14–16 years

Life cycle assessment: shopping bags

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Learning objectives

1. Understand how the overall environmental impact of a product is assessed using a life cycle assessment.
2. Evaluate the use of three different types of shopping bag using a life cycle assessment of each one.

The problem

In 2008, supermarkets in the UK gave away approximately 10 billion lightweight single-use carrier bags. This is around 10 bags a week per household.*

Under pressure from the public, the media and their commitment to environmental policy the government needed to act on single-use plastic.

The Environment Agency stepped up to assess the environmental impact of lightweight single-use carrier bags against other alternatives.

Their findings informed the government's plan to tackle plastic waste.

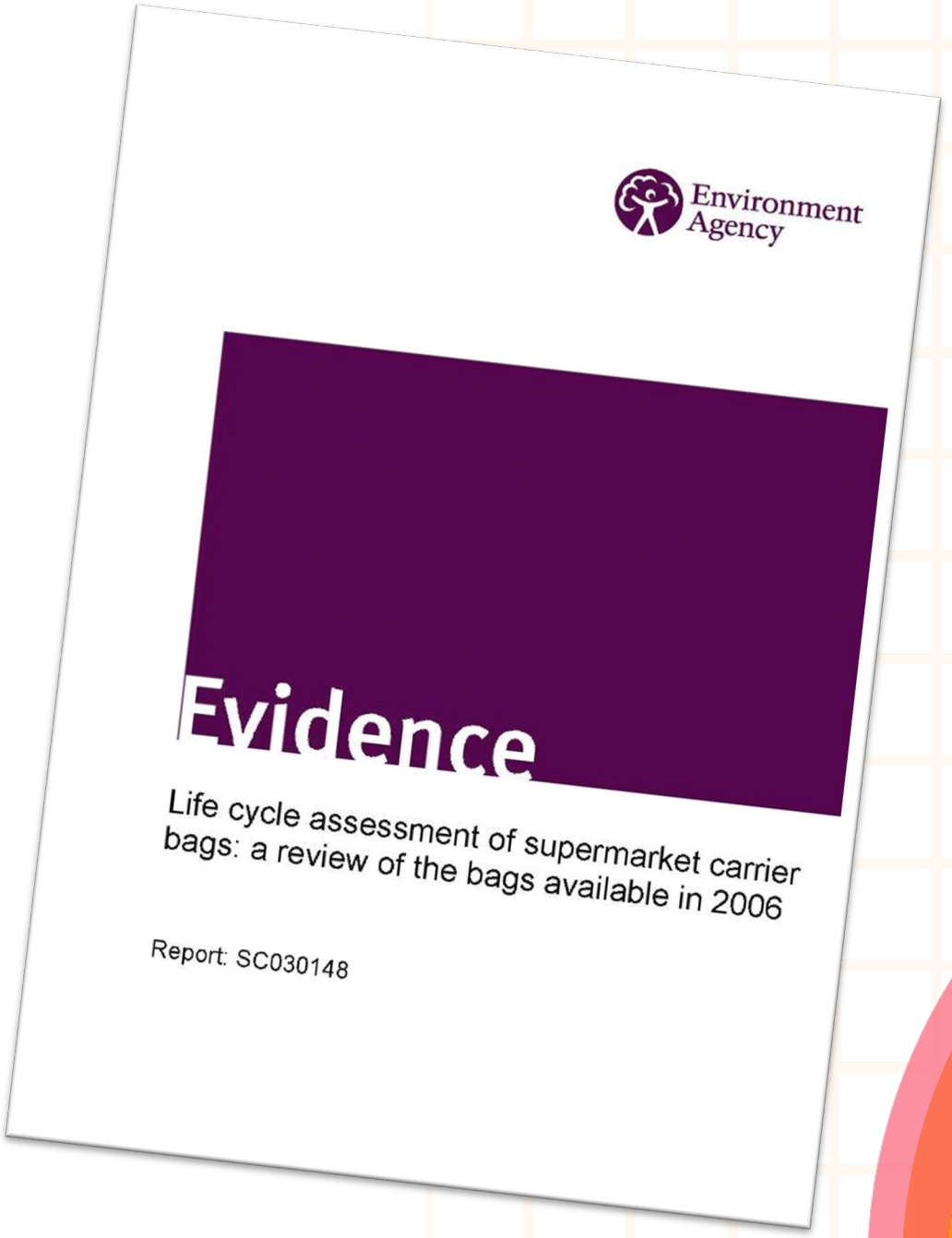
Finding data

A study was commissioned by the Environment Agency (EA) to assess the life cycle environmental impacts of different supermarket carrier bags available in the UK in 2006. The report was completed and published in 2011.

This type of study is called a **Life cycle assessment** or **LCA**.

The target audience for this report was outlined as:

- supermarkets, other retailers, environmental organisations and consumers
- public authorities, eg the Department for Environment, Food and Rural Affairs (DEFRA).



What is a life cycle assessment?

A life cycle assessment looks at every stage of a product's life and assesses the impact it has on the environment during each stage.

Five main stages are analysed during a life cycle assessment:

- Obtaining the raw materials
- Manufacturing and processing
- Transport (at all stages)
- Consumer use
- Disposal

Your task

1. Use the student sheet to complete a life cycle assessment for three different types of supermarket carrier bag:

- Single-use plastic bag
- Reusable plastic bag
- Cotton bag

Use the information on these slides or research on the internet, plus your own subject knowledge.

2. Make a recommendation to the Department for Food and Rural Affairs (DEFRA) based on your assessment.

Bag 1: single-use plastic bag

The EA life cycle assessment describes this bag type as:

Conventional high-density poly(ethene) (HDPE) bags

This is the lightweight, plastic, carrier bag used in almost all UK supermarkets [in 2006] and often provided free of charge … It has been termed 'disposable' and 'single use'.

The raw material for a single-use bag is a polymer made from crude oil.

Fractional distillation and cracking are used to obtain ethene from the crude oil. This is then polymerised under carefully controlled conditions to form HDPE.

- Mass of raw material to make one bag = 8.12 g

Bag 2: reusable plastic bag

The EA life cycle assessment describes this bag type as:

Low-density poly(ethene) (LDPE) bags

These are heavy duty plastic bags, commonly known as 'bags for life' and are available in most UK supermarkets. The initial bag must be purchased from the retailer but can be replaced free of charge when returned. The old bags are recycled by the retailer.

The raw material for a reusable bag is a polymer made from crude oil.

Fractional distillation and cracking are used to obtain ethene from the crude oil. This is then polymerised under carefully controlled conditions to form LDPE.

- Mass of raw material to make one bag = 34.94 g

Bag 3: cotton bag

The EA life cycle assessment describes this bag type as:

This type of bag is woven from cotton, often calico, an unbleached cotton with less processing, and is designed to be reused many times.

The raw material for the bag is cotton from the cotton plant. The processes involved in growing cotton include soil cultivation, fertilisation, application of pesticides, irrigation, harvesting and ginning (where the cotton is dried and cleaned in a factory).

- Mass of raw material to make one bag = 183.11 g

Energy consumption and waste generation

All plastic bags are produced from plastic melt. This is generally blown and sealed to form a bag. The energy demand for these processes in mainly met by grid electricity and this energy consumption depends on the polymer type, density, production equipment and capacity.

The processing involved in turning cotton into cotton bags includes yarn production, textile refinement and weaving.

The energy consumption and waste (mass of material not converted into the end-product*) generated by the production of 1000 bags is shown in the table.

Bag type	Electricity (kWh kg^{-1})	Waste (g)
Single-use plastic bag	0.758	418.4
Reusable plastic bag	0.932	171.2
Cotton bag	0.06	1,800

The transport scenarios for carrier bags

Bag type	From	To	Transport modes	Distance
Single-use plastic bag	Polymer resin* producer in China/ Indonesia/Malaysia	Bag producer in China/ Indonesia/Malaysia	Lorry Sea freight	100 km 500 km
	Bag producer in China/ Indonesia/Malaysia	Bag importer in UK	Lorry Sea freight Rail	100 km 15,000 km 280 km
	Bag importer	Supermarket	Lorry	200 km
Reusable plastic bag	Polymer resin producer in Europe	Bag producer in Turkey**	Lorry	300 km
	Bag producer in Turkey	Bag importer in UK	Sea freight Rail	5,000 km 280 km
	Bag importer	Supermarket	Lorry	200 km
Cotton bag	Textile producer in China	Bag producer in China	Lorry	100 km
	Bag producer in China	Bag importer in UK	Lorry Sea freight Lorry	100 km 15,000 km 280 km
	Bag importer	Supermarket	Lorry	200 km

Global warming potential

Global warming potential is a measure of how much the greenhouse gas emissions in a particular process are estimated to contribute to **global warming**.
It is measured in **CO_2 equivalents**: all the different greenhouse gas emissions are converted to the amount of CO_2 that would cause the same amount of warming.
This way, global warming potential can be expressed as a single number.

Bag type	Global warming potential (kg CO_2 equivalents)
Single-use plastic bag	1.578
Reusable plastic bag	6.924 (no reuse) 1.385 (used 5 times)
Cotton bag	271.533 (no reuse) 1.570 (used 173 times)

See next slide

Exact percentages vary for each bag, but the most emissions are caused by the extraction and production of the raw materials. Manufacturing and processing are next, then transport, then disposal.

Primary and secondary consumer use

The table below shows the number of times you need to use reusable bags (plastic or cotton) to take them below the global warming potential of single-use bags.

If any type of bag is used again it further reduces its environmental impact.

	Number of times bag needs to be used to match global warming potential			
	Single-use bag (no reuse)	**Single-use bag (40.3% reused as bin liners)**	**Single-use bag (100% reused as bin liners)**	**Single-use bag (used 3 times)**
Reusable plastic bag	4	5	9	12
Cotton bag	131	173	327	393

Testing to destruction

The EA study used expanded polystyrene beads to measure the volume of the bags by filling each bag to capacity (up to the handles).

They then used a jog testing machine to simulate walking with a bag containing a 5 kg load for 4 minutes before adding an additional 1 kg every minute until the bag failed.

The study found that an average single-use bag had a capacity of 18.22 kg and lasted for 17 minutes and 32 seconds. The average reusable bag had a capacity of 19 kg and lasted 18 minutes and 30 seconds.

Ensuring a fair comparison

The weight, volume, quality and capacity of the bags assessed in the study is not the same. The EA needed to adjust the number of bags compared so that the LCA was fair. They used the average volume and the average weight each type of bag can carry (see previous slide), to calculate the average number of items that each bag can carry.

They used this to work out the total number of bags need to carry a month's shopping (found to be 483 items on average).

	Average volume per bag (litres)	Average number of items per bag	Number of bags needed per month for average shopper
Single-use plastic bag	19.10	5.88	82.14
Reusable plastic bag	21.52	7.96	60.68
Cotton bag	28.65	10.59	45.59

Reuse of single-use plastic carrier bags

A study of lightweight carrier bag usage (Waste and Resources Action Programme, 2005) found that 59 percent of respondents reused all carrier bags, 16 percent reused most of them, 7 percent reused around half and 7 percent reused some of them.

Reuse applications*	Percentage of respondents that reuse single-use carrier bags in each application
Use as a bin liner in kitchen	53
Use as a bin liner in other rooms	26
Put rubbish into it then throw it away	43
For dog/cat/pet mess	11
Reuse for supermarket shopping	8
Reuse for other shopping	10
To store things in at home	14
For packed lunches	8
Do not have a use/discard	11

End-of-life processes

The following options were considered for each bag in the analysis. The recycling of cotton bags was not included as no evidence was found to support this as a realistic option.

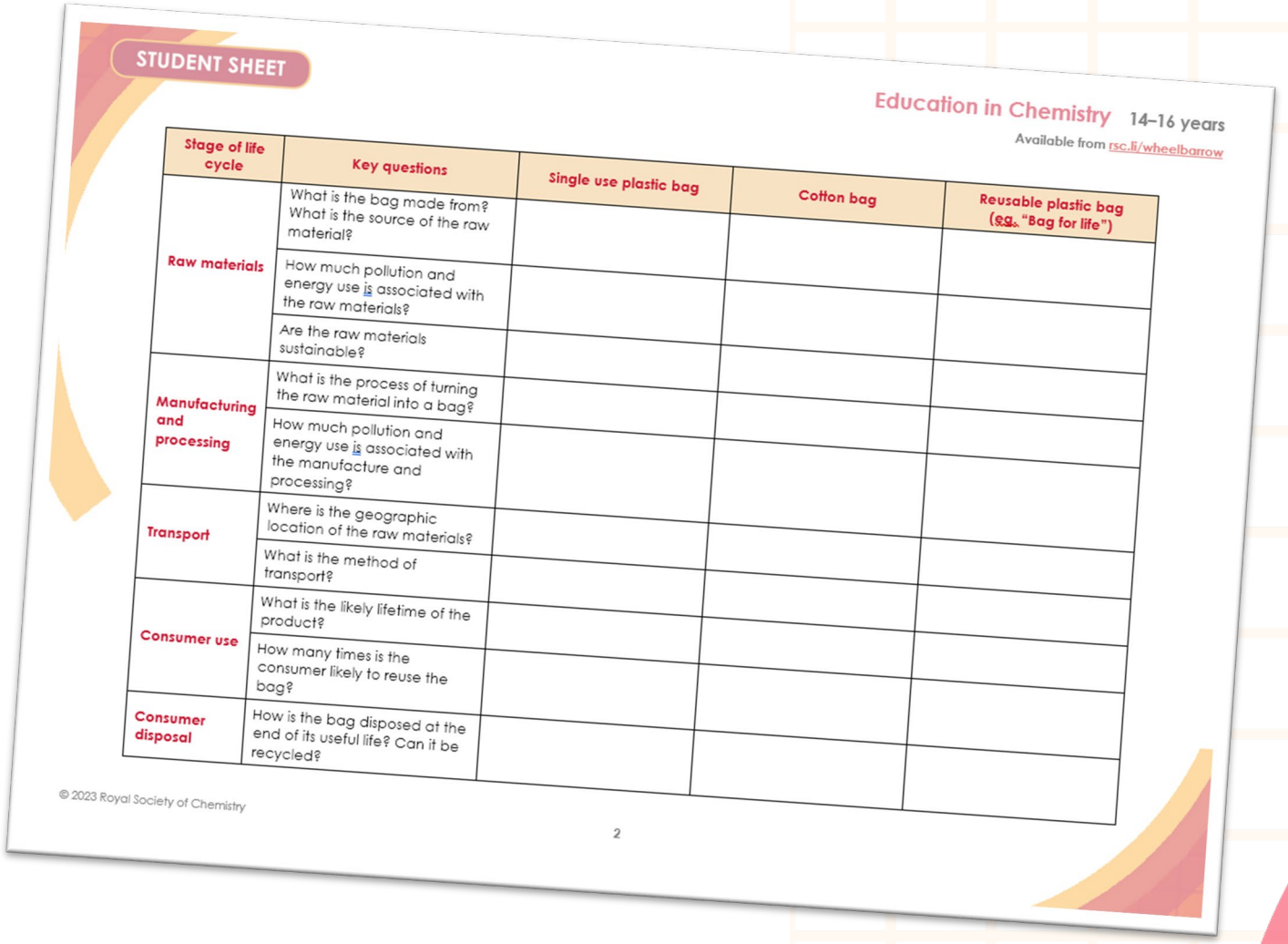
Can you think of any other options for the disposal of these items?

Bag type	Landfill	Incineration	Mechanical recycling
Single-use plastic bag	✓	✓	✓
Reusable plastic bag	✓	✓	✓
Cotton bag	✓	✓	

Conclusion

Which of the bags do you think has the **least environmental impact**?

Suggest an action for the government to reduce the impact of shopping bags on the environment. **Use evidence from your completed LCA to support your recommendation.**



STUDENT SHEET

Education in Chemistry 14–16 years

Available from rsc.li/wheelbarrow

Stage of life cycle	Key questions	Single use plastic bag	Cotton bag	Reusable plastic bag (eg. "Bag for life")
Raw materials	What is the bag made from? What is the source of the raw material?			
	How much pollution and energy use is associated with the raw materials?			
	Are the raw materials sustainable?			
Manufacturing and processing	What is the process of turning the raw material into a bag?			
	How much pollution and energy use is associated with the manufacture and processing?			
Transport	Where is the geographic location of the raw materials?			
	What is the method of transport?			
Consumer use	What is the likely lifetime of the product?			
	How many times is the consumer likely to reuse the bag?			
Consumer disposal	How is the bag disposed at the end of its useful life? Can it be recycled?			

The carrier bag charge

In October 2015, the 5p carrier bag charge was introduced in England for single-use carrier bags in supermarkets. This was increased to 10p and extended to other retailers in May 2021. Similar charges are also in place across Scotland, Wales and Northern Ireland.

DEFRA reports that, since the introduction of the single-use carrier bag charge, the number of single-use plastic bags used in supermarkets in England has gone down by more than 95%.

The charge is not a tax. Supermarkets and retailers are encouraged to donate the money to good causes.

Do you think this was a successful scheme?

What might you have done differently?

What's next?

- Did you find it easy to judge which bag had the most impact on the environment? Could you easily compare the bags, or did you have to make some assumptions or judgements based on data you didn't have?

- How could you extend this study to include other packaging? Think about how you would assess paper bags or packaging for clothes, online purchases or takeaway food.

References

Carrier bags: why there's a charge, *Department for Environment, Food and Rural Affairs* Policy paper, Updated 21 May 2021 https://www.gov.uk/government/publications/single-use-plastic-carrier-bags-why-were-introducing-the-charge/carrier-bags-why-theres-a-5p-charge [Accessed: 08.01.2024]

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