REPORT

Study Prepared for Airdri Ltd. and Bobrick Washroom Equipment Inc.

Streamlined Life Cycle Assessment Study

August 2001

Environmental Resources Management
Eaton House, Wallbrook Court,
North Hinksey Lane
Oxford OX2 0QS
Telephone 01865 384800
Facsimile 01865 384848
Email post@ermuk.com
http://www.ermuk.com

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For and on behalf of Environmental Resources Management
Approved by: SIMON AUMÔNIER
Signed:
Position: TECHNICAL DIRECTOR
Date: 3rd SEPTEMBER 2001

CONTENTS

1 INTRODUCTION

This report summarises the results of the Streamlined Life Cycle Assessment (LCA) Study conducted for Airdri Ltd. and Bobrick Washroom Equipment Inc. by ERM.

The purpose of the study is to provide a comparison of the environmental footprints for two hand drying methods: paper towels and an electric hand air drier as manufactured by Airdri and supplied by Bobrick. The environmental profile was generated by identifying and quantifying the 'cradle-to-grave' environmental consequences associated with the two product systems.

The drier system involves the manufacture and supply of the drier (plus packaging), the consumption of electricity for the drying of hands and the disposal of the drier at the end of its useful life.

The paper towel approach to drying hands requires the manufacture, supply and disposal (at the end of their useful life) of:

- a towel dispenser (plus packaging);
- a bin for disposal of towels (plus packaging);
- bags for use in the bin (plus packaging); and
- paper towels (plus packaging).

The study quantifies the environmental footprint resulting from the production of materials and energy, the disposal of wastes and transport of materials for the two product systems.

The models that have been constructed can be used:

- to provide an indication as to which system places less burden on the environment;
- as a scoping study for further more detailed assessment of the products.

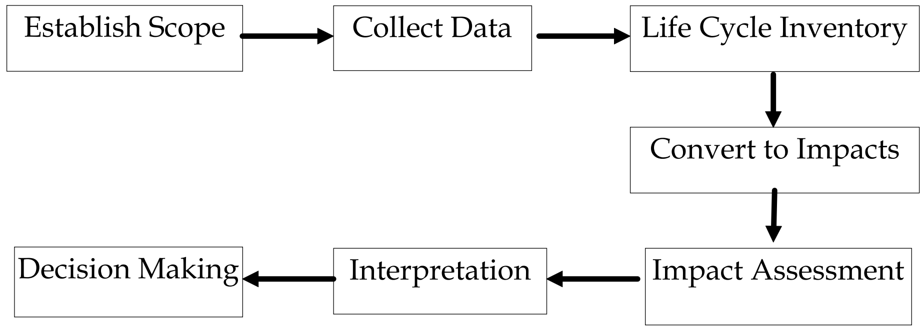
1.1 INTRODUCING LCA

Life Cycle Assessment (LCA) is a standardised technique for measuring and comparing the environmental consequences of providing, using and disposing of a product or a service.

LCAs have a number of interrelated stages: Goal Definition and Scoping, Inventory Analysis (LCI), Impact Assessment and Interpretation.

LCA users attempt to trace back to the environment all of the resources consumed at all stages in the manufacture, use and disposal of products. The methodology considers all of the emissions to air, water and land at each of these stages. In combination, data on each stage provide an inventory of exchanges of substances between the product and the environment associated with the entire life cycle of the product, from the 'cradle to the grave'. A flow chart detailing the LCA process is shown in *Figure 1.1*.

Figure 1.1 ***LCA process***



Impact Assessment is a technical, quantitative process to assess the effects of the environmental burdens identified in the inventory analysis. Impact Assessment consists of three steps; classification, characterisation and valuation.

At the Impact Assessment stage of an LCA a calculation is made of the potential contribution made by each of the environmental exchanges in the Inventory to important environmental effects such as global warming, acidification, photochemical smogs, human- and eco-toxicity, nutrification and the depletion of non-renewable fossil fuel resources.

Classification groups the inventory data into a number of impact categories, eg global warming and ozone layer depletion. Characterisation involves assessing the relative contribution of individual burdens to each impact category. The valuation step assesses the relative importance of the impact categories by applying weighting factors to them.

A streamlined LCA involves limiting the scope of the LCA. By scope we mean the system to be studied, the resolution of the data collected and the range of environmental impacts/issues to be addressed. For example, we can omit life cycle stages if we believe them to be insignificant, we can use generic data instead of collecting system specific data and we can address specific environmental impacts such as the global warming burden for the life cycle if this is a particularly relevant assessment criterion.

1.2 THE JUSTIFICATION FOR USING LCA

For the purpose of comparison and decision making, the best way of considering the advantages of one product over another (assuming they provide the same function) is to compare environmental footprints (cradle to grave) of each product. LCA allows us to do this.

2 GOAL AND SCOPE OF THE LIFE CYCLE ASSESSMENT

The goal of this study is to quantify and compare the environmental profiles of the the paper towel system and the hand air drier system.

Due to resource limitations this study has not been subjected to external peer review.

The scope defines the boundaries of the system to be studied, the data required and any assumptions and limitations.

As this study is a streamlined study, readily available data regarding the production of the materials and electricity have been used. No data has been sourced regarding the production of components for the air drier or the fabrication of the bin and dispenser. Nevertheless, it is expected that these would be insignificant in comparison to the production of the material themselves. A study of washing machines conducted by PA Consulting (1992) for the UK Eco-Labelling Board states that 'machine production has about 5% of the environmental impact of materials production'.

