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**Absorbent Hygiene Products
Comparative Life Cycle Assessment**

Knowaste Ltd

Summary of Findings



Prepared for Knowaste Ltd

April 2011

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One Page Summary

The Project

This study assessed the environmental performance of Knowaste's Absorbent Hygiene Products (AHP) recycling process compared to standard UK disposal practice, namely landfill and incineration. Findings were based on a Life Cycle Assessment (LCA) consistent with the ISO 14040 (LCA) international standard, including a third party review by a panel of experts.

The Findings

Compared to standard UK waste practices, the Knowaste process (a) diverts AHP waste from standard waste disposal avenues (i.e. landfill and incineration) and (b) produces useful recyclates that can be reused for manufacturing other products. More specifically, the following insights are relevant:

- Compared to landfill and incineration, the Knowaste recycling process emits up to 71% less carbon emissions
- Based on an annual capacity of 36,000 metric tonnes of AHP waste, a UK Knowaste plant could save 22,536 metric tonnes of greenhouse gas emissions per year. Annually, this would be equivalent to:
 - 7,487 cars removed from UK roads¹
 - The annual carbon emissions of 2,064 UK citizens²
 - 102,436 LCD televisions switched off³
 - £270,432 - cost of carbon (CO₂e) emissions under the UK Carbon Reduction Commitment (CRC) scheme⁴
- Knowaste has reduced impacts for all other environmental impacts assessed in this study, namely: toxicity impacts to humans reduced by up to 97%, toxicity impacts to animals and plants reduced by up to 99%, acid rain impacts reduced by up to 48%, resource depletion reduced by up to 54%, eutrophication reduced by up to 93%.
- Based on a number of alternative scenarios created to test the sensitivity of results, the Knowaste process was still found to provide reduced impacts for all the environmental issues reviewed.

¹ Based on UK average petrol car (DEFRA, 2010), average annual mileage of 9,000 miles

² Based on average Briton's annual carbon footprint of 10.92 tCO₂e (Carbon Trust, 2006)

³ Based on annual emissions of 220 kgCO₂e (www.carbonfootprint.com)

⁴ Based on carbon price of £12 per tonne (DECC, 2011)

Background

The 21st century has witnessed unprecedented global growth, which in turn has led to environmental and social pressures requiring international policy responses. Frameworks for carbon mitigation, waste management, the protection of biodiversity and sustainable food and water are in constant formation. In the European Union, waste is managed in line with the waste hierarchy which positions waste as a valuable resource and promotes waste prevention, re-use and recycling.

About Knowaste Ltd

Knowaste Ltd is the UK subsidiary of a private North American organisation founded in 1989, specialising in recycling Absorbent Hygiene Product (AHP) waste. Absorbent Hygiene Products consist of disposable child nappies, adult incontinence products, feminine hygiene and similar products. Knowaste's first UK recycling plant in West Bromwich, West Midlands, is designed to process 36,000 tonnes of AHP waste annually. Knowaste's recycling process sterilises the materials using autoclave technology and creates two product outputs – plastics and fibres – for re-use in products or green energy generation. Knowaste works with the commercial care and hygiene sectors and the public care and domestic sectors to provide recycling for AHP waste.

About Deloitte LLP

Deloitte UK is a member firm of Deloitte Touche Tohmatsu Limited, a UK private company. Deloitte is the largest professional services firm worldwide, with a presence in over 140 countries, and more than 160,000 people. The UK firm has over 12,000 partners and employees, with offices in 23 cities and towns across the UK and Channel Islands.

Deloitte's UK Sustainability and Climate Change team provides services covering Responsible Business, Climate Change & Carbon Management, and Sustainable Property & Real Estate. This includes services in Life Cycle Assessment (LCA), used to conduct the study on behalf of Knowaste Ltd.

About Data & Reviews

Data was based on a variety of sources, including the UK Department for Environment, Food and Rural Affairs (Defra), the Environment Agency and Intergovernmental Panel on Climate Change (IPCC). In accordance with the requirements of ISO 14040 for comparative LCAs, the project LCA was reviewed by a panel of experts. The Chair was Dr. Richard Murphy (specialist in Life Cycle Assessment of Imperial College London), Dr. Nick Voulvoulis (specialist in waste and water management, and Director of the Environmental Technology Masters course, Imperial College London), and Christopher Foster (specialist in LCA at EuGeos Ltd).

Project Introduction

Life Cycle Assessment (LCA) provides a unique approach to managing and relating the environmental impacts of a product to its supply chain and life cycle from cradle to grave. An LCA is also required for a business to understand, and should it wish, to communicate the environmental benefits and impacts of its product or process.

