPts per use. The total usage was kept at 205,500 for ease of comparison with the Dyson Airblade™. The carbon footprint of the paper towels was calculated to be 0.029 CO<sub>2</sub> eq kg per use. These values are significantly greater than the Dyson Airblade™. The major environmental impacts were ecotoxicity (contributing 23.7%), human carcinogens (contributing 41.0%), and human toxicity (contributing 34.3%). A majority of the impacts result from the transportation of the paper towel shipments. Figure 2 shows the scorecard generated for paper towels next to the scorecard for the Airblade™.

The overall environmental impact of the Dyson Airblade™ compared to paper towels show an improvement of 80%. The carbon emissions would be reduced by 75% by using an Airblade™ instead of paper towels.

The costs were calculated per user for the Dyson Airblade™ and paper towels. The cost per user for paper towels was determined to be \$0.0625 per person. The cost of electricity used from the Dyson Airblade™ was found to be \$0.0003 per user. The cost of the unit is \$1,600 or \$0.00779 per use, giving a total cost of \$0.00809 per use. This results in an 87% cost savings if the Dyson Airblade™ is used instead of paper towels at the university. Impacts and costs are summarized in Table 1.



Figure 2: Life cycle analyses of three hand drying types

**Table 1: Summary of the impacts of costs of three hand drying methods.**

<b>Category</b>	<b>Dyson Airblade™ Recycled</b>	<b>Dyson Airblade™ Disposed</b>	<b>Paper Towels</b>
Carbon footprint (CO <sub>2</sub> eq kg per use)	0.0041	0.0043	0.029
Environmental impact (mPts per use)	0.015	0.016	0.0790
Cost (\$ per use)	0.00809	0.00809	0.0625

## **Conclusions**

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Results of this project indicate that if a patron at the university chooses to use the Dyson Airblade™ over paper towels, they will be reducing their environmental impact and carbon footprint. We also can conclude that the use of the Dyson Airblade™ instead of paper towels will benefit the university financially. However, user survey results indicate that user acceptance of the Dyson Airblade™ is low.

## **Future Work**

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Clearly, the benefits of the hand dryers cannot be accrued if they are not used. Therefore, a second experiment is proposed where signage will be placed inside high traffic flow bathrooms informing patrons of the environmental footprint reduction from Dyson Airblade™ use. The university's sustainability officials and Facilities staff has expressed interest in this second study.

## Works Cited

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