It has been assumed for the purpose of comparison that the drier, bin and dispenser have an average life time of 5 years.

For both systems, the disposal of the equipment has been ignored as the weight of the bin and dispenser is of the same order of magnitude as that of the drier and are made of similar materials (steel). In addition it is expected that the scrap equipment will be recycled at the end of its life.

2.1 THE SYSTEM BOUNDARIES

The systems for the two products are provided graphically in *Figures 2.1* and *2.2*.

For the air drier, the following life cycle stages have been included:

- production of drier materials;
- production of packaging materials;
- assembly of drier parts;
- transport of all materials;
- generation and supply of electricity for drying of hands; and
- disposal of packaging to landfill.

For the paper towel system, the following life cycle stages have been included:

- production of bin and dispenser materials;
- production of bin liners and packaging materials;
- production of paper;
- transport of all materials; and
- disposal of towels, bin liners and packaging to landfill.

Figure 2.1 Drier system

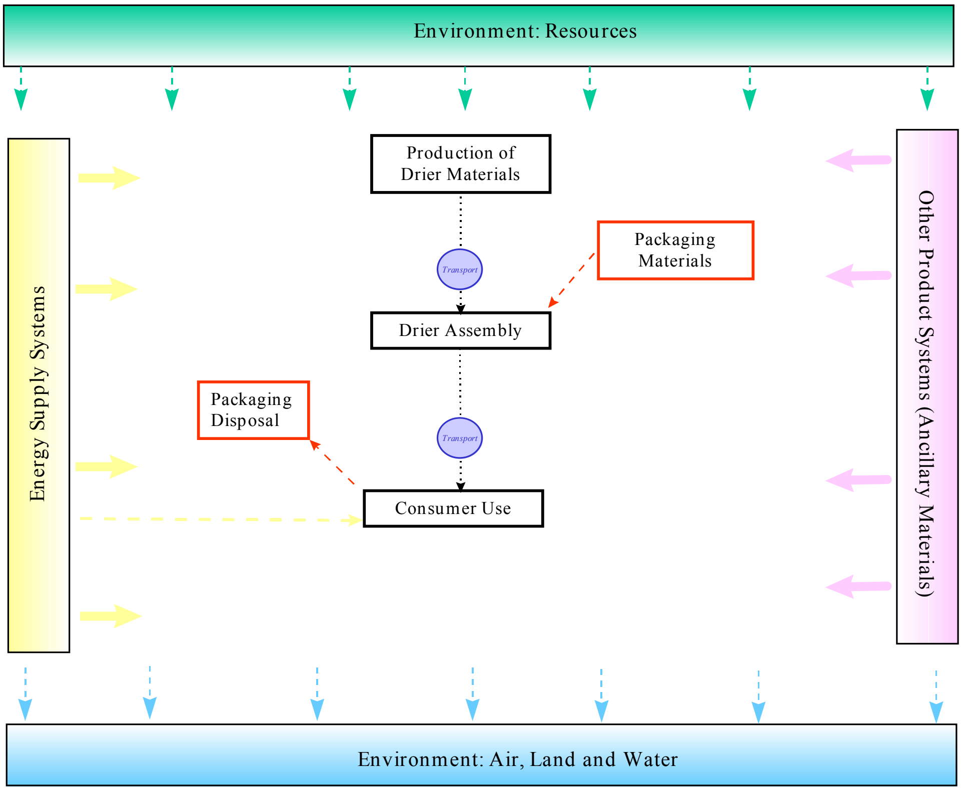
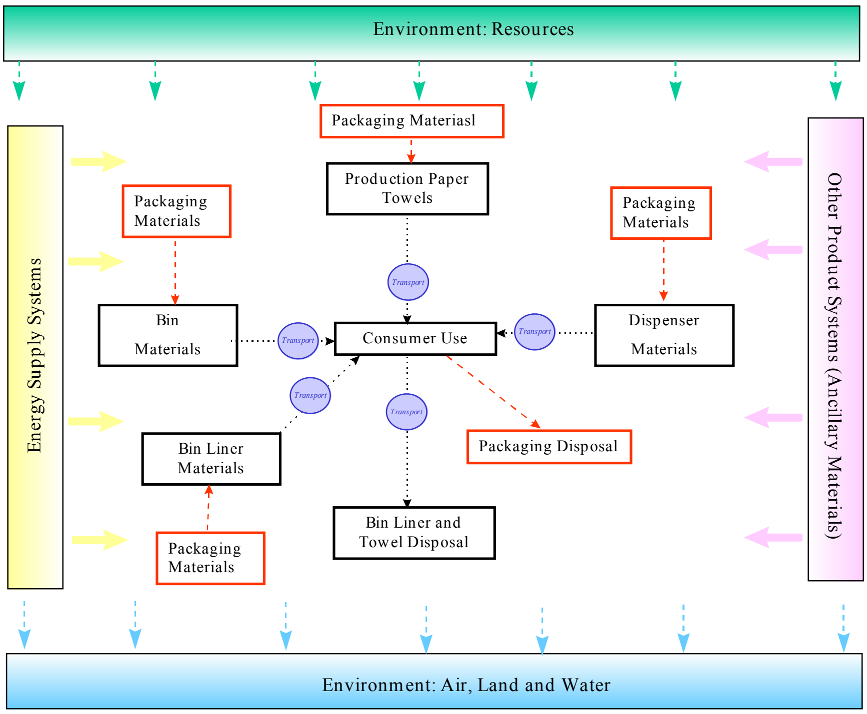


Figure 2.2 Paper towel system



2.2 DRIER SYSTEM

2.2.1 *Drier type*

The hand drier that has been used for the basis of this comparison is the Classic model manufactured by Airdri (B-709 model as supplied by Bobrick).

