



Sustainability Case Study

Electric Appliances

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Summary

This short case study compares the environmental, economic, and social aspects of a local choice: that of hand dryers in the washrooms of a small company.

This resource is divided into two sections: a handout to be used with students in the classroom and an example assessment. There is also an associated lecture presentation.

Referenced websites were accessed at the time of the first publication date.

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Which hand dryer?¹-- Handout

The proposal

Employers in most Nations are required by law² to provide hygienic hand-washing facilities and towels or other suitable means of hand drying. Industry statistics suggest a probable duty cycle of four dries per person per day. What is the most sustainable way to provide this drying? It is not just a case of choosing the one using the least energy or with the lowest carbon footprint. There are issues of economics, maintenance, hygiene and user acceptance, which, if ignored may compromise the process.

Initial facts

How do you like to dry your hands? The images on the cover show the usual methods (add, if you wish, wiping hands on trousers). Table 1 lists approximate performance and price.

Table 1: Hand dryers and their characteristics

| Characteristics | Drying Cloth | Paper towels | Slow electric dryer | Fast electric dryer |
|------------------------------|---|--|--|---------------------------------|
| Power, kw | 0 | 0 | 2.55 | 1.6 |
| Drying time, sec | 10, if cloth is dry | 10 | >35 | 12 |
| Fixture cost | £3 per unit | £25 | £140 | £700 |
| Fixture weight and materials | Cotton, 0.15 kg | Injection molded ABS, 1.3 kg | Die cast aluminum, copper, iron, plastics, 6.4kg | See bill of materials, 14 kg |
| Consumables | Washing, if changed daily: £40 per cloth per year | Paper, £6.50 and 3.2kg per thousand towels | Electric power: £0.12 per kW.hr | Electric power: £0.12 per kW.hr |

A small company with 150 employees has seven washrooms (two each for men and women plus one equipped for disabled) and two kitchens areas. Each of these has one hand dryer. The company asks for a “sustainability” reassessment to guide the best choice of dryer based on cost, employee preference and environmental impact. Two of the four options have already been eliminated: the drying cloth (unhygienic) and the slow electric dryer (far too slow). So the competition is between paper towels and high-speed electric dryers. The choice is not immediately obvious, as the this pair of newspaper headlines shows:

“Ditch the hand dryer: Paper towels are more hygienic because they remove more germs³” Daily Mail, 5 June 2013. The UK Newspaper condemns electric hand dryers.

“Paper towels least green way of drying hands, study finds⁴” The Guardian, Friday 11 November 2011. Paper towels found to generate 70% more carbon emissions than the newest technology

1 LCA for hand driers <http://msl.mit.edu/publications/HandDryingLCA-ExecutiveSummary.pdf>

2 The Health and Safety at Work etc. Act 1974 and subsequent amendments

<http://www.legislation.gov.uk/ukxi/1992/3004/contents/madev>

3 <http://www.dailymail.co.uk/health/article-2335811/Ditch-hand-dryer-Paper-towels-MORE-hygienic-remove-germs.html>

4 <http://www.guardian.co.uk/environment/2011/nov/11/paper-towels-drying-hands-energy>

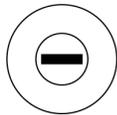
This resource follows the five-step method, which is simply explained below and explained in detail elsewhere.

- What is the prime objective? What is its scale and timing? What is the functional unit?
- Who are the stakeholders and what are their concerns?
- What facts will be needed to enable a rational discussion of the proposal?
- What, in your judgment, is the impact of these facts on Natural, Manufactured, and Social Capitals?
- Is the proposal a sustainable development? Could the objective be better met in other ways?

Where can Granta EduPack help with Fact Finding?



The **Materials data-table** has records for the materials of which the dryers are made and for consumables-- in this case, paper. The records include data for price, embodied energy, carbon and water footprints, and recycle fraction.



The **Regulations data-table (Level 3 Sustainability)** includes records for Health and Safety regulation, specifically mentioning provision of workplace hand-washing and drying facilities.



The **Eco Audit Tool** allows for a fast comparison of the carbon footprint of the alternative hand dryers.



The **Nations of the world data-table (Level 3 Sustainability)** contains data for the cost and carbon footprint of domestic electricity for each nation.



The **Graph facility of Granta EduPack** allows data to be plotted as property charts, annotated, and saved to Word Documents.

Which Hand Dryer?-- Example of Assessment

The number of the sections corresponds to that of the 5 steps of the analysis. Granta EduPack databases help with fact-finding in ways described in the handout for this case study.

