Material change for a better environment

Summary report

Environmental life cycle assessment (LCA) study of replacement and refurbishment options for domestic washing machines

The first Independent Standard Organisation (ISO) compliant study to investigate the relative benefits of replacing compared to refurbishing domestic washing machines.

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We work with businesses and individuals to help them reap the benefits of reducing waste, develop sustainable products and use resources in an efficient way.

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Front cover photography: Washing machine with EU energy rating label

Executive Summary

WRAP (Waste & Resources Action Programme) evaluated the environmental impacts of a range of replacement and refurbishment scenarios for domestic washing machines, carried out through an ISO-compliant and independently peer-reviewed Life Cycle Assessment. This document summarises the work, the full ISO Life Cycle Assessment is available from WRAP on request.

The study aimed to identify the "best environmental option" for a washing machine: whether repair or replacement produced lower environmental impacts. The study found that this balance depended on the efficiency of the old model and the new mode with which it might be replaced.

"Best environmental option"		New replacement energy rating		
		A	A+	A++
Old machine energy rating	C	Repair	Replace	Replace
	A	Repair	Repair	Replace

The study supports the view that:

- In general, environmental savings can only be achieved when replacing a machine if the highest rated machines available on the market (A+ or A++) are used as a replacement.
- Immediate replacement of A and C rated washing machines with A++ machines offers the most environmentally beneficial option across all environmental impact categories (except solid waste generation and photochemical oxidation).
- Refurbishing an A rated machine is environmentally preferable to immediate replacement with A or A+ rated machines. This applies with the exception of water use.
- Refurbishing a C rated machine is preferable to immediate replacement with A rated machines, this can offer benefits only if it leads to a lifetime extension of more than three years. Benefits differ across the environmental impact categories.
- The potential carbon UK saving from refurbishing C rated machines and using them for a further 9 years compared with replacing them immediately with A rated machines is 220,000 tonnes of CO_2 equivalent per year. This figure includes the lower energy use of A rated machines.

- While these conclusions are valid for most impact categories, we acknowledge that water usage is a significant factor in some areas of the UK and in those areas there may be a specific case for upgrading to new washing machines and accepting a higher environmental impact in other categories.
- At the time of carrying out the study, few A++ models were available on the market and therefore we estimated the performance of A++ machines based on available data. These estimates assumed higher energy efficiency than the products on the market, so the conclusions drawn for A++ rated machines will become more valid as more efficient A++ machines come on to the market.

The behaviour around washing machine use is complex to model. Defra's study on clothes cleaning shows that existing habits around line drying and wash temperature have the greatest impact on greenhouse gas emissions arising from clothes cleaning.

Additionally, there is a large degree of variability in the washing performance of a single machine depending on the way it is used: the size of wash load, the types of garments, how the garments are placed in the machine and how well they mix during the cleaning process.

Based on this assessment, until there is a significant step-change in the energy performance of washing machines available to the market, WRAP recommends that machines are designed for easy repair and to ensure that repaired or refurbished machines continue to operate for a long time.

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Reuse or replace – which makes the most environmental sense?

Which course of action has a lower environmental impact: to refurbish a washing machine and extend its working life, or buy a new machine?

To identify the best option it is necessary to understand what impacts the product has throughout its lifecycle. It is then possible to predict whether any increase in energy efficiency of a replacement machine offsets the impacts of making the new machine.

The greatest impacts of a washing machine are in the use of the machine. New products are likely to be more efficient in use than older ones, but the improvement in efficiency can be small. Even though production and supply impacts are a small part of the whole life cycle, can the efficiency of a new machine offset the production impacts it creates?

This study aimed to address these issues by reviewing the scientific and technical data currently available and developing new models where required.

Assessing environmental impacts

WRAP commissioned Environmental Resources Management Limited (ERM) to investigate the various replacement and refurbishment options for domestic washing machines.