Table 2.1 details the inventory of materials that are associated with the drier.

Table 2.1 Drier materials

Drier (includes Packaging) Materials	**Weight (g)**
Galvanised Steel	1900
Steel	1125
Al (Recycled)	843
Al	843
Zinc	484
Card	444
Copper	231
wood	190
Nylon	103
Ceramic	91
Polyethylene	54
PBT	40
Other materials	82
Total	6430

2.2.2 *Electricity use during assembly*

Data relating to energy consumed to produce one drier was supplied by Airdri Ltd.

2.2.3 *Electricity consumption during the use stage*

It has been assumed that the drier is used 500 times per week and for an average of 30 seconds per dry. The drier has a power rating of 2.4 kW. This equates to an electricity consumption of 9360 MJ over the 5 year life time.

2.3 PAPER TOWEL SYSTEM

The paper towel system consists of a dispenser, bin, bin liners, paper towels and the associated packaging.

Table 2.2 Towel system materials

Material Input	Weight (kg)	Associated Packaging (Card)
Metal bin	6.2	1
1 Polyethylene bin liner	0.033	0.0016
Dispenser	2.605	0.195
Average wt 1 C-Fold Towel	0.004	0.00018

2.3.1 *Towel type*

For the purposes of this study a 'C-Fold towel' with an average weight of 3.79g has been assumed.

2.3.2 *Dispenser and bin*

A common mild steel dispenser weighing 2.6 kg has been modelled, together with a common mild steel bin weighing 6.2 kg.

Associated with the bin is the daily use of a new polyethylene bag weighing 33g. For the purpose of this study, 5 bags per week have been assumed to be used.

2.3.3 *Life time towel consumption*

For the purposes of this study an equal lifetime and equal number of dries to that of the drier has been assumed.

For each dry it has been assumed that a person uses two paper towels.

2.4 DATA REQUIREMENTS

For the purposes of this study, readily available data have been used to describe the system. With the exception of steel and one of the paper types modelled, the inventory data for materials, energy, transport and waste disposal were sourced from the PEMS4 (1) databases. Life cycle inventory data for steel products were provided by the International Iron and Steel Institute.

Four different systems have been modelled for paper towels, using different databases on then environmental impacts of paper. The only difference between the models is the paper data that has been used. This was done to determine the sensitivity of the towel system to the paper data. One of the paper databases used was created using the SCA Environmental Report, 2000, the other three were created using the databases in PEMS4 (ETH paper, bleached paper and unbleached paper).

(1) Pira Environmental Management System

For the purposes of this comparison, all materials were assumed to be transported an equal distance by road and sea, a total of 1500 km.

All modelling and analysis was conducted using the PEMS4 LCA software tool.

All electricity inputs to the systems were modelled using an average European fuel mix.

2.5 *FUNCTIONAL UNIT*

The functional unit is a measure of the 'service' provided by the product systems. It is used to normalise the environmental effects, allowing comparisons with other periods, systems or scenarios which might provide an identical service. In this case, the functional unit is based on a lifetime of five years for the two systems and the same number of dries, 130,000.

3 ENVIRONMENTAL FOOTPRINT OF THE TWO PRODUCT SYSTEMS

3.1 LIFE CYCLE INVENTORY

The system was described by quantifying all of the resources (materials and energy) consumed, and the products and wastes produced, at each stage in the system under investigation.

A summary inventory for each system is contained in *Annex A*.

3.2 IMPACT ASSESSMENT METHOD

Impact Assessment is a technical, quantitative and/or qualitative process to characterise and assess the effects of the environmental burdens identified in the inventory.

The approach used to conduct the Impact Assessment is known as the Problem Oriented Approach. The data in the inventory were aggregated according to relative contributions made to the following surveyable environmental concerns:

- resource depletion;
- global warming;
- ozone layer depletion;
- acidification;
- nutrification;
- human toxicity;
- ecotoxicity; and
- photochemical smog.

3.2.1 Resource depletion

The classification of resource depletion is limited to non-renewable resources only, i.e. coal, oil, gas and minerals. Resource depletion is calculated by multiplying the amount of extracted resource (kg) by its individual classification factor. The classification factors are calculated by dividing the global oil reserves by the global reserves of the specific resource. The classification results in 'oil equivalents' can then be summed.

3.2.2 Global warming

The gases involved in the greenhouse effect (eg carbon dioxide (CO_2), methane (CH_4), carbon monoxide (CO), nitrous oxide (N_2O), sulphur hexafluoride (SF_6)) all have the property of absorbing energy and emitting thermal infra-red radiation. An increase in the atmospheric concentration of greenhouse gases will change the absorption of infra red radiation in the atmosphere. This may lead to changes in climatic patterns and higher average global temperatures.

Global Warming Potentials (GWP) have been developed by the IPCC (Intergovernmental Panel on Climate Change) and can be used to express the potential contribution of different gases to the greenhouse effect.

The Global Warming Potential (GWP) is a relative parameter that uses carbon dioxide (CO_2) as a reference gas. The emissions of each greenhouse gas are multiplied by their GWP and the system's potential contribution to the greenhouse effect is expressed in a single score by summing the individual contributions.

3.2.3 *Ozone depletion*

Changes in atmospheric ozone will modify the amount of harmful ultraviolet radiation penetrating to the earth's surface with potential effects on human health. For gases that contribute to the depletion of the ozone layer (eg chlorofluorocarbons), ozone depletion potentials (ODPs) have been developed. These can be used to express the potential contribution that these substances make to the depletion of the ozone layer. The ODP uses CFC 11 as a reference substance.