Conducting an LCA requires a thorough investigation of the supply chain and processes across a product's Life Cycle, as shown below:

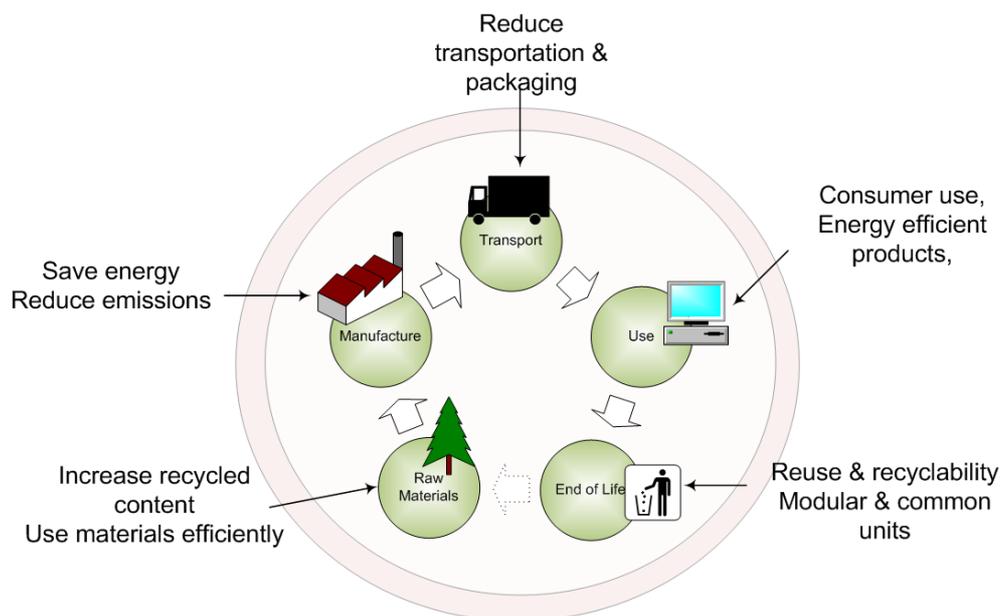


Figure 1: Life Cycle Assessment and the potential environmental improvements at each stage.

Aim

In order to investigate and improve its environmental performance, Knowaste commissioned Deloitte to conduct a Life Cycle Assessment (LCA) study. By investigating the environmental impacts at each stage of this process, Knowaste wished to benchmark itself against typical UK waste disposal, and identify how to improve its own processes.

Therefore, the aim of this LCA study was to measure and determine the environmental impacts potentially caused by the Knowaste recycling process. These results were then compared to the environmental impacts of disposing the same amount of AHP waste in a typical UK disposal scenario, namely a combination of landfill and incineration (referred to henceforth as 'Business As Usual' / BAU).

Scope of the Study

The LCA compared the environmental impacts of disposing one metric tonne of AHP waste according to a 'Business As Usual' (BAU), and Knowaste scenario. Three stages were considered in each case, namely the inputs/collection, processing, and outputs from AHP waste. The two scenarios were compared on a like-for-like basis, as outlined below:

- BAU consists of a standard UK waste scenario consisting of waste collection, landfill (81%) and incineration (19%), including useful energy recovery from landfill (as a result of methane capture) and incineration processes. Finally, since no recyclate materials (such as plastic) are recovered from this process, the extraction and manufacture of additional virgin materials are included.
- Knowaste covers the collection and processing of AHP waste. The breakdown of materials in this waste is shown in Figure 2. Using a 'two-stream' process, this scenario (1) generates its own energy from the gasification of organic fibres produced by the process and (2) produces useful recyclates for the UK market (mainly as plastics, but also some metals and other process rejects). Since the AHP waste is not landfilled or incinerated, this scenario includes the extraction and combustion of additional fuels for energy that would have been produced in a BAU situation.