The study examined the environmental impacts of replacement and disposal at end of life, compared to refurbishment and extending the lifetime of the machine by three, six and nine years, followed by replacing it. Washing machines of efficiency ratings A and C were studied across a range of scenarios for replacement with higher-efficiency machines (rated A, A+ and A++).

This is the first ISO 14040 compliant, independently peer-reviewed LCA in the UK to look into the environmental impacts of these decisions.[1] [2]

[2] *ISO 14040:2006. Environmental management -- Life cycle assessment - Principles and framework. Edition 2, International Standard Organisation*
[3] *ISO 14044:2006. Environmental management -- Life cycle assessment – Requirements and guidelines Edition 1, International Standard Organisation*

The study

A comparative Life Cycle Assessment (LCA) was undertaken that evaluated replacement and refurbishment scenarios for domestic washing machines.

A range of scenarios

As well as examining in detail the lifecycle impacts of the two main scenarios: disposal and replacement with a new item, compared with refurbishment and later replacement, the study also considered a wider range of replacement options.

A total of 21 replacement and refurbishment scenarios were investigated, covering a range of machine efficiencies on the market and immediate and future outcomes were predicted.[3]

The scenarios selected for the study focussed on replacing or refurbishing A and C rated machines as these are typical of the most common machines used in UK homes. The study assumed that replacement models would be A, A+ or A++ since these are the most prevalent on the new product market.

Sensitivity analysis

A sensitivity analysis was carried out to find out how the impacts varied with changes in the key assumptions for the following six factors:

[3] *Under the EU Energy Label, domestic washing machines are rated A to G according to their energy consumption performance over a standard wash cycle of 60°C. The industry has recently developed A+ and A++ ratings for the most efficient machines.*

- variations in the distances and mode of transport from production source to the consumer;
- the use of the Market Transformation Programme's reference scenario energy consumption data for a 40°C cycle;
- a reduction in washing machine lifetime from just over 12 years to 9 years;
- future replacement of a refurbished machine with a more energy efficient A+ rated machine compared to current replacement with an A rated machine;
- energy efficiency reduction due to lime scale accumulation on the heating elements; and
- use of a projected electricity generation mix for the year 2020.

Three of these scenarios were found to have no influence over refurbishment vs. replacement outcomes:

- variations in modes of transport and distances from producer to consumer;
- energy efficiency reduction due to lime scale accumulation; and
- projected future electricity generation mix.

For two factors – a 40°C wash cycle and a reduction in the assumed machine lifetime from just over 12 to 9 years – there was only a slight reduction in the environmental impact associated with refurbishment compared to replacement.

For the future replacement of a refurbished machine with a more energy efficient A+ rated machine compared to current replacement with an A rated machine – results showed that for all impact categories, refurbishment is environmentally preferable to replacement.

The machines

According to the Energy Saving Trust, the majority of washing machines on the current UK market are A rated.[4] While A+ rated machines are expected to overtake sales and stock of A rated machines between 2016 and 2020 and rise in popularity thereafter[5], A rated machines are likely to dominate UK stock until then.

Less efficient B and C rated machines were also considered. Although these machines make up a relatively small percentage of current sales and stock, they still represent a substantial proportion of the units still in use in the home. Those consumers may now be considering discarding or refurbishing. WRAP's study therefore concentrates on A and C rated machines.

Estimating impacts of A++ rated machines

The findings in respect of A++ rated machines are limited. At the time of this study only two manufacturers were producing A++ machines, so real performance data were not widely available. To help complete the model we used theoretical data from the Market Transformation Programme, available through an online modelling tool called "What If?" This tool includes predictions of future purchasing patterns, energy impacts and machine efficiencies.