3.2.4 *Acidification*

Acidification results from the deposition of acids that lead to a decrease in the pH, a decrease in the mineral content of soil and increased concentrations of potentially toxic elements in groundwater. These effects are caused by acid rain and the major gaseous pollutants associated with this are sulphur dioxide (SO_2) and nitrogen oxides (NO_x). These are dissolved in rainwater and subsequently deposited. The effects of acid deposition are very site specific and will vary depending on the receiving environment (ie the buffering capacity of the soil and any dilution effects which might occur).

Acidification Potential (AP) factors have been developed for potentially acidifying gases such as SO_2, NO_x, HCl, HF and NH_3. The AP of a substance is calculated on the basis of the number of hydrogen ions that can be produced per mole of a substance, using SO_2 as the reference substance.

3.2.5 *Ecotoxicity*

The ecotoxicity effect scores represent the quantity of aquatic or terrestrial ecosystem potentially polluted to the maximum tolerable concentration. It must be stressed that classification factors for ecotoxicity are still in the early stages of development and that, in practice, emissions may be dispersed and diluted below a 'no effect' level.

The inventory output burdens categorised under this environmental burden include releases to water of metals, non metals and organic compounds.

3.2.6 *Nutrification*

This is caused by the addition of nutrients (eg NO_x, nitrates, phosphates and ammonia) to a soil or water system that leads to an increase in biomass. Any nutrient can have a nutrifying effect, however nitrogen and phosphorous are the most important. Those substances that have the potential for causing nutrification are aggregated using nutrification potentials (NPs) which are a measure of the capacity to form biomass compared to phosphate (PO_4^{-3}).

There are various issues surrounding this category and, as with acidification, the impact of pollutants will depend on the sensitivity of the receiving environment.

3.2.7 *Human toxicity*

The human toxicity effect score represents the potential for human body weight to be contaminated up to the maximum acceptable limit. It must be stressed that classification factors for human toxicity are still in the early stages of development and that, in practice, emissions may be dispersed and diluted below a 'no effect' level and an unknown fraction (less than one) will actually be taken in by humans.

The inventory output burdens categorised under this environmental burden include releases of metals to air and water, organic compounds to water, volatile organic compounds, nitrogen oxides, ammonia and sulphur dioxide.

3.2.8 *Photochemical Smog*

Low level smog contains irritants that can adversely affect human health. Photochemical oxidant formation potential (POCP) factors have been developed for substances (VOCs, CFCs) that contribute to the formation of photochemical oxidants/smog. The POCP is a measure of the capacity to form ozone in the lower atmosphere using ethylene as the reference substance.

3.3 *IMPACT ASSESSMENT RESULTS*

The figures in *Table 3.1* are the potential contributions from the life cycle in each of the impact categories for the towel and drier systems. Though energy consumption is not an environmental impact it has been included in the table for the reader's interest.

Table 3.1 Impact burden for drier and towel systems

Impact Category	Drier	Paper Type 1	Paper Type 2	Paper Type 3	Paper Type 4	Towel: Average Paper
Resource depletion (kg Oil equiv.)	1780	800	594	424	476	574
Global Warming (CO_2 equiv.)	1607	4330	2187	5574	6289	4595
Acidification (kg SO_2 equiv.)	10.2	12.4	15.3	12.4	15.3	13.8
Ecotoxicity (Aquatic m^3)	0.052	0.104	0.079	0.050	0.064	0.07
Human Toxicity (kg/kg)	15.7	24.1	27.2	23.9	22.8	24.5
Nutrification (kg PO_4 equiv.)	1.2	1.7	0.9	1.4	1.6	1.38
Ozone depletion (kg CFC 11 equiv.)	0.0003	0.0016	0.0009	0.0002	0.0002	0.00
Smog (kg ethylene equiv.)	0.4	3.0	1.9	4.6	2.2	2.94
Energy MJ	*35999*	*38527*	*34167*	*76079*	*87084*	*58964*

The drier system performs better than the average paper towel systems with the exception of resource depletion (all the paper towel systems perform better).

From *Table 3.1* it can be see that a drier, over its life time, will result in a global warming burden of 1.6 tonnes of CO_2. This is an equivalent burden to that associated with a car travelling 5 100 km. Over the same period, the use of paper towels would result in an average CO_2 burden of 4.6 tonnes. This is an equivalent burden to that associated with a car travelling 14 500 km.

From *Table 3.1* it can be seen that a drier over its life time will result in a acidification burden of 10.2 kg of SO_2. This is an equivalent burden to that associated with a car travelling 5000 km. Over the same period, the use of paper towels would result in a average burden of 13.8 kg of SO_2. This is an equivalent burden to that associated with a car travelling 6700 km.

3.3.1 *Drier system*

For the drier, by far the largest contributor to the environmental footprint is the generation and supply of electricity, see *Table 3.2*. This table shows that the environmental profile of the drier is dependent on the quantity and nature of electricity used. By using European average data for electricity generation and supply, local and national variations have been ignored. There is wide variation in the generating methods of countries and these variations would affect the results.

As the average European data is pre 1997 it is reasonable to expect the environmental burdens associated with electricity to reduce in the coming years with the growing use of renewable energy and improvements in generating efficiency.