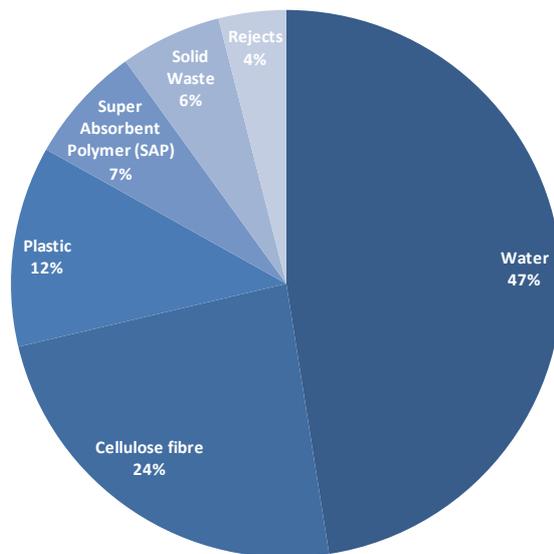


Figure 2: A diagram showing the breakdown of waste materials AHP

Figure 3 shows the boundary of the system described above:

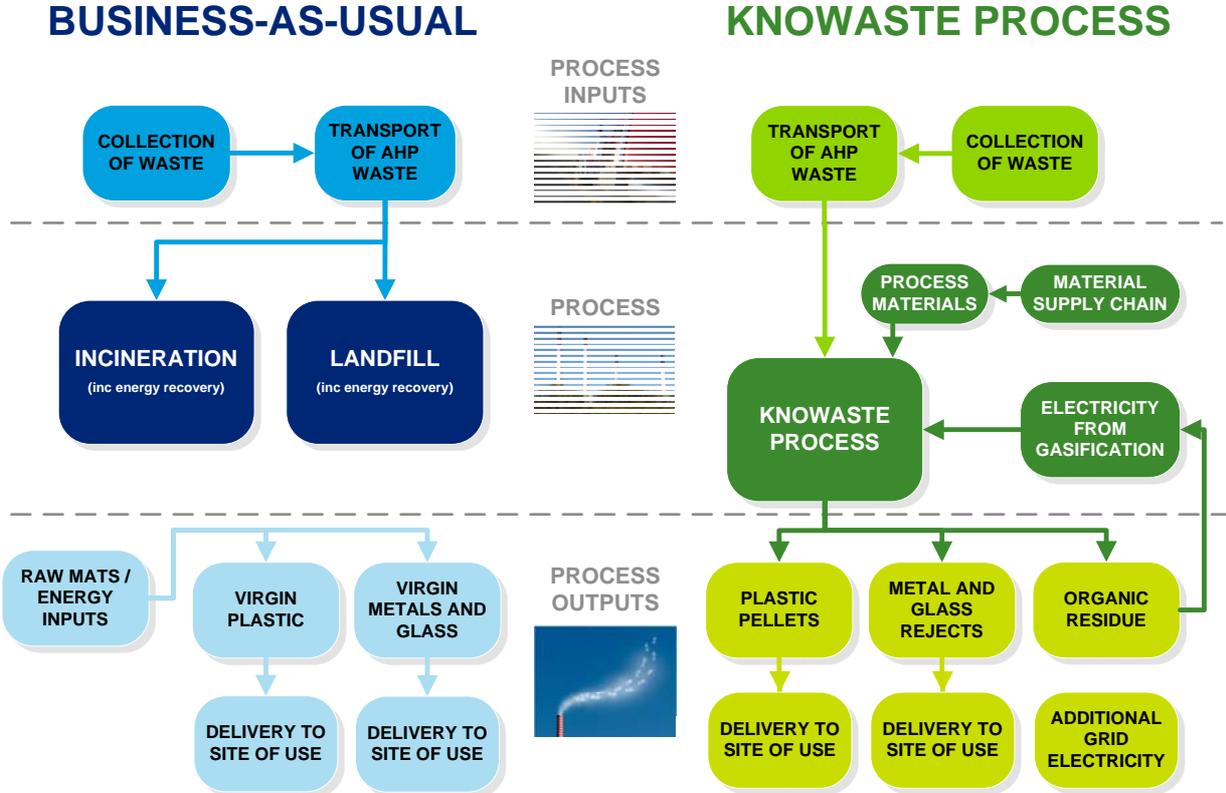


Figure 3: A diagram showing the boundary and processes assessed under this LCA project

Environmental Impacts Covered

The results of this study looked at how the BAU and Knowaste processes could contribute to six important environmental impacts, briefly described below:

Global warming impact or 'carbon' emissions

This looks at the potential impacts of Greenhouse Gases (for example, carbon dioxide and methane) in the atmosphere. Created by processes such as the burning of fossil fuels, agriculture and deforestation, when these gases are produced at a rate higher than nature's ability to absorb them, the Earth's natural climate systems are disturbed. The serious consequences of these changes to climate are expected to impact global food supply, water availability and biodiversity, requiring significant mitigation and adaptation measures across public and private sectors.