After we completed the study we found that the theoretical performance data used for A++ machines may be over-optimistic. The theoretical data used for A++ machines from the "What If?" Tool was found to be lower than actual performance data declared by the manufacturers, so we calculated the model with

[4] *Energy Savings Trust (2007) Commercial Buyers' Guide – Indicative Sustainable Product Performance Standards for Washing Machines and Tumble dryers*

[5] *MTP What-if? Tool, P1 Scenario assuming policy interventions and Reference scenario*

aspirational rather than actual performance. If the assumed 0.10375 kWh per cycle per kilogram of laundry is not achieved by new A++ machines coming onto the market the benefits of upgrading to an A++ may be overestimated in this study.

So, until further evidence can be made available, this should be considered in the interpretation of the study results for these machines. As further evidence is clearly required in this area, WRAP welcomes engagement with industry.

From production to end of life

The study considered environmental impacts throughout the product lifecycle, from manufacture through to the end of life and eventual disposal.

Data were obtained and presented for these key stages:

- production and assembly, including the transport of components;
- use, including transport to the retailer and consumer;
- refurbishment, including transport to and from the repairer; and
- end of life, including transport to and between waste management operations.

The variation in consumer use of washing machines was not addressed in this study, nor was the subsequent drying of laundry.

Environmental impacts

Environmental impacts were assessed by using the Institute of Environmental Studies, University of Leiden methodology[6] which categorises environmental impacts under six headings:

- Climate change – uses Global Warming Potential (GWP) to express the potential contribution of various gases such as carbon dioxide and methane to the greenhouse effect.
- Abiotic resource depletion – an environmental indicator that considers the depletion of finite resources.
- Acidification – the deposit of acids affecting soil and groundwater caused by acid rain.
- Photochemical oxidation potential – low level smog that can adversely affect human health.
- Solid waste generation – waste generated by appliance and packaging disposal, waste treatment and impacts of recyclate or landfill.
- Water consumption – the amount of water used by the washing machine during its lifetime.

Study limitations

As the first study of this type and scope to investigate these issues, some of the data encountered were incomplete, insufficient or not in existence. Where this occurred, it gave a clear indication of areas where additional research would be beneficial.

Although the study fulfils WRAP's goal of providing a robust indication of the lifecycle burden of different replacement and refurbishment scenarios, it cannot provide a complete picture of

[6] *Version 2.04, February 2008, developed by the Centre for Environmental Studies, University of Leiden, The Netherlands.*

the actual burden of a washing machine in its lifetime due to the availability of data.

The energy and water use profiles for each rated machine were based on published data on potential impacts[7] rather than actual data for washing machines on the market. The study was also limited by the availability of environmental impact data on machine production, refurbishment and end of life, and the actual lifetime extension achievable by refurbishment.

Since no reliable data were available on how long refurbished machines are used in the home, the study assessed extension periods of three, six and nine years for each option. Following consultations with refurbishing businesses, the study identified typical replacement parts commonly refurbished, including stainless steel bearings, carbon brushes and hoses. The composition and weight of these components was factored into the study.

We acknowledge that there are many factors that contribute to the performance of a washing machine, including the types and amount of garments loaded and how well they mix during the washing process. This study estimated a "typical" value for performance, assuming that variation would be averaged out across the life of the machine.

It was not possible to model use of a wide range of wash programmes. A sensitivity analysis of a lower wash temperature programme was carried out, but we acknowledge that where a new machine enables and encourages a user to switch to washing at 30°C this would probably offset any increased impact from switching to a new machine. Defra's study on clothes cleaning considers this issue[8].

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[7] *Market Transformation Programme. What If? tool*

[8] *Final Report – EV0419: Reducing the environmental impacts of clothes cleaning, Defra, 2009*