Table 3.2 Percentage contribution of electricity use to each impact burden

Impact Category	Drier Electricity Use (%)
Resource Depletion	69
Global Warming	98
Acidification	98
Ecotoxicity	98
Human Toxicity	95
Nutrification	99
Ozone Depletion	98
Smog	97

3.3.2 *Paper towel system*

For the paper towel system, the largest contributors to the environmental footprint are the production of the paper for the paper towels, the production of polyethylene associated with the plastic bin bags, the disposal of the paper towels and the transport of materials, see *Table 3.3*. The bin, dispenser materials and their transport have not been included in the table as they contribute less than 0.5% of the burden in each impact category.

Table 3.3 indicates that assumptions and limitations associated with the data related to these stages of the life cycle have significant implications for the environmental profile of the paper towel system.

As waste paper towels are not considered suitable for recycling, the choice of landfill as the disposal route is reasonable considering that landfill is the main waste disposal route in both the UK and USA. In the UK, USA and mainland Europe incineration is playing an increasing role in waste disposal. Incineration of paper towels would result in different environmental burdens. Of particular note would be the reduction in greenhouse gas emissions associated with methane emissions from the waste disposal to landfill.. However, incineration would result in larger releases of species with an impact on air quality.

The transport assumptions made are considered to underestimate the environmental burden as the distances are conservative. Road transport also assumed a 40 tonne truck, which is significantly more efficient for moving material than the smaller capacity vehicles that might be used in practice. In addition, a 100% utility has been assumed for transport, where in practice, half or even empty loads could be expected.

Table 3.3 *Percentage contribution of life cycle stages to each impact for the 'Paper Type 1' towel model*

Impact Category	Bin Liner Materials (%)	Towel Production: Paper Type 1 (%)	Landfilling of Paper Waste (%)	Transport (%)
Resource depletion (Oil equiv.)	12	73	0	12
GWP (CO_2 equiv.)	1	59	37	3
Acidification (kg SO_2)	6	76	0	14
Ecotoxicity (Aquatic m^3)	27	60	1	10
Human Toxicity (kg/kg)	3	78	1	15
Nutrification (kg PO_4)	4	78	2	13
Ozone depletion (kg CFC 11)	0	88	0	10
Summer Smog (kg ethylene)	12	60	18	9

3.3.3 *Comparison*

The 'value' of each impact contribution can be assessed by converting actual scores into a scale of 0 - 1, where 1 is the worst performance and 0 the best. This simplifies the impact assessment values whilst retaining the cardinal nature of the data and allowing performance against all criteria to be placed on a common scale. The normalised data is presented in *Table 3.4*. Note that the unit is now 'value' for each criterion. *Figure 3.1* is a graphical representation of *Table 3.4*. If we were to assume that each impact is of equal importance, then the total (*Table 3.5*) for each model provides a single score for environmental performance. On this basis, the drier outperforms the paper towel system as it has a lower total score.

Figure 3.1 *Impact assessment comparison*

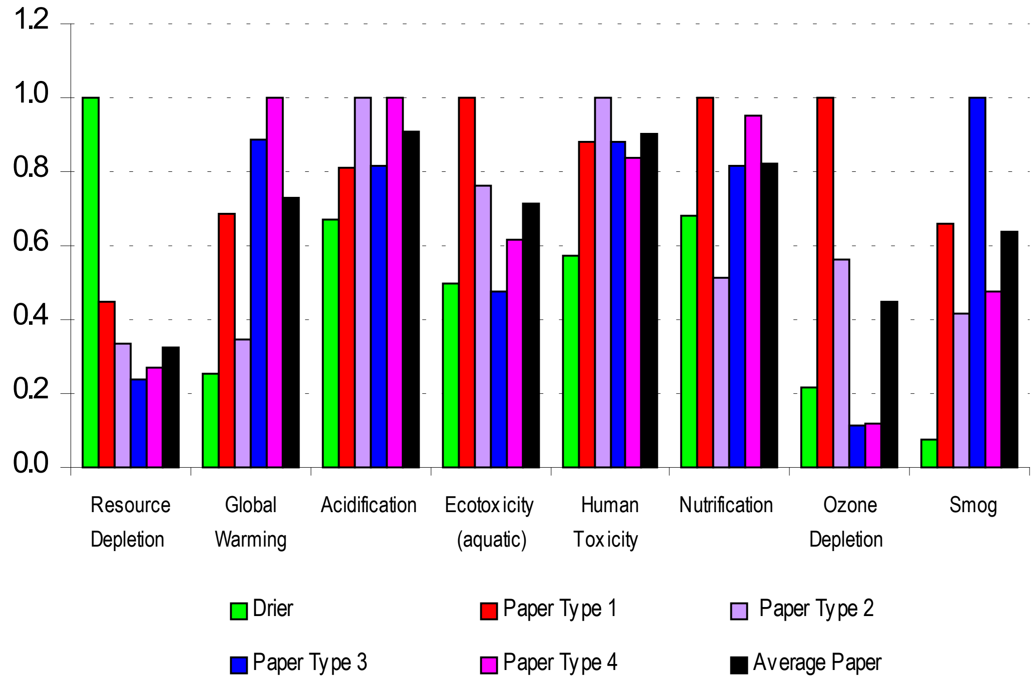


Table 3.4 **Normalised impact data**

Impact	Drier	Paper Type 1	Paper Type 2	Paper Type 3	Paper Type 4	Average Paper
Resource Depletion	1.00	0.45	0.33	0.24	0.27	0.32
Global Warming	0.26	0.69	0.35	0.89	1.00	0.73
Acidification	0.67	0.81	1.00	0.81	1.00	0.91
Ecotoxicity (aquatic)	0.50	1.00	0.76	0.48	0.62	0.71
Human Toxicity	0.58	0.88	1.00	0.88	0.84	0.90
Nutrification	0.68	1.00	0.51	0.82	0.95	0.82
Ozone Depletion	0.22	1.00	0.56	0.11	0.12	0.45
Smog	0.08	0.66	0.42	1.00	0.48	0.64
Total	**3.98**	**6.49**	**4.94**	**5.22**	**5.26**	**5.48**

By using different paper databases, we have shown that, on a equal weighting basis, the choice of paper does not affect the overall performance of the towel system in comparison with the drier.