Toxicity to humans and ecosystems

This refers to the impacts of excess chemicals – natural or man-made – to human health, and animals, plants and bacteria. Toxins can be poisonous substances like dioxins from uncontrolled industrial atmospheric emissions. Metals such as mercury and cadmium, present in excess, can cause harm to the nervous system, or cause cancer. Past cases of human and ecological toxicity have resulted from inappropriate chemical effluent discharge, chemical spills, and leaks.

Acid rain impact (Acidification)

This considers the effects of acidic substances created by pollution such as sulphur from the burning of coal. Since these pollutants can travel for long distances depending on wind and climatic conditions, acid rain can be deposited in natural environments such as lakes and forests. It can impact plant life, aquatic life, birds and other animals, and limestone buildings.

Resource depletion

This impact occurs when raw materials and fossil fuels are extracted quicker than the nature's ability to replenish them. Resource depletion covers the reduction of non-renewable sources, such as coal, oil and minerals. It is typically caused as a result of processes such as industrial development, mining and deforestation.

Eutrophication impact

'Eutrophication' is the accumulation of nutrients such as fertilisers (made from nitrates and phosphates) in water sources. For example, fertilizer run-off from farms has led to algal blooms wherein the algae, in the presence of nutrients, absorb all the oxygen dissolved in water leading to death of aquatic life.

Results

Based on Figure 4 below, it was found that the one tonne of AHP waste processed by Knowaste, rather than through landfill and incineration, gives rise to the following: carbon emissions reduced by up to 71%, toxicity impacts to humans reduced by up to 97%, toxicity impacts to animals and plants reduced by up to 99%, acidification impacts reduced by up to 48%, resource depletion reduced by up to 54%, eutrophication reduced by up to 93%.

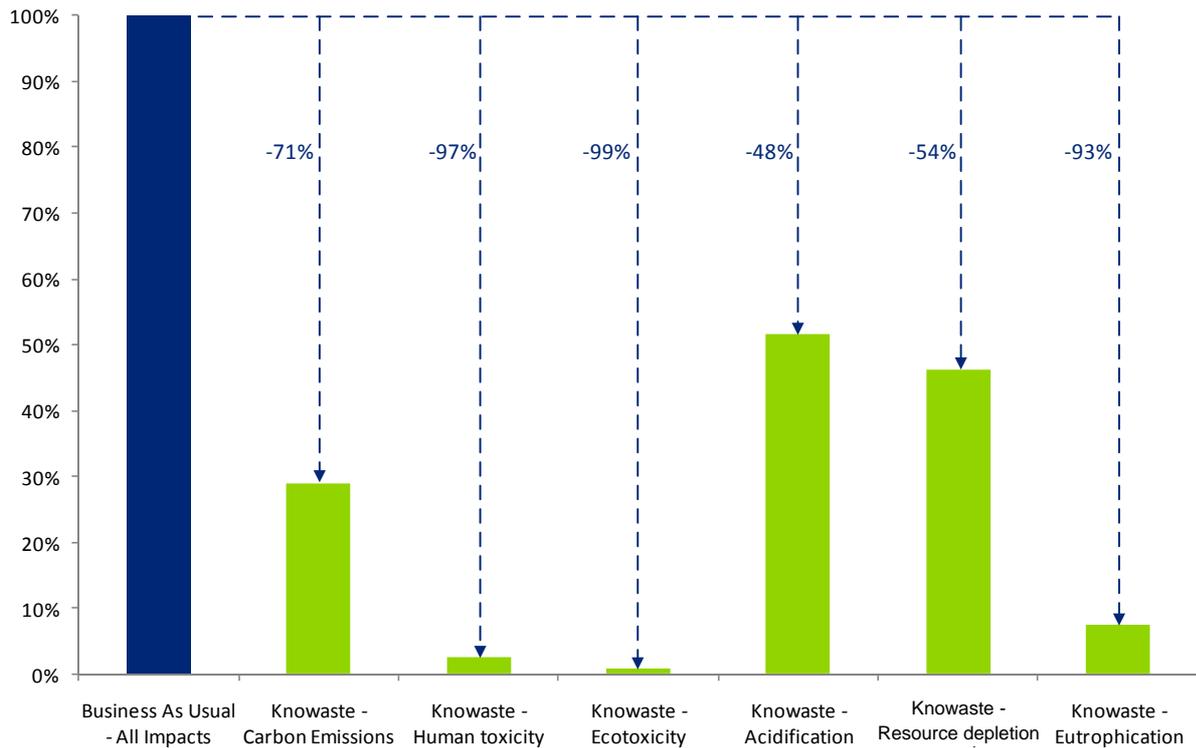


Figure 4: Results of the impact assessment

Translations & Insights

Since the annual AHP waste capacity of a UK Knowaste plant is based on 36,000 metric tonnes, the results discussed previously can be translated into the following metrics:

- A UK Knowaste plant as designed could save 22,536 metric tonnes of greenhouse gas emissions per year. Annually, this is equivalent to:
 - 7,487 cars removed from UK roads⁵
 - The annual carbon emissions of 2,064 UK citizens⁶
 - 102,436 LCD televisions switched off⁷
 - £270,432 - cost of carbon (CO₂e) emissions under the UK Carbon Reduction Commitment (CRC) scheme⁸
- This mass of AHP waste is equivalent to the volume of:
 - 32 Olympic swimming pools⁹
 - 6.5% of the remaining capacity of an average UK landfill site¹⁰

⁵ Based on UK average petrol car (DEFRA, 2010), average annual mileage of 9,000 miles

⁶ Based on average Briton's annual carbon footprint of 10.92 tCO₂e (Carbon Trust, 2006)

⁷ Based on annual emissions of 220 kgCO₂e (www.carbonfootprint.com)

⁸ Based on carbon price of £12 per tonne (DECC, 2011)

⁹ Based on 50m x 25m x 2m pool; assuming AHP waste density of 450kg/m³ (BS 5906:1980)

¹⁰ Based on 614 million m³ remaining capacity at 497 UK sites (Environment Agency, 2009); assuming AHP waste density of 450kg/m³

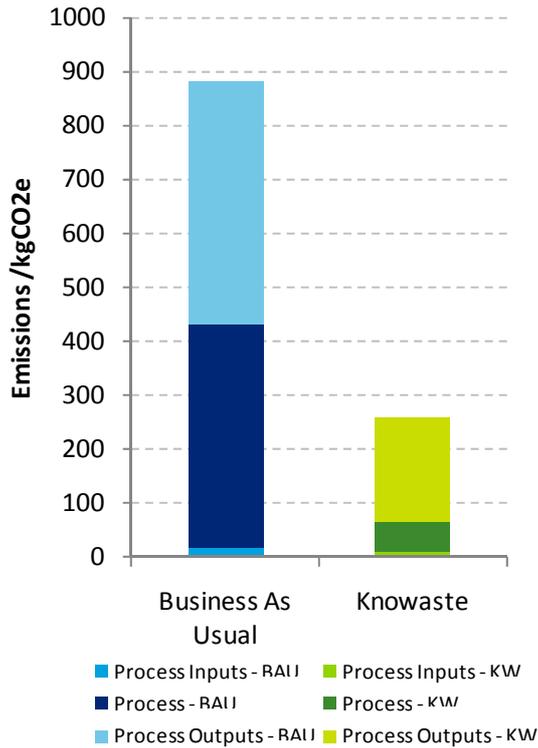


Figure 5: Results per tonne AHP (Global Warming)

Following the breakdown for each lifecycle stage (shown for carbon in Figure 5), the following insights emerged from this study regarding the most impactful processes:

- The largest carbon impact for BAU and Knowaste is from the ‘outputs’ stage. For BAU, the ‘outputs stage’ refers mainly to carbon emissions from the manufacture of virgin plastics, as all material that could potentially be reclaimed or recycled via Knowaste processing is effectively ‘lost’ under BAU. For Knowaste, the outputs stage refers to the generation of grid electricity from Landfill gas and Energy from Waste incineration which is effectively ‘lost’ under Knowaste.
- Toxicity impacts are lower for Knowaste compared to BAU since potential emissions from landfill, incineration and the manufacture of plastics (which can give rise to toxic effluents to the environment) are avoided.
- Similarly, the manufacture of plastics in the BAU stage, requiring non renewable fossil fuels and associated sulphur emissions, means resource depletion and acidification impacts are proportionally larger than Knowaste.
- The disposal processes of BAU give rise to potentially higher eutrophication impacts due to landfill activities and associated effluents.
- A number of alternative scenarios were created to analyse the sensitivity of the results: (1) BAU assuming only landfill, (2) BAU assuming only incineration, (3) BAU assuming a higher recycled content for plastics entering the UK market, (4) the Knowaste process using grid electricity rather than generating its own electricity from gasification. Based on all these variations, Knowaste was still found to provide reduced impacts for all the environmental issues reviewed.
- In the case of Knowaste using grid electricity instead of drawing energy from gasification of the fibres, the carbon emissions are reduced by 50%, toxicity to humans by 96%, toxicity to ecosystems by 81%, acid rain by 18%, resource depletion by 27% and eutrophication by 88%.

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