Step 1: the objective, size, time scale, and functional unit

- **Objective:** to provide acceptable, hygienic hand-drying at lowest environmental impact and cost.
- **Size scale:** a company with 150 employees each requiring 5 dries per day for 230 working days per year gives 172,500 dries per year, distributed among 5 dryer units, thus 34,500 dries per unit per year.
- **Time scale:** a decision is wanted now
- **Functional unit:** 1000 pairs of dried hands



Step 2: stakeholders and their concerns

Makers, providers, users, and regulators of the hand dryers are all stakeholders



Table 2: Stakeholders

| Stakeholders | Concerns |
|----------------------------------|---|
| Health authorities | Local authorities have a duty to monitor hygiene in the workplace |
| Environmental campaigners | Wood demanded for paper towels and the volume of waste and the carbon release on disposal |
| Manufacturers of hand dryers | Capturing market share and building customer satisfaction. Defending the environmental and health credentials of their products. |
| Providers of washroom facilities | Minimizing cost while meeting statutory requirements for hygienic hand washing |
| Users with wet hands | Speed, hygiene, convenience, and flexibility (ability to dry face as well as hands). Secondary use of paper towels (as a serviette with lunch, dealing with spills) valued. |

Comment: here we have the typical conflicts associated with proposals for sustainable development: those between cost, environmental impact, health, and personal convenience. Research will be needed in the Fact finding step to establish the relative material and energy demands and the relative eco-impact and cost per functional unit-- meaning the drying of one pair of hands.

Step 3: fact finding⁵

Materials. The paper towel dispenser uses only mild steel sheet, enamel, and paper. The high-speed dryer has stainless steel shell and a microprocessor-controlled brushless digital motor. The appendix lists an approximate bill of materials for each.



Environment⁶. We assume (based on monitoring use in the Company) a product life of 10 years and a duty cycle of 24,500 dries per year per hand drier.

The paper dispenser, weight 1.3kg, is made of injection molded ABS. An eco-audit gives a carbon footprint of 6.4kg for materials and manufacture, negligible when pro-rated over the life of the dispenser. Paper, even when

⁵ <http://msl.mit.edu/publications/HandDryingLCA-Report.pdf>

⁶ <http://www.exceldryer.com/PDFs/LCAFinal9-091.pdf>

recycled and despite being sourced from nature, has a net carbon footprint of approximately 1.1 kg CO_{2,eq}/kg, because the energy required to process it, so the 2000 sheets (weight 6.4kg) required for 1000 dries has a carbon footprint of 7 kg CO_{2,eq}.

The power for the high speed dryer is sourced from the national grid. The electric dryer takes 12 seconds per dry, consuming (12/3600)x1.6x1000=5.3kW/hrs. If the grid is supplied by gas-fired power stations with European-average emissions of 0.5kgCO_{2,eq}/kW.hr the carbon footprint becomes 2.7 CO_{2,eq} per 1000 dries. The dryer itself is of sophisticated design with high speed motor and electronic control. There is a carbon footprint associated with its manufacture, to be pro-rated over the life of the dryer. An eco-audit based on the bill of materials in the appendix gives 220 kgCO_{2,eq}.

Economics. Paper towels cost £6.50 per 1000. If, on average, drying a pair of hands uses 2 towels, the cost per 1000 dries is £13 or £17. The fixture costs per 1000 dries pro-rated over the use life is negligible.

The electric dryer takes 12 seconds per dry, consuming (12/3600)x1.6x1000=5.3 kW.hrs. Domestic electricity costs £0.12 per kW.hr., giving a power cost of 5.3x0.12=£0.64 per 1000 dries. The fixture cost, pro-rated over 24,500 dries per year over 10 years is £2.86 per 1000 dries. Total cost (neglecting servicing) is £3.00 per 1000 dries.

The totals are summarized in Table 1. Like the carbon footprints, they are sensitive to the intensity of use. If the number of dries per dryer per year is doubled, the cost per 1000 dries using paper towels is unchanged, that using the high speed dryer falls to £2.1 per 1000 dries.

Table 1: Cost and Carbon per 1000 dries*

| <i>Item</i> | <i>Paper Towels</i> | <i>Hi-speed dryer</i> |
|---|------------------------------|--------------------------------|
| Cost of equipment | £25 | £700 |
| Cost, equipment, per year per 1000 dries | £0.02 | £0.41 |
| Cost of consumables and electrical power per 1000 dries | £13 | £2.2 |
| TOTAL COST per 1000 dries | £13 | £2.6 |
| CO ₂ footprint of equipment | 6.4 kgCO _{2,eq} | 220 kgCO _{2,eq} |
| CO ₂ footprint of equipment per 1000 dries | 0.02 kgCO _{2,eq} | 0.64 kgCO _{2,eq} |
| CO ₂ footprint, consumables and electricity per 1000 dries | 7 kgCO _{2,eq} | 2.7 kgCO _{2,eq} |
| TOTAL CO₂ footprint per 1000 dries | 7 kgCO_{2,eq} | 3.4 kgCO_{2,eq} |

*The capital cost of equipment has been amortized over 100 years. Assuming 0.5 kgCO₂/kW.hr. and £0.12/kW.hr; 2 paper towels per dry, carbon footprint of paper 1.1 kg/kg.