3.4 VALUATION

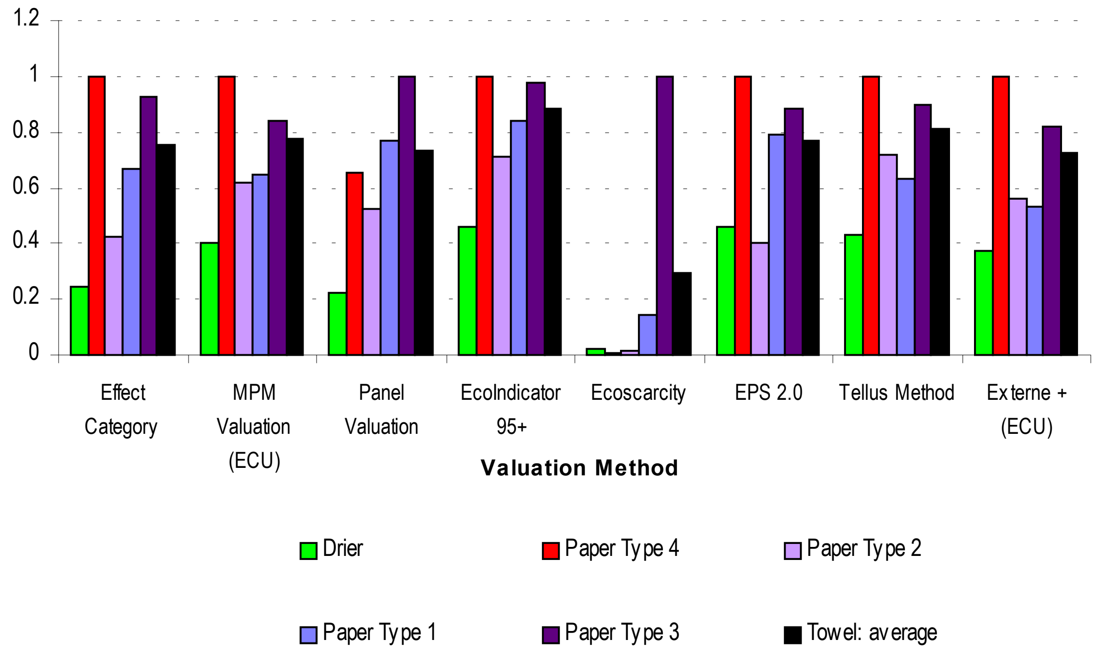
Valuation rates the importance of the different impact categories against each other. This allows the individual impact groups to be compared (and summed) and conclusions to be drawn on which are most significant.

The development of valuation methods is still in its early stages and fraught with controversy. It is unlikely that a single standard valuation method can be developed as differences in the value judgement of individuals and governments will always exist and are quite legitimate.

The desirability of conducting the valuation stage is often questioned. It is argued that, because of its lack of a scientific basis and the need for value judgements, it is an unreliable foundation on which to base a decision. It is also argued that a single figure is an over simplification of a complex subject and may be misused. However, in order to draw any overall conclusion from the vast majority of comparative studies some form of valuation/weighting between impact areas is likely to be necessary. At present it is generally left to the decision maker to weight between the various impact areas.

The PEMS4 software tool allows the user to apply some valuation techniques. *Figure 3.2* shows how the product systems perform with regard to the valuation techniques contained in PEMS. The valuation techniques Ecoscarcity, EPS2.0 and the Tellus are common methods (these three techniques are briefly explained below). Although the results have been normalised to allow comparison on the same scale, no comparison of values can be made between the different valuation techniques. *Figure 3.2* shows that the drier system performs better than the average towel system for all the valuation techniques. The drier system performs better than the towel systems for 6 of the valuation methods. For the Ecoscarcity valuation method, two of the paper towel systems performs better than the drier system, and for the EPS 2.0 valuation method, one of the towel systems performs better than the drier system.

Figure 3.2 *Valuation comparison*



3.4.1 *Ecoscarcity (Sweden)*

This is a valuation system where emissions are multiplied by ecofactors which are calculated from the total yearly consumption of a given flow in a specific area and the maximum acceptable yearly flow for the same area.

3.4.2 *EPS 2.0*

This is a valuation method, but part of it can be described as classification and characterisation. It is based on willingness to pay to restore five 'safeguard subjects' to their normal status. These safeguard subjects are biodiversity, production capacity, human health, resources and aesthetic values. Emissions are then valued according to their estimated contribution to the changes in the safeguard subjects.

3.4.3 *Tellus method*

This methodology was developed at the Tellus Institute in Boston in 1992. It is based on the investment that society has to make to meet policy objectives and environmental standards. It is basically a valuation system, however parts can be described as characterisation. The valuation part of the system is based on the pollutants' prices. The data used was obtained from the LCA Nordic reports.

3.5 SENSITIVITY ANALYSIS

The key assumption that a person will use two towels for each dry needs to be assessed as this has the greatest influence on the results for the paper towel systems. *Table 3.5* presents the impact burdens if one paper towel per dry was to be used.

The figures in *Table 3.5* are the potential contributions from the life cycle in each of the impact categories for the towel and drier systems. Though energy consumption is not an environmental impact, it has been included in the table for the readers' interest.

Table 3.5 Impact burden for drier and towel systems

Impact Category	Drier	Paper Type 1	Paper Type 2	Paper Type 3	Paper Type 4	Towel: Average Paper
Resource depletion (kg Oil equiv.)	1780	444	341	258	281	331
Global Warming (CO_2 equiv.)	1607	2198	1127	2824	3107	2314
Acidification (kg SO_2 equiv.)	10.2	6.6	8.0	6.7	8.4	7.4
Ecotoxicity (Aquatic m^3)	0.052	0.064	0.052	0.039	0.048	0.05
Human Toxicity (kg/kg)	15.7	12.5	14.1	12.7	12.4	12.91
Nutrification (kg PO_4 equiv.)	1.15	0.88	0.47	0.73	0.83	0.73
Ozone depletion (kg CFC 11 equiv.)	0.00034	0.00078	0.00044	0.00010	0.00010	0.00
Smog (kg ethylene equiv.)	0.36	1.69	1.12	2.47	1.28	1.64
Energy MJ	36000	20229	18049	39068	43627	30243

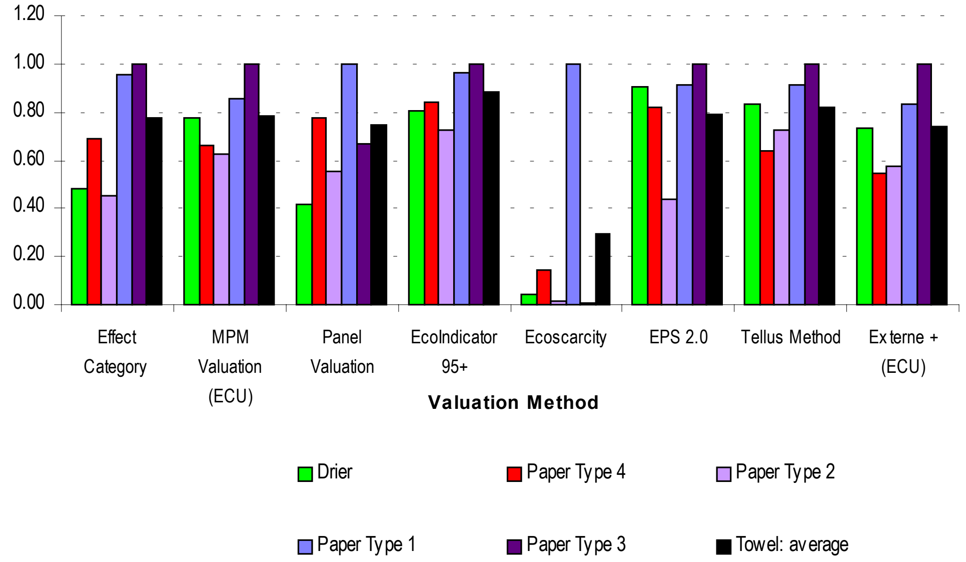
The 'value' of each impact contribution has been assessed by converting actual scores into a scale of 0 - 1, where 1 is the worst performance and 0 the best. This simplifies the impact assessment values whilst retaining the cardinal nature of the data and allowing performance against all criteria to be placed on a common scale. The normalised data is presented in *Table 3.6*. Note that the unit is now 'value' for each criterion. If we were to assume that each impact is of equal importance then the total (*Table 3.5*) for each model provides a single score for environmental performance. On this basis, the drier performs less well than the paper towel systems as it has a lower total score.

Table 3.6 Normalised impact data

Impact	Drier	Paper Type 1	Paper Type 2	Paper Type 3	Paper Type 4	Average Paper
Resource Depletion	1.00	0.25	0.19	0.14	0.16	0.19
Global Warming	0.52	0.71	0.36	0.91	1.00	0.74
Acidification	1.00	0.64	0.79	0.66	0.82	0.73
Ecotoxicity (aquatic)	0.81	1.00	0.81	0.60	0.74	0.79
Human Toxicity	1.00	0.80	0.90	0.81	0.79	0.82
Nutrification	1.00	0.76	0.41	0.64	0.72	0.63
Ozone Depletion	0.43	1.00	0.57	0.12	0.12	0.45
Smog	0.15	0.68	0.45	1.00	0.52	0.66
Total	**5.90**	**5.84**	**4.47**	**4.88**	**4.87**	**5.02**

Figure 3.7 shows how the product systems perform with regard to the valuation techniques contained in PEMS. The valuation techniques Ecoscarcity, EPS2.0 and the Tellus method are common methods. Although the valuation techniques apply weightings to the different impact categories. The results have been normalised to allow comparison on the same scale, no comparison of values can be made between the different valuation techniques. On the basis of one towel per dry, *Figure 3.7* shows that no conclusion can be drawn as to which drying method is preferred on the basis of environmental impact.

Figure 3.7 Valuation comparison



With regard to the drier system, the most important assumption is that the drier will be used for 30 seconds per dry. This is a longer drying time than specified by the manufacturer. The manufacturer specifications state a 20 second drying time. If the specified drying time had been used, the environmental impact burdens would be reduced by approximately a third, with the exception of resource depletion. To err on the side of caution, and in the absence of real data, a 30 second drying time was assumed.

It is difficult to argue the case for one towel per dry as experience and logic would suggest it is greater than one. Bobrick Washroom Equipment Inc. estimate 2.5 towels per dry.

4 CONCLUSIONS

The streamlined study shows that the use of hand air driers results in a smaller environmental footprint than the use of paper towels, though this is based on a number of assumptions such as the use of two paper towels per dry and the use of the hand air drier for an average of 30 seconds per dry.

Due to the influence that the number of paper towels consumed and the drying time have on the results of the study, it is our recommendation that research is carried out to determine average consumption of towels and the average drying time (for hand air driers) per dry.

Though this study is not definitive, it does suggest that, with regard to environmental performance, paper towels should not be chosen in preference to the hand air drier modelled in this study.

The use of the drier results in lower global warming, acidification, ecotoxicity, human toxicity, nutrification, ozone depletion and photochemical smog burdens.

The use of paper towels results in a lower resource depletion burden than the use of the drier.

The use of paper towels results in double the global warming burden when compared to the use of the hand air drier.

A drier over its life time will result in a global warming burden of 1.6 tonnes of CO_2. This is an equivalent burden to that associated with a car travelling 5 100 km. Over the same period the use of paper towels would result in an average CO_2 burden of 4.6 tonnes. This is an equivalent burden to that associated with a car travelling 14 500 km.

The results of this study are dependent on the assumptions made. Of significance is the drying time, the electricity database used, the number of towels used per dry, transport steps and the disposal paper wastes.

Annex A

Summary Inventory

Table A.1 Summary inventory for systems modelled

Burden	Drier	Towel: Paper Type 2	Towel: Paper Type 1	Towel: Paper Type 3	Towel: Paper Type 4	Towel: Average Paper
Input (kg unless stated)						
energy biofuel (MJ)	396.4	13728.4	1592.2	1543.5	1543.6	4601.94
energy biotic (MJ)	1.6					0.00
energy fossil (MJ)	25081	23184	54721	87555	99527	66246.80
energy hydro (MJ)	2269	534	862	221	314	482.74
energy nuclear (MJ)	10620	2892	4033	541	749	2053.60
gas reserves	60	108	79	59	67	78.28
oil reserves	88	263	489	269	307	332.07
coal reserves	831	280	322	63	86	187.93
mineral reserves	42.44	54.41	49.08	30.48	70.17	51.03
water in	69160	38438	71970	58796	79442	62161.40
Output (kg unless stated)						
acetaldehyde	0.00	0.00	0.00	0.00	0.00	0.00
As	0.00	0.00	0.00	0.00	0.00	0.00
CFC (unspecified)	0.00					0.00
CO	0.42	2.35	6.77	27.26	31.54	16.98
CO_2	1506.2	844.5	2983.5	4279.4	4993.1	3275.12
dioxin	0.00	0.00	0.00	0.00	0.00	0.00
H_2S	0.00	0.04	0.03	0.03	0.03	0.03
halides	0.30	0.15	0.13	0.02	0.26	0.14
HC (unspecified)	0.00	1.30	1.30	1.30	1.30	1.30
HC excl CH_4 (unspecified)	0.70	2.21	3.71	1.02	1.52	2.12
metals (unspecified)	0.00	0.00	0.00	0.00	0.00	0.00
methane	3.98	63.50	64.03	61.55	61.61	62.67
N_2O	0.02	0.03	0.01	0.00	0.00	0.01
NH_3	0.01	0.00	0.00	0.00	0.00	0.00
Ni	0.00	0.00	0.00	0.00	0.00	0.00
Nox	3.38	5.64	8.72	10.19	11.94	9.12
other (air)	0.03	0.08	0.07	3.75	16.90	5.20
other metals (air)	0.09	0.07	0.04	0.01	0.01	0.03
other VOC	0.10	0.16	1.04	6.54	0.03	1.94
Pb	0.00	0.00	0.00	0.00	0.00	0.00
SO_2	7.57	11.08	6.04	5.17	6.78	7.27
TSP	2.79	3.41	3.98	11.41	14.13	8.23
VOC	4.78	67.17	70.46	71.86	66.12	68.90
AOX	0.00	0.00	0.00	0.00	0.00	0.00
BOD	0.00	0.96	1.38	0.62	0.62	0.89
COD	0.01	4.29	9.08	1.53	1.53	4.11
acid as H+ (waterborne)	0.00	0.00	0.00	0.00	0.00	0.00
Cr (unspecified) (waterborne)	0.00	0.00	0.00	0.00	0.00	0.00
metals (unspecified) (waterborne)	0.00	0.01	0.01	0.02	0.03	0.02
metals (water)	5.52	6.12	9.97	1.40	1.45	4.73
N (waterborne)	0.01	0.05	0.16	0.04	0.04	0.07
nitrogen (organic) (waterborne)	6.60	0.00	2.23	0.00	0.00	0.56
non metals (water)	14.01	11.01	17.48	2.60	4.86	8.99
oils & greases (waterborne)	0.08	0.21	0.38	0.04	0.05	0.17
organic (water)	0.12	0.47	0.69	0.08	0.09	0.33
P (waterborne)	0.00	0.00	0.01	0.00	0.00	0.00
Unspecified (water)	0.74	1.37	4.65	16.20	31.74	13.49
water out	69757	39006	75351	60375	81441	64043.43
oils	0.0	0.0	0.0	0.0	0.0	0.01
open loop outputs	0.0		98.2	729.7	455.2	320.79
solid waste	1.4	456	1247	3210	3694	2151.80
landfill (dm3)	0.5	1136	1190	1561	1782	1417.24