Study findings

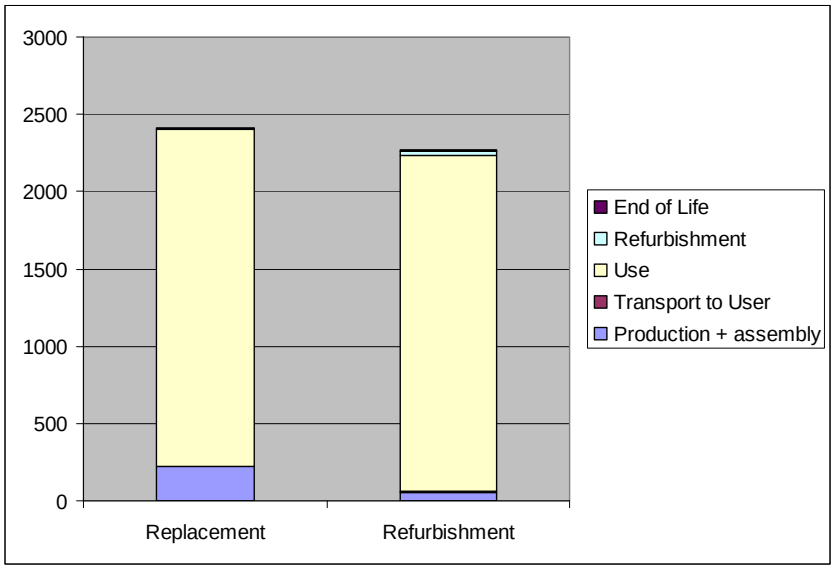
Impacts at different stages in the lifecycle

The use phase represents the largest impact of a washing machine lifecycle across all environmental impact categories except solid waste generation, which occurs mainly at end of life.

Washing machine production and assembly makes a significant contribution to global warming, resource depletion, acidification and photochemical oxidation. The majority of the impacts in this phase are associated with the production of ferrous and non-ferrous metals, plastics and the electricity and gas used for the assembly process.

The refurbishment scenarios modelled make a small contribution to global warming, resource depletion, acidification and photochemical oxidation and reduce the production and assembly impacts significantly.

Figure 1 Global Warming Potential impact (in kg CO_2 eq) for like-for-like replacement of a single A rated machine compared to refurbishment.



Impacts of different machines

Replacement/refurbishment with A rated machines

The results of the study demonstrate that refurbishing both A and C machines delivers benefits in the majority of environmental impact categories compared to replacement with an A rated machine. This is due to the material impacts being significantly higher for a new machine than for refurbishment (which effectively postpones the need to produce a new machine) compared to the energy savings achievable.

Refurbishing an A rated machine delivers benefits in all impact categories except water use and since the lifetime of the machine is extended, these beneficial effects increase over time. The benefits of refurbishing a C rated machine compared to replacement with an A rated machine depend on how long its working life can be extended. It is only of benefit in the majority of impact categories if it leads to a lifetime extension of more than three years.

Table 1 Global Warming Potential values (in kg CO_2 eq) for replacement vs. refurbishment for replacement with an 'A' rated washing machine. Figures in bold show the lowest GWP impact option.

Machine rating change	Immediate replacement with A rated machine	Refurbished, used for 3 years and replaced with A rated	Refurbished, used for 6 years, then replaced with A rated	Refurbished, used for 9 years, then replaced with A rated
A → A	2420	2390	2330	**2270**
C → A	2420	2420	2400	**2370**

The potential carbon savings across UK households that could be achieved by refurbishing an A rated machine, using for 9 years and replacing with an A rated machine is over 220,000 tonnes of CO_2 equivalent per year[9].

Replacement/refurbishment with A+ rated machines

Refurbishment of an A rated machine is beneficial for four of the six impact categories studied, compared to immediate replacement with an A+. Again this is because the impacts of refurbishment are lower than replacement, compared to the potential energy that could be saved by a more efficient machine.

For global warming potential, only refurbishment leading to a lifetime extension of more than three years is beneficial for A rated machines. For C rated machines refurbishment is only beneficial in two impact categories: photochemical oxidation and waste generation, and immediate replacement is the most beneficial option for GWP impact.

Table 2 Global Warming Potential values (in kg CO_2 eq) for replacement vs. refurbishment for replacement with an 'A+' rated washing machine.

Machine rating change	Immediate replacement with A+ rated	Refurbished, used for 3 years and replaced with A+ rated	Refurbished, used for 6 years and replaced with A+ rated	Refurbished, used for 9 years and replaced with A+ rated
A → A+	2290	2290	2260	**2240**
C → A+	**2290**	2320	2330	2340

[9] *Based on GfK UK sales data of A rated washing machines April 08-Mar 09, and on an assumption that all the machines being replaced are A rated.*

In either of the above lowest impact scenarios in bold, replacement with an A+ machine could potentially save 40,785 tonnes of CO_2 equivalent across UK households[10].

Replacement/refurbishment with A++ rated machines

A++ rated machines currently represent a small proportion of the market by volume, however an increase in the sales of these machines is anticipated from now onwards.

Based on their modelled performance, and considering the small amount of actual performance data available, this study shows replacement with an A++ machine is environmentally preferable to refurbishment in all impact categories except solid waste generation (in the case of A rated machines also photochemical oxidation). However it is likely that as energy efficiency improvements become harder to achieve, future savings will be focussed in the impacts associated with materials and refurbishment.

Overall the impacts associated with producing a new A++ washing machine are lower than those associated with the refurbishment and extended use of A and C rated machines.

Consideration should be given to the section “Estimating impacts of A++ Rated Machines”.

[10] *Based on GfK UK sales data of A+ rated washing machines April 08-Mar 09.*

Table 3 Global Warming Potential values (in kg CO_2 eq) replacement vs. refurbishment for replacement with an 'A++' rated machine.

Machine rating change	Immediate replacement with A++ rated	Refurbished, used for 3 years, then replaced with A++ rated	Refurbished, used for 6 years, then replaced with A++ rated	Refurbished, used for 9 years, then replaced with A++ rated
A → A++	**1940**	2030	2090	2150
C → A++	**1940**	2060	2160	2250

Although immediate replacement of a C rated machine to an A++ rated machine potentially represents the greatest savings across all the scenarios studied, numbers on the UK market are still anticipated to remain low until 2020.

Where next?

While the issues may not be straightforward, it has become clear during the course of this study further evidence is needed if we are to build a better picture of the environmental implications of the choices between replacing or refurbishing domestic washing machines.

This knowledge is critical in informing discussions and decisions, not only for informing policy, but also so that manufacturers and retailers have the information they need to develop new products and processes that have a lower environmental impact, whilst being able to predict and meet the needs of the marketplace.

Our study has provided an initial contribution of evidence to enable discussion with industry and help identify the main issues to this important debate, as well as highlighting where lack of data restricts understanding.

In view of the findings, WRAP believes further evidence for the following areas would be beneficial and welcomes industry engagement on:

- analysis of the declared performance of A++ machines currently available in the UK;
- a lifecycle assessment of energy and water consumption data for the home, across a representative sample of washing machines and for a range of consumers;
- an investigation into the effect of washing machine load sizes on energy and water consumption; and
- assessments to establish the average lifetime of refurbished machines in the home.

Conclusion

This study has found that in half of the scenarios examined, machine refurbishment is the most environmentally beneficial option. We acknowledge that where new machines enable and encourage the user to reduce their usage impact (for example by washing at lower temperature) there are clear benefits to upgrading.

This study aimed to provide information for manufacturers and retailers wanting to reduce their environmental impact through their production and procurement decisions, by highlighting areas where products' impacts can be reduced.

The ability for machines to be designed to meet the challenge of cost effective refurbishment therefore is important, both for machines currently on the market, and increasingly so for future models including A++ rated machines. Where future energy efficiency improvements may be small, product impacts can be reduced by increasing their lifetime.

WRAP aims to continue to work closely with manufacturers, retailers, consumer bodies and other stakeholders and engage further debate to drive forward our knowledge in this environmentally significant area, not only in washing machines but across the range of electrical appliances.

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