Legislation. Most Nations have Workplace Health and Safety laws that require provision of washroom with hand drying facilities in public places or places of work – the EU Workplace Health and Safety Directive (89/391/EEC) and the US Occupational Safety and Health Act of 1970 are examples. The laws set standards for maintenance and hygiene. Government inspectors have the power to fine or close the workplace or institute if the regulations are not met.

Society: hygiene and convenience. A dryer that takes too long to dry provokes users to see other ways to finish the job (toilet paper or wiping hands on trousers, for instance). Moisture left on partially-dried hands makes the spread of bacteria more likely^{7,8}. This was the reasoning that eliminated two of the original four drying methods, but is not an issue here: the two remaining methods take the same short time.

Does this make them equally acceptable? Interviews suggest otherwise. Electric dryers dry hands but they do not dry faces, mop up spilled coffee or provide a napkin function at meals. They do, however, produce on waste, while the paper towel dispenser generates 6.4 kg of it per 1000 dries, assuming 2 towels per dry. To some, this seems an unacceptable use of a natural material. Convenience and conscience play significant but often conflicting roles in decision-making of this sort.

Step 4: Forming a judgment

Natural capital. The facts here speak for themselves: the high speed dryer has a lower carbon footprint than any other. If the number of dries per day increases, it becomes yet more attractive. Paper towels require disposal and cannot normally be recycled, so they contribute to landfill.



Manufactured capital. The electric dryer has a significant cost advantage provided it needs no servicing in a 10 year life. Paper towels are at least 3 times more expensive than electric dryers and this difference increases with intensity of use. But the electric dryer requires a significant up-front investment, meaning that it does not become economically more attractive than paper towels until the cumulative cost of paper towels exceeds the difference in capital cost of the two drying methods

Human Capital. The most telling issues arise here. A product can be environmentally and economically sound yet be unacceptable to the user. Studies¹⁰ suggest that human patience is stretched by a drying time exceeding 15 seconds causing many users to abandon the dryer before the hands are properly dried. Users leave with still-wet hands and then dry them in way that a less than perfectly hygienic. Both dryers meet this criterion

Here a dialog between provider and user becomes important. The electric dryer is likely to appeal to the provider because it is cheaper in the long run and generates on waste. For many users, however, paper towels offer greater convenience. They are fast and hygienic, and they dry well. They can dry the face as well as the hands, they can mop up mess: they have utility beyond that of just hand-drying. Providers of hand dryers in public spaces (airports, stations, supermarkets) will probably be swayed by the economics. A small company that listens to its staff may perceive the additional satisfaction of paper towels outweighs to extra cost.

Step 5: Reflection

Treating this choice as “either / or” overlooks the potential for a compromise. Electric dryers in the men’s and women’s washrooms and a paper towel dispenser in the disabled washroom is a possibility, or electric dryers in all five but a paper towel dispenser in a more public place (the tea room or coffee area) could maximize satisfaction all round.



7 Snelling AM, Saville T, Stevens D and Beggs CB. Comparative evaluation of the hygienic efficacy of an ultra-rapid hand dryer vs conventional warm air hand dryers. Journal of Applied Microbiology, September 7 2010 (early view publication)

8 <http://www.mayoclinicproceedings.org/article/S0025-6196%2812%2900393-X/abstract>

Appendix: Approximate Bill of Materials

Bill of materials: paper towel dispenser and waste bin

| Paper Towel Dispenser | Mass, kg | Shaping Process |
|------------------------------------|----------|------------------|
| ABS towel dispenser | 1.3 | Injection molded |
| Polypropylene bin for waste towels | 6.2 | Injection molded |
| Packaging, cardboard | 2.08 | |

Bill of materials: electric dryer

| Electric Dryer | Mass, kg | Shaping Process |
|-------------------------|----------|--------------------|
| Steel | 3.0 | Rolled and stamped |
| Aluminum | 10.8 | Rolled |
| Zinc | 0.48 | Die cast |
| Copper | 0.23 | Wire drawing |
| Neodymium-boron magnets | 0.1 | Powder molding |
| Nylon | 0.1 | Injection molding |
| Polyethylene | 0.05 | Injection molding |
| PBT | 0.04 | Injection molding |
| Ceramic | 0.09 | Powder molding |
| Packaging, cardboard | 0.44 | |
| Other | 0.08 | |

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