Funeral Industry

Technical Report

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All prior versions are now obsolete and no longer valid

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1. Objectives.

Objectives.

1. Understand the carbon emissions associated with different body disposal choices.
2. Understand the carbon emissions associated with frequently used coffins, handles, lining and packaging types.
3. Offer advice and decarbonisation solutions for manufacturers and the industry to reduce carbon emissions.
4. Improve public knowledge and awareness to make evidence-based environmental choices.
5. Encourage industry change and improvement by supporting carbon reduction targets.

2. Introduction.

Introduction.

Sarah Jones from Full Circle Funerals approached Planet Mark for support in generating data to quantify carbon emissions associated with different funeral options in the UK. The drive for this data surfaced after concluding that this information is not publicly available as an open source or any other way to support the industry and the customer.

The urgency of this project has surfaced from the acknowledgment that the industry is not currently informed and supported to reduce its carbon emissions. As this is one of the key industries in the UK, it can significantly impact the UK's carbon footprint. It, therefore, has a key role to play in meeting the UK Government's Net Zero target by 2050 as well as the interim target of 50% reduction by 2030 to limit warming to 1.5°C. In 2018, the Intergovernmental Panel on Climate Change warned that global warming must not exceed 1.5°C to avoid the catastrophic impacts of climate change.

Data about the environmental impact of different coffin choices and body disposal choices will enable us to educate the industry, support coffin manufacturers, and improve public awareness to make conscious environmental choices.

It is hoped that key stakeholders will use the publicly available data in this report to support customers with less carbon-intensive choices, meet legislation and identify commercial opportunities in the future.

The information presented in this report is based on the available data from LCA databases such as Ecoinvent and BEIS. However, we would like to acknowledge that the data within these databases is limited, and as a result, not all materials could be quantified. Additionally, it is important to note that the scope and finances of the project have imposed certain limitations, which may have prevented the inclusion of more scenarios. Therefore, not all possible scenarios are reflected in this report. Please be aware that the findings and conclusions presented in this report are based on the information and data that were accessible and considered during the research process. Any future updates or improvements to the data may alter the outcomes and recommendations provided herein.

We would like to emphasize the importance of considering a second phase of research, where other aspects such as funeral arrangements and transportation to the funeral (including commuting) can be quantified and included. This would provide a more comprehensive understanding of the environmental impacts associated with the analysed subject.

Furthermore, we strongly recommend that the industry takes steps to improve the quality and accessibility of the data available for life cycle assessments. Enhancing the accuracy and completeness of such data will contribute to more reliable and comprehensive environmental analyses in the future.

The Brief.

This report aims to understand the carbon emissions associated with two specific parts of the funeral care supply chain - coffins and body disposal. This data is then put into context by considering the bigger picture.

Manufacture of Coffins and accessories:

- 16 coffin types
- 3 lining types
- 5 handle types
- 2 packaging types

Methods of final disposal:

- Natural burial
- Traditional burial
- Cremation
- Resomation

The bigger picture:

- Visiting a specific place for memorial purposes
- Impact on air, water and soil
- Combination of scenarios

As there are so many variables, the research team decided to look at the overall impact when coffin material, handles, lining, packaging and disposal methods are combined – small details like choosing cardboard packaging and wooden handles could reduce the emissions.

Additional to the environmental impact of the coffin and body disposal choices throughout the funeral process as listed above. This report will offer advice on how to reduce carbon emissions, improve public knowledge and awareness to make evidence-based environmental choices, encourage industry change and improvement and advise consumers by highlighting opportunities for less carbon intensive body disposal choices.

This report does not consider the total environmental impact of the funeral. Significant variables such as choice of flowers, travel and headstones have not been included. It is hoped that this report may reduce the threshold for others to undertake further analysis. It is important to note that when calculating the environmental impact of a funeral, the data in this report will be relevant to coffin and body disposal but not the entire funeral (as this would depend on other choices made).

Executive summary.

Our analysis shows that many variables and decisions are key to the overall impact including the coffin material, handles, lining, packaging and the disposal methods. When combined the small details could reduce the emissions significantly. To place the coffin and body disposal methods into some context, the emissions associated with visiting a specific location on repeated occasions for the purpose of memorialization was estimated. The results show that over a number of years, recurrent travel may have a higher impact than any single coffin or disposal method.

Materials and Accessories:

- Mahogany Veneer coffin is the most carbon-intensive coffin type.
- Biodegradable bag was the least carbon-intensive option.
- Polythene sheet is the most carbon-intensive lining type.
- Paper is the least carbon-intensive lining.
- Plastic handles are the most carbon-intensive ones.
- Wooden and wicker handles are the least carbon-intensive option.
- The two most common types of packaging to transport coffins were assessed: cardboard and bubble wrap. Emissions associated with bubble wrap packaging were almost 5 times higher than cardboard. However, as packaging is not always necessary for this application, having no packaging would mean emitting zero carbon.

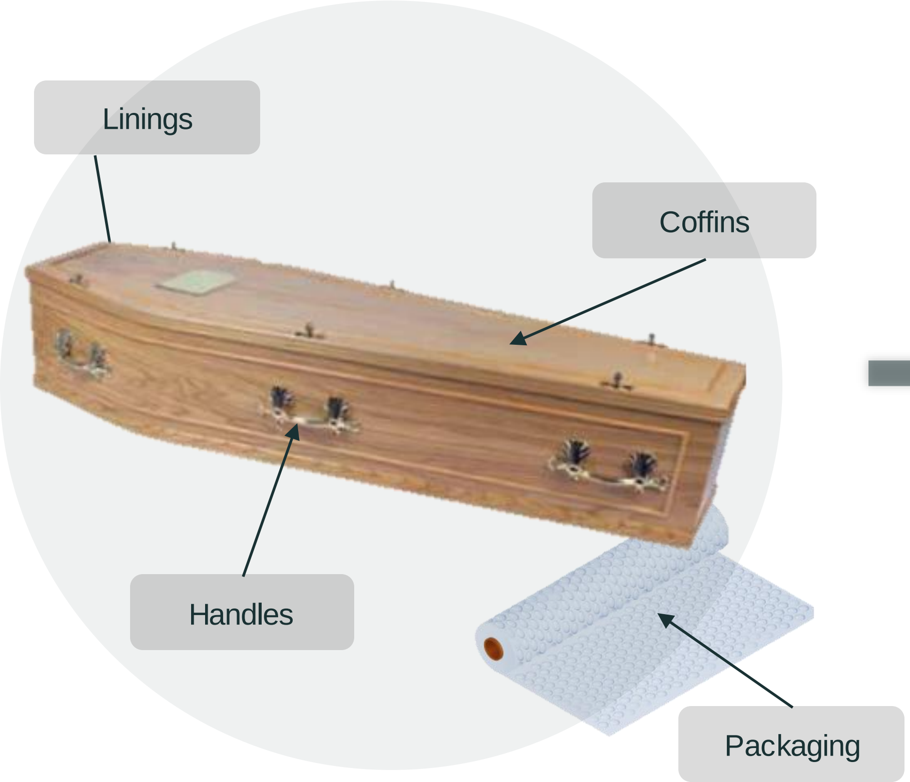
Final disposal:

- The carbon emissions associated with natural burial are minimal, especially considering that the digging could be done manually, without the use of machines and any fuel (e.g. diesel). Our peer reviewers advised that currently most graves are dug using machines but this was inconsistent with literature review findings.
- Immediate carbon emissions associated with traditional burial are small, the key contribution coming from the digging done by a machine that uses fuel. However, when we look at the impact on the environment for the longer period of 100 years, there is a seepage of nutrient-and carbon-rich fluid into soils, with possible impact on groundwater as well as more CO_2e emission and there is only a small positive contribution to biomass.
- Natural Gas Cremation is the process with the highest carbon footprint for the energy consumption stage of lifecycle.
- Peer reviewers noted that air contamination was likely to be very high, but this data is not currently available and therefore couldn't be accounted for at this stage.
- When looking at the whole end-to-end process, recurrent visits to the final resting place has a much higher impact over the years than any of the disposal methods.
- Carbon emissions associated with Resomation are low. However, the impact associated with chemicals used and effluent disposal are not yet available and therefore not analysed in this report.
- An overview of the land and water impact is also presented for each method for reference, as this is an important and currently poorly understood impact.

3. Materials assessed.

Materials assessed. Specifications.

We have analysed 16 coffin types, 3 lining types, 5 handle types, 2 packaging types, 4 different methods for final disposal and 4 different fuel types for cremation. These were chosen based on their frequency of use and data availability. These are defined as shown in the picture below and detailed in sections 3c and 3d of this report.



Natural and traditional burial

Resomation

Cremation

Coffin types.

16 coffin types were assessed, from traditional to alternative ones. Key information is described below and on the following page.
The complete description can be found in Appendix 2.

Oak Veneer with chipboard sides and MDF base
- Total volume of veneer 0.01395 m^3
- MDF base volume 0.0169 m^3
- Chipboard sides weight 24 kg

Oak Veneer with chipboard sides and base
- Total volume of veneer 0.01395 m^3
- Chipboard sides and base weight 35kg

Mahogany Veneer with chipboard sides and MDF base
- Total volume of veneer 0.01395 m^3
- MDF base volume 0.0169 m^3
- Chipboard sides weight 24 kg

Solid Oak
- Total volume of material 0.067169 m^3

Solid Pine
- Total volume of material 0.067169 m^3

Elm Veneer with chipboard sides and MDF base
- Total volume of veneer 0.01395 m^3
- MDF base volume 0.0169 m^3
- Chipboard sides weight 24 kg

Cardboard from recycled content
- Total weight 10 kg

Imported Wicker

- There was no data on emissions associated with Willow, Pandanus and Banana in the databases or publications thus could not be presented.

Coffin types.

Cardboard with MDF base
- Total volume of material 0.074 m^3
- MDF bottom volume 0.0169 m^3

Bamboo (from Vietnam)
- Coffin weight 15 kg

woollen textile with cardboard sides and MDF base
- Total volume of material 0.021 m3

Wicker (British willow)
- Coffin weight 15 kg

Vinyl wrapped MDF
- MDF base and chipboard sides
- MDF base volume 0.0169 m^3
- Chipboard sides weight 24 kg
- Vinyl wrap weight 0.01 kg

Cotton shroud
- Shroud weight 0.66kg
- 100% standard cotton

woollen shroud (sheep's wool)
- Shroud weight 0.66kg
- 100% sheep's wool

Biodegradable PVA bag (Resomation)
- Weight of the bag 0.023 kg
- 100% PVA

Lining types.

3 lining types were assessed, as described below. The complete description can be found in Appendix 2.

Polythene sheet (for example, CremFilm)

- Total weight 0.29 kg

Paper (primary material production)

- Total weight 0.16 kg

Linen

- Total weight 0.33 kg

Handle types.

5 handle types were assessed, as described below. The complete description can be found in Appendix 2.

Plastic

- total weight 0.04 kg

Brass

- total weight 0.215 kg

Rope

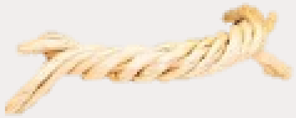
- total weight 0.12 kg

Wood

- total weight 0.18 kg

Wicker

- total weight 0.18 kg



Packaging types.

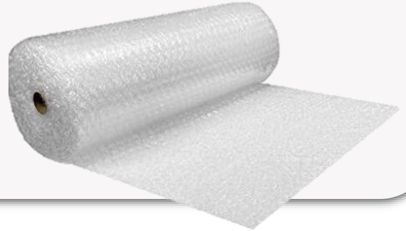
2 packaging types were assessed, as described below. These are packaging used in the transportation of the coffins. The complete description can be found in Appendix 2.

Cardboard

- Total weight 2 kg
- Average: 78% corrugate and 22% cartonboard

Bubble Wrap

- Total weight 2 kg
- Standard bubble wrap



Materials assessed. Summary.

Coffin types	Lining types	Handle types	Packaging types
Mahogany Veneer with chipboard sides and MDF base	Polythene sheet	Plastic	Bubble Wrap
Vinyl wrapped MDF	Paper	Brass	Cardboard
Elm Veneer with chipboard sides and MDF base	Linen	Rope	None
Oak Veneer with chipboard sides and MDF base		Wood	
Oak Veneer with chipboard sides and base		Wicker	
Wicker (British willow)			
Bamboo (from Vietnam)			
Woollen textile with cardboard sides and MDF base			
Cardboard with MDF base			
Woollen shroud (100% sheep’s wool)			
Solid Oak			
Solid Pine			
Cardboard from recycled content			
Cotton shroud (100% standard cotton)			
Biodegradable bag for resomation			

4. Processes for final disposal.

Final disposal.

In considering final disposal, four main scenarios were considered:

Natural burial is the interment of the body (that has not been embalmed or treated with chemicals after death) in the soil in a manner that does not inhibit decomposition but allows the body to be naturally recycled (through microbial action). All materials that are interred are biodegradable. No impervious membranes are used to line the coffin. It is an alternative to other contemporary Western burial methods and funerary customs. Natural burial is typically within an area that also supports habitat for flora and fauna.

- *Single depth*
- *LCA stages measured: Operational energy usage (LCA stage B6) - Closing of the grave for burial*
- *Biodegradable coffin type and/or shrouds, both cotton and woollen*

Traditional burial involves the interment of the body in the soil (typically in a shroud or lining) in a coffin (typically made of treated timber).

- *Uses formaldehyde embalming fluid to preserve the body*
- *Double depth*
- *LCA stages measured: Operational energy usage (LCA stage B6) - Closing of the grave for burial*
- *All coffin types*

Cremation is a method of the final disposal of a dead body through burning. 4 types of cremation were analysed, including the traditional one using natural gas, and 3 alternatives which are biofuel, electric and electric with electricity from renewable sources.

- *Uses natural gas, biofuel, electricity, or renewable electricity*
- *LCA stages measured: Operational energy usage (LCA stage B6) - Operation of cremator*
- *All coffin types*

Resomation is a chemical process of alkaline hydrolysis which is used to turn the organic tissue of the body into a liquid form.

- *LCA stages measured: Operational energy usage - Operation of resomator (LCA stage B6) and Operational water use and waste water (LCA stage B7)*
- *Uses a biodegradable bag and optional woollen shroud*

Natural and Traditional Burials.

Natural and traditional burial methods involve burial (interment) of the body within the ground, either within a lined coffin or in a simple biodegradable cover, at depth (traditional) or shallow (natural). In both instances, where the soil is considered to be of suitable character, coffins of perishable materials may be placed at a reduced depth.

Traditional burial may include the use of chemical preservatives or disinfectants, such as embalming fluid (including formaldehyde), which will delay decomposition. With natural burials, the process of decomposition is faster. In both instances, there will be additional carbon released from the structure in which the body is buried.

Within a traditional burial it may take around 100 years for the body to fully degrade, depending upon the conditions (principally, temperature, presence of oxygen and moisture content). By ten to fifteen years, given enough moisture, low-oxygen environment sets off a chemical reaction that will see the degradation of fat within the body - in drier conditions, this process would be significantly slower, with the body effectively mummified. By 50 years, the remaining tissues will have liquefied or degraded to CO_2 and methane (CH4), leaving behind skin and tendons. Eventually these too will disintegrate, leaving a residue of bones, dust and teeth.

Within the traditional burial we could, therefore, expect to see the slow release of gases and leaching of nutrients and other metals into the surrounding soils over a period of approximately 100 years. The carbon release time within the timber will largely depend upon the nature and thickness of the wood, the treatment and ground conditions. There may be other chemicals released in the process, including formaldehyde, a toxic gas, which is often used in the glues and resins.

Cremation.

Cremation is the burning, under controlled conditions, of both the body and the coffin. Because of the high-water content of the body, a lot of energy has to be used in its combustion. Average time of the day, length and temperature was used for measurement in this report.

In this process, the body and coffin is reduced to ash and gases (mainly CO_2). In addition to the CO_2 released from the body, coffin and accessories, the CO_2 used in the fuel will have to be factored in. Other considerations would include the release of toxic metals, such as mercury from fillings.

The cremated remains are returned to the family for onward disposal by another means, which can also have an environmental impact, but this is beyond the scope of this report.

Resomation.

Resomation uses a chemical process of alkaline hydrolysis for the disposal of a body.

The body is placed in a bag or shroud made from biodegradable materials and positioned in a sealed pressure chamber. The body is boiled in superheated alkaline solution. In this process the body is decomposed and dissolved, so that most of the organic matter is reduced to salts, sugars, amino acids and other organic compounds – with no tissue left.

The disposal of the final solution will be discarded within the sewage system, but it requires proper treatment.

Bones are not dissolved, and the remains are returned to the family for onward disposal by another means, which can also have an environmental impact.

Instead of using fire, resomation uses electricity and a concentrated alkali-based solution, which speeds up decomposition. The process is on average 3-4 hours long.

Resomation is a relatively new option in the UK for the final disposal of the body.

5. Methodology.

Carbon Dioxide Equivalent.

Carbon dioxide (CO_2) is not the only greenhouse gas causing global warming and that is why carbon dioxide equivalent (CO_2e) is used when talking about climate change.

According to the Environmental Protection Agency (EPA), greenhouse gases (GHGs) warm the Earth by absorbing energy and slowing the rate at which the energy escapes to space; they act like a blanket insulating the Earth. Different GHGs can have different effects on the Earth's warming. Two key ways in which these gases differ from each other are their ability to absorb energy (their "radiative efficiency"), and how long they stay in the atmosphere (also known as their "lifetime").

The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases. The larger the GWP, the more that a given gas warms the Earth compared to CO_2 over that time period.

- Carbon Dioxide (CO_2) has a GWP of 1
- Methane (CH_4) is estimated to have a GWP of 27-30 over 100 years
- Nitrous Oxide (N_2O) has a GWP of 273 over 100 years
- Chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) are sometimes called high-GWP gases because, for a given amount of mass, they trap substantially more heat than CO_2. The GWPs for these gases can be in the thousands or tens of thousands.

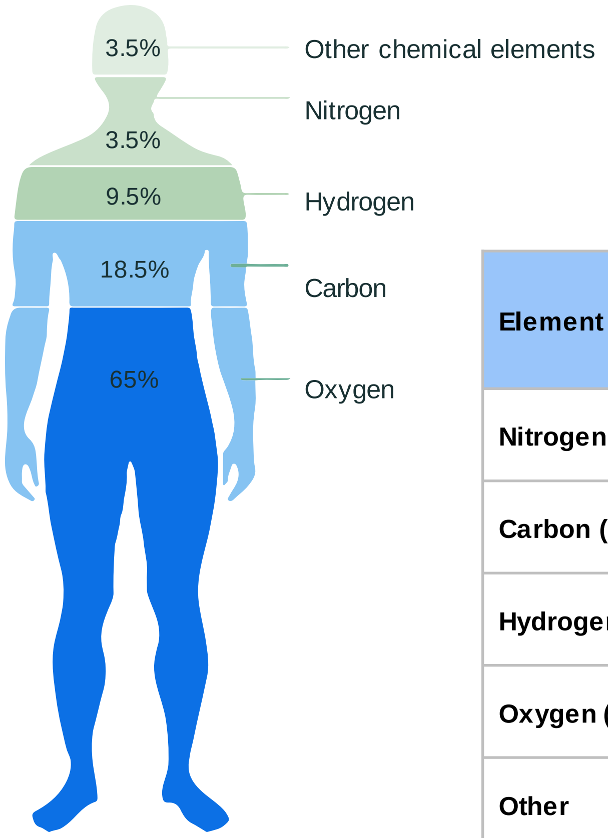
The human body.

The human body represents a reservoir of water, carbon and nutrients, the composition of which is roughly as shown in the image on the right-hand side. There is, notably, also an increasing amount of plastic within the human body, including within the gastrointestinal tract.

According to the Environmental Protection Agency (EPA), 1 kg of carbon (C) is equivalent to 3.67 kg CO_2e. For example, a 70 kg body holds a total of approximately 13 kg of carbon, which represents 47.7 kg of CO_2e. Whether the carbon within the body, which will be in a wide range of organic forms, from complex proteins to carbohydrates and fats, ultimately becomes CO_2 depends principally upon the time, presence of oxygen and water and temperature of storage.

A body exposed to weather/environmental impacts may degrade over a few years through microbial action into microbial carbon and CO_2. Where there is a lack of oxygen, might also appear as CH_4 (methane), which is a more potent greenhouse gas. By contrast, a body held in cool and dry conditions might show minimal degradation over hundreds of years.

While the human body represents a store of carbon over a lifetime, our consumption of food, respiration, and transport all contribute to the CO_2e content of the atmosphere – our carbon 'footprint'. On death, these activities obviously cease but there are other considerations in relation to how the body is treated (burial, cremation etc.), and where and what form the carbon is resident.



Element	Mass (kg) assuming a body of 70Kg
Nitrogen (N)	2.45
Carbon (C)	12.95
Hydrogen (H)	6.65
Oxygen (O)	45.5
Other	2.45

The 'others' include: phosphorus (1.1%), magnesium, potassium (1.0%), calcium (1.4%), iron and trace elements, such as mercury, selenium, sodium, chlorine, sulfur etc.

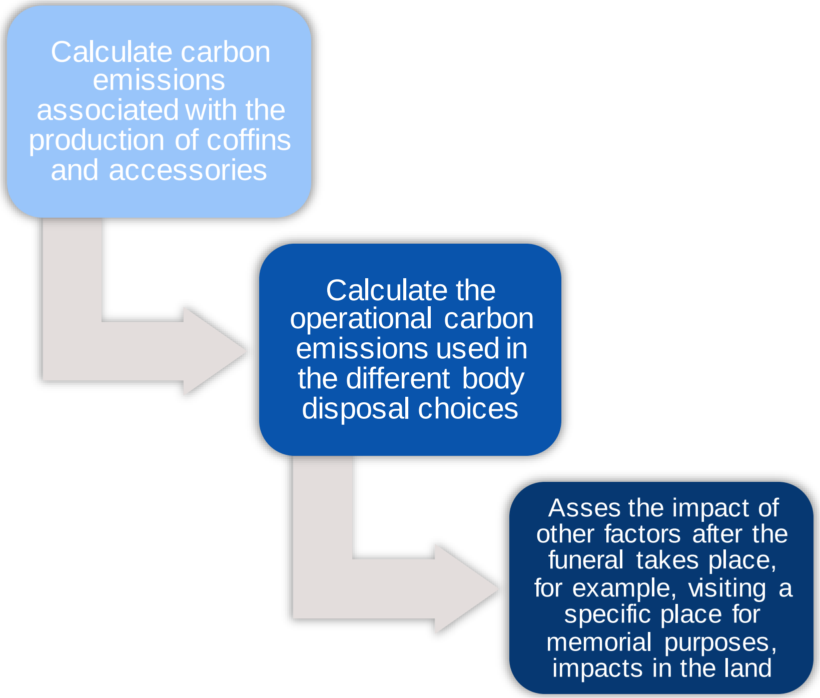
Methodology.

In order to understand the carbon emissions associated with different body disposal choices, provide a like for like comparison and support the knowledge gaps within the industry, we have assessed 14 coffin types with different accessories as well as 4 main types of body disposal choices, described in the following pages.

- The carbon emissions associated with the production of different coffin types and accessories were calculated through Life Cycle Assessments (LCA). LCA is a methodology for assessing environmental impacts associated with all the stages of the life cycle of a product, process, or service. For instance, in the case of a manufactured coffin, environmental impacts are assessed from raw material extraction and processing (cradle), through the product's manufacture, distribution and use, to the recycling or final disposal of the materials composing it.
- The calculations for operational carbon emissions associated with different body disposal choices followed the GHG Protocol.

The results are mainly expressed in carbon equivalent, which includes the main seven Greenhouse Gases (GHGs) that contribute to climate change, as covered by the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

The goal is to provide a general view of the industry and not to promote specific brands or companies. For that, averages for size and volume for coffins and accessories were used, as well as for the different body disposal choices.



Methodology Map.

The carbon emissions related to the following stages were calculated.

Material Extraction

- Coffins
- Handles
- Linings
- Packaging

Production

- Coffins
- Handles
- Linings
- Packaging

Transportation

- Default distance of 100 miles, unless described in the product specification

Final Disposal (operations)

- Cremation
- Traditional burial
- Natural burial
- Resomation

It does not take into account coffin material

Estimation for visiting a specific place for memorial purposes

- Travel
- Granite stone
- Flowers

Note that the methodology adopted was a calculation approach, through Life Cycle Assessments and following the GHG Protocol, as described in this section. No physical testing has taken place.

Calculation method.

For the materials and processes assessed, the calculations were done based on the quantity of material used or energy, fuel and water consumed and the emission factor available. An emission factor is a coefficient that describes the rate at which a given activity releases greenhouse gases (GHGs) into the atmosphere.

For example, the formula for the materials assessed is:

Quantity of material (kg)	X	Emission factor ($kgCO_2e$ per kg of material)	=	Total carbon emission ($kgCO_2e$)

The same applies for energy consumed, for instance:

Energy consumed (kWh)	X	Emission factor ($kgCO_2e$ per kWh consumed)	=	Total carbon emission ($kgCO_2e$)

If a process uses more than one source, the formulas above are applied for each source separately and the final result is the sum of all of them.

There are various sources for the emission factors. The most used ones in the UK are BEIS, Ecoinvent and ICE.

5.a. Constants, Exclusions and assumptions

Constants and assumptions.

In order to support comparison between the different materials and body disposal choices, some assumptions and constants were considered across the calculations.

- Non-gender-specific 70kg body (No tumors, implants, pacemakers or metals)
- No embalming of any type
- No additional ornaments / furniture on coffin
- No personal items in the coffin and no body bag around body in the coffin
- Wearing cotton clothes
- Coffin size 78" x 28" x 16", from 150 coffin data points
- Facility location in mid-England
- For cremation: average time of the day, duration and temperature (energy consumption could not be adopted by coffin type as data was provided as averages – it is accounted but not specified)
- Cremation tests are carried out when the cremators are at optimum running temperature. Please note that the time of day is likely to have a significant impact on the results as more energy is required to heat a cremator from cold.
- For cremation: no re-use of the outer coffin and no re-use of the inner coffin
- Body decomposition to bones period of 10 and 100 years using a generic coffin (this would normally vary on soil, depth, humidity and coffin material)
- Washing the body prior to burial and cremation was excluded as the emissions would be de-minimus: it would be 0.421 $kgCO_2e$ per m^3 of water (including wastewater). For reference, a common shower uses 60 litres of water which would be 0.03 $kgCO_2e$

Exclusions.

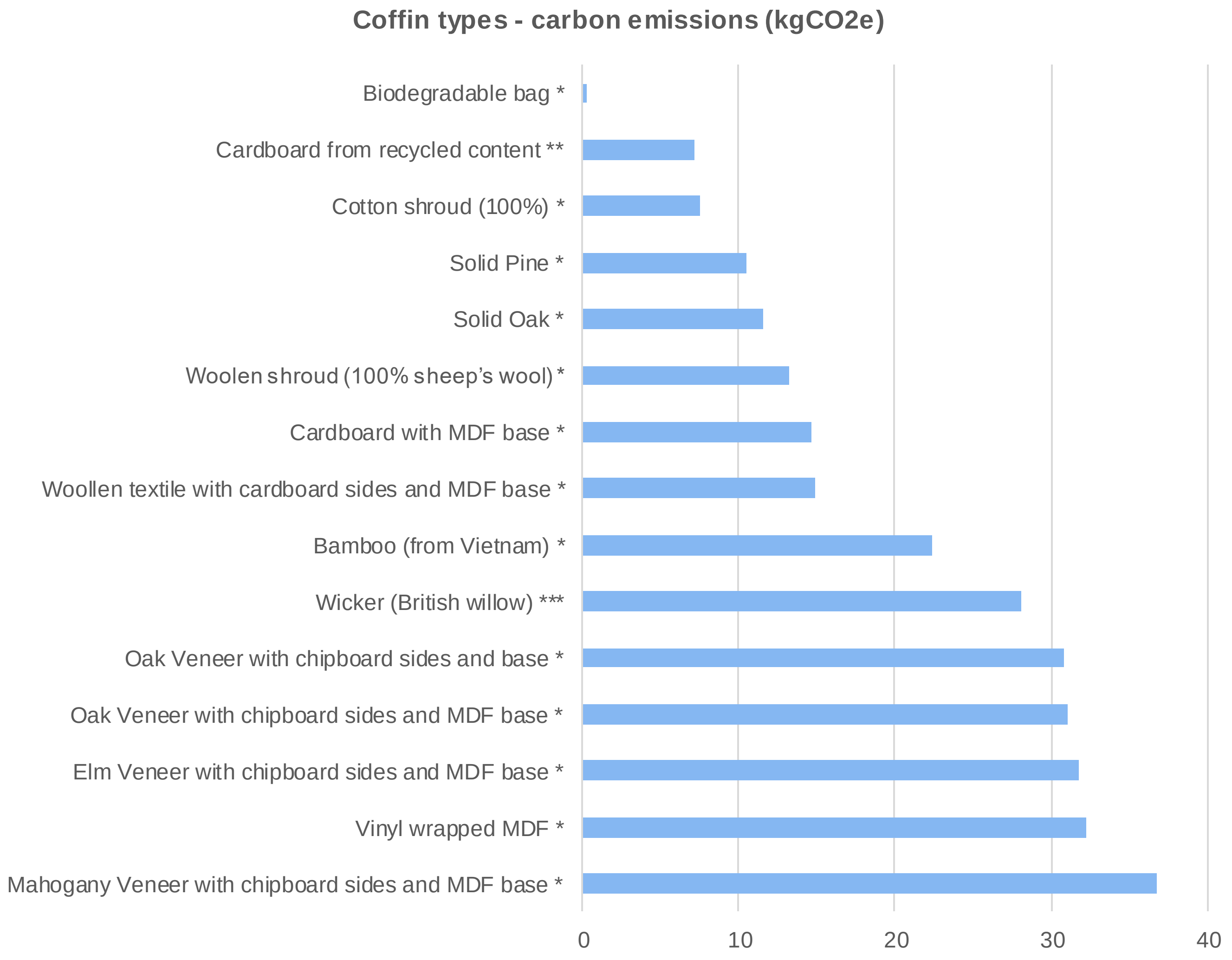
- Guest and coffin transportation, flowers, candles and other decorations during the funeral
- Visiting the final resting place – measured but not included in like for like comparison and displayed separately
- Monument (raw material extraction, production, transport and engraving) – measured but not included in like for like comparison and displayed separately
- Graveyard/cemetery/crematorium memorial garden maintenance
- Flowers for the burial – measured but not included in like for like comparison and displayed separately
- Candles and other decorations for the burial
- Interred ashes plot
- Cards and newspaper advertisement
- Food and drinks at the funeral
- Construction and manufacture of the facility and equipment where the disposal takes place
- Waste treatment infrastructure required to treat and safely dispose of liquid remains resulting from Resomation
- Running the location where the disposal takes place
- Running the building for the funeral service
- Flue gas cleaning and maintenance energy in the scope for the cremation
- Milling of the bones for cremation and resomation
- Scattering/Burial/Conservation in columbarium after cremation (including permanent/temporary ash vase)
- Memorial safety (grave removal)
- Land occupation impact
- No end-of-life and maintenance emissions for equipment (cremator, cremulator, resomator, burial: digging tools and elevator/ropes)
- Did not consider alternative materials for coffin e.g. banana, panadas
- Glue fixtures – assumed to be negligible
- Metal American style caskets excluded due to their ability to be used just in the traditional burial, also only a small proportion of coffin choices in UK

Results.

Coffin types.

The results show that Mahogany Veneer coffin would be the most carbon intensive coffin type considering the emissions associated with the production of coffins and biodegradable bag the least carbon intensive option.

Calculations are detailed in Appendix 2.

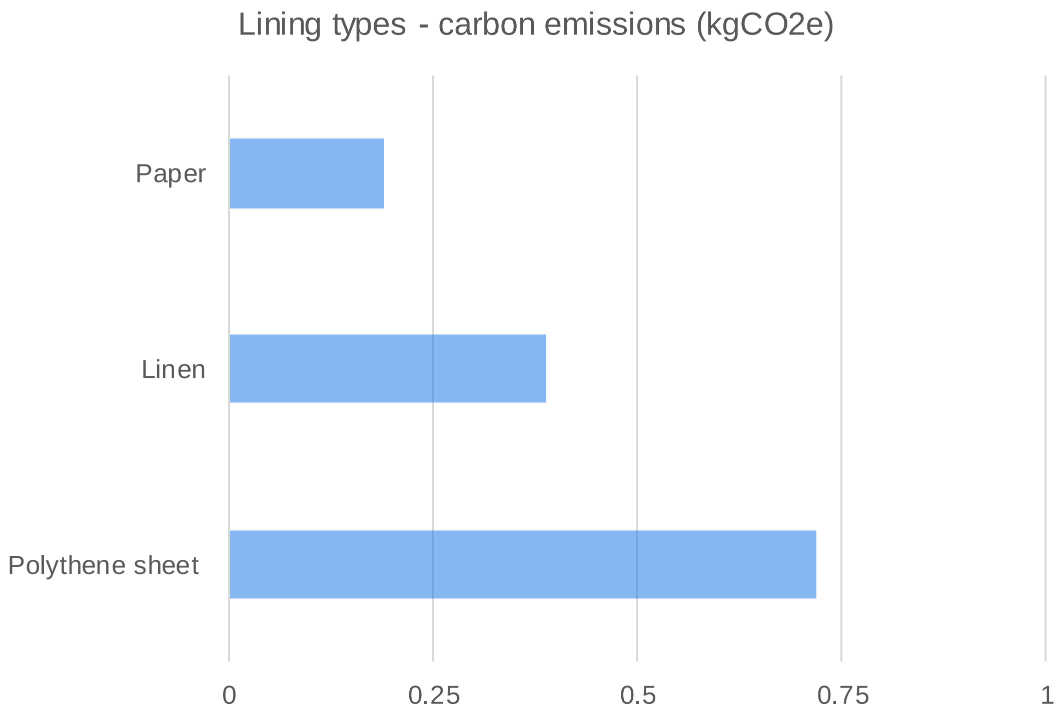


* Calculated by Whitecode and verified by Planet Mark – find details in Appendix 2
** Figure calculated and verified by Planet Mark
*** Figure provided by the industry – find details in Appendix 2

Lining types.

The results show that polythene sheet would be the most carbon intensive lining type considering the emissions associated with the production of the products and paper would be the least carbon intensive option.

Calculations are detailed in Appendix 2.



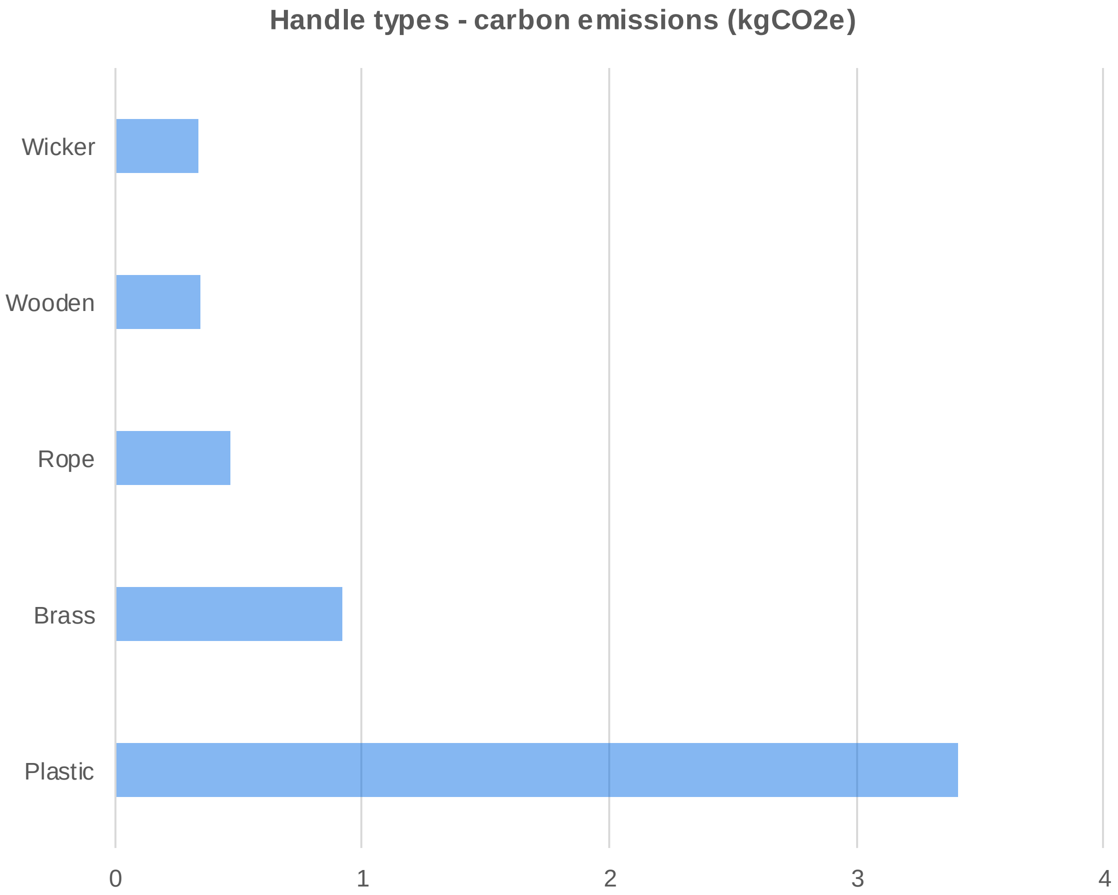
Handle types.

The results show that Plastic handles would be the most carbon intensive ones considering the emissions associated with the production of handles and wooden and wicker handles would be the least carbon intensive option.

It is important to highlight that not all types of handles can be used with every type of coffin. See matrix below.

Calculations are detailed in Appendix 2.

	Handle types				
Coffin types	**Plastic**	**Brass**	**Rope**	**Wooden**	**Wicker**
Mahogany Veneer	yes	yes		yes	
Bamboo (from China)					yes
Vinyl wrapped MDF	yes		yes		
Elm Veneer	yes	yes		yes	
Oak Veneer with chipboard and MDF base	yes	yes		yes	
Oak Veneer – chipboard	yes	yes		yes	
Wicker (British willow) - includes handles					yes
Woollen – cardboard with MDF base					
Cardboard with MDF base			yes		
Solid Oak	yes	yes	yes	yes	
Solid Pine	yes	yes	yes	yes	
Cardboard from recycled content			yes	yes	
Shroud (100% cotton)					
Biodegradable bag					
Woollen shroud (sheep's wool)					

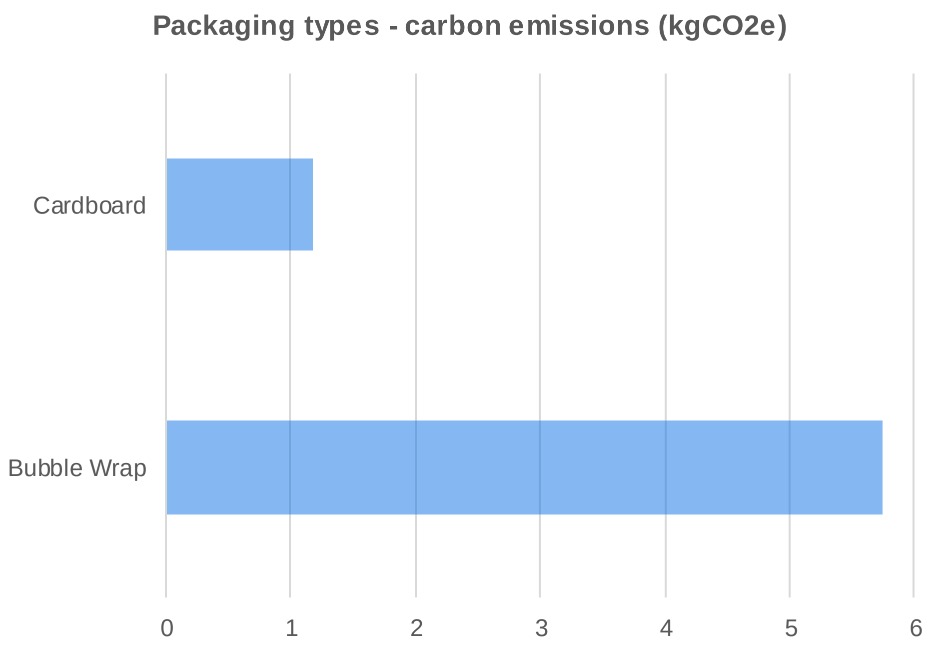


Packaging types.

The two most common types of packaging for coffins' transportation were assessed: cardboard and bubble wrap. Emissions associated with bubble wrap packaging were almost 5 times higher than cardboard.

However, as packaging is not always necessary for this application, having no packaging would mean emitting zero carbon.

Calculations are detailed in Appendix 2.



Summary of coffins and accessories.

The table presented in the next page shows the emissions associated with each coffin, handle, lining and packaging chosen.

Emissions vary from 0.3 kgCO_2e for the biodegradable bag to 43.6 kgCO_2e for the Mahogany Veneer coffin with plastic handles, polythene sheet lining and bubble wrap packaging.

The key is to look at the overall impact when coffin material, handles, lining and packaging are combined – small details like choosing cardboard packaging and wooden handles could reduce the emissions.

Summary.

Coffin types	Packagin types	Plastic Handle Lining types			Brass Handle Lining types			Rope Handle Lining types			Wooden Handle Lining types			Wicker Handle Lining types			None
		Polythene sheet	Linen	Paper	Polythene sheet	Linen	Paper	Polythene sheet	Linen	Paper	Polythene sheet	Linen	Paper	Polythene sheet	Linen	Paper	
Mahogany Veneer with chipboard sides and MDF base	Bubble Wrap	46.6	46.3	46.1	44.1	43.8	43.6				43.5	43.2	43.0				
	Cardboard	42.0	41.7	41.5	39.5	39.2	39.0				39.0	38.6	38.4				
	None	40.9	40.5	40.3	38.4	38.0	37.8				37.8	37.5	37.3				
Vinyl wrapped MDF	Bubble Wrap	42.2	41.8	41.6				39.2	38.9	38.7							
	Cardboard	37.6	37.3	37.1				34.6	34.3	34.1							
	None	36.4	36.1	35.9				33.5	33.1	32.9							
Elm Veneer with chipboard sides and MDF base	Bubble Wrap	41.7	41.4	41.2	39.2	38.9	38.7				38.6	38.3	38.1				
	Cardboard	37.1	36.8	36.6	34.6	34.3	34.1				34.1	33.7	33.5				
	None	36.0	35.6	35.4	33.5	33.1	32.9				32.9	32.6	32.4				
Oak Veneer with chipboard sides and MDF base	Bubble Wrap	40.9	40.6	40.4	38.4	38.1	37.9				37.9	37.5	37.3				
	Cardboard	36.4	36.0	35.8	33.9	33.5	33.3				33.3	33.0	32.8				
	None	35.2	34.9	34.7	32.7	32.4	32.2				32.1	31.8	31.6				
Oak Veneer with chipboard sides and base	Bubble Wrap	40.7	40.3	40.1	38.2	37.8	37.6				37.6	37.3	37.1				
	Cardboard	36.1	35.8	35.6	33.6	33.3	33.1				33.0	32.7	32.5				
	None	34.9	34.6	34.4	32.4	32.1	31.9				31.9	31.5	31.3				
Wicker (British willow)	Bubble Wrap													34.9	34.6	34.4	
	Cardboard													30.4	30.0	29.8	
	None													29.2	28.9	28.7	
Bamboo (from Vietnam)	Bubble Wrap													29.2	28.9	28.7	
	Cardboard													24.7	24.3	24.1	
	None													23.5	23.2	23.0	
Woollen textile with cardboard sides and MDF base	Bubble Wrap																20.6
	Cardboard																16.1
	None																14.9
Cardboard with MDF base	Bubble Wrap							21.6	21.2	21.0							
	Cardboard							17.0	16.7	16.5							
	None							15.8	15.5	15.3							
Woolen shroud (100% sheep's wool)	Bubble Wrap																
	Cardboard																
	None																13.2
Solid Oak	Bubble Wrap	21.4	21.1	20.9	19.0	18.6	18.4	18.5	18.2	18.0	18.4	18.1	17.9				
	Cardboard	16.9	16.5	16.3	14.4	14.1	13.9	13.9	13.6	13.4	13.8	13.5	13.3				
	None	15.7	15.4	15.2	13.2	12.9	12.7	12.8	12.4	12.2	12.6	12.3	12.1				
Solid Pine	Bubble Wrap	20.4	20.1	19.9	17.9	17.6	17.4	17.4	17.1	16.9	17.3	17.0	16.8				
	Cardboard	15.8	15.5	15.3	13.3	13.0	12.8	12.9	12.5	12.3	12.8	12.4	12.2				
	None	14.6	14.3	14.1	12.2	11.8	11.6	11.7	11.4	11.2	11.6	11.3	11.1				
Cardboard from recycled content	Bubble Wrap							14.1			13.9						12.9
	Cardboard							9.5			9.4						8.3
	None							8.3			8.2						7.1
Cotton shroud (100%)	Bubble Wrap																
	Cardboard																
	None																7.5
Biodegradable bag	Bubble Wrap																
	Cardboard																
	None																0.3

Emissions lower than 15.0 $kgCO_2e$

Emissions between 15.1 and 40.0 $kgCO_2e$

Emissions greater than 40.1 $kgCO_2e$

Key findings:

Coffins and accessories.

- Mahogany Veneer coffin would be the most carbon intensive coffin type considering the emissions associated with the production of coffins and the biodegradable bag the least carbon intensive option.
- Polythene sheet would be the most carbon intensive lining type considering the emissions associated with the production of the products and paper would be the least carbon intensive option.
- Plastic handles would be the most carbon intensive ones considering the emissions associated with the production of handles and wooden and wicker handles would be the least carbon intensive option. It is important to highlight that not all types of handles can be used with every type of coffin.
- The two most common types of packaging to transport coffins were assessed: cardboard and bubble wrap. Emissions associated with bubble wrap packaging were almost 5 times higher than cardboard. However, as packaging is not always necessary for this application, having no packaging would mean emitting zero carbon.
- Coffin emissions can vary from 0.3 kgCO2e for the biodegradable bag to 43.6 kgCO2e for the Mahogany Veneer coffin (with plastic handles, polythene sheet lining and bubble wrap packaging).
- In general, coffins have a much bigger carbon impact than the handles or lining.
- The key is to look at the overall impact when coffin material, handles, lining and packaging are combined – choosing cardboard packaging and wooden handles could reduce the emissions.

Methods and processes for final disposal. Natural Burial.

Results	Air	Water	Land
B6: Operational	0 $kgCO_2e$ The carbon emissions associated with natural burial are minimal, especially considering that the digging could be done manually, without the use of machines and any fuel (e.g. diesel).	-	-
10 years	Minimal Release of CO_2 and CH_4	Potential seepage of nutrient-rich fluid into soils, with uptake by surrounding vegetation	Complete degradation of body Majority of the body becomes biomass (microbes, invertebrates, fungi etc)
100 years	-	-	Residual biomass in soil

Most significant environmental impacts that are out of scope: Funeral (including transport to the location), stones and flowers, visiting the final resting place, energy and materials used in the upkeep of the cemetery, land-use.

Potential for improvement

Natural burial graves could be dug without machinery or using machines powered by renewable and sustainable energy.

Please do consider the most sustainable coffins and visiting schedule.

Methods and processes for final disposal. Traditional Burial.

Results	Air	Water	Land
B6: Operational	4.1 $kgCO_2e$ Similarly, to natural burial, carbon emissions associated with traditional burial are not high, the key contribution coming from the digging done by a machine that uses fuel (e.g. diesel).	-	-
10 years	Minimal Release of CO_2 and CH_4	Seepage of nutrient-and carbon-rich fluid into soils, with possible impact on groundwater*	Partial degradation – break down of fats, carbohydrates etc by microbes within the body Minor contribution to biomass
100 years	Higher percentage of carbon released as CO_2 and CH_4		Complete degradation of body Minor contribution to biomass

Most significant environmental impacts that are out of scope: Funeral (including transport to the location), stones and flowers, visiting the final resting place to the cemetery, energy and materials used in the upkeep of the cemetery, land-use.

*There is not a definitive answer and there is not any definitive research as to how much seepage there would be from the coffin in the first ten years - because it would be determined by a number of factors, including the rate that the body decomposes, the state of the coffin after ten years ie how leaky would the coffin be after ten years and the nature of the clothing - so, if the body is dressed in polyester for instance, this might act as a partial sponge. Wet sandy soils in an insubstantial coffin with the body dressed in thin cotton that there might be substantial seepage in the first ten years and movement of the liquid into the soils, but in a heavy, clay soil in a more substantial coffin that it would take a lot longer than 10 years for substantial seepage into the soil and even longer to reach the groundwater.

Potential for improvement

Any opportunity to choose natural burial as more sustainable alternative. Also, please do consider the most sustainable coffins, other funeral choices and any ongoing visiting schedule.

Some materials cause more damage to the environment. For example, the use of plastic accessories could contaminate the soil.
Consider grave re-use as this would allow cemeteries to be re-used indefinitely and could be a sustainable solution to overflowing graveyards.
Consider investing in electric equipment/diggers.

Methods and processes for final disposal. Cremation.

Results	Air			Water	Land
B6: Operational	Natural Gas Cremation	Electric Cremation electricity from national grid average*	Electric Cremation electricity from renewable source**	-	-
	126 $kgCO_2e$	40 $kgCO_2e$	0 $kgCO_2e$		
	Emissions related to body and coffin being combusted can include: - Combustion gases: CO, NOx, SO2 and VOC; - Particulate matter and fine dust: PM10 and PM2.5; - Organic pollutants: PCDDs and PCDFs and PAH; - Heavy metals: Hg				
10 years	-			Throwing ashes in water is largely a question of volume - if the ashes of person are put into a small pond, it would substantially change the chemistry, adding principally calcium phosphates, potassium and sodium and few trace metals. The effect would be to make the water more turbid, alkaline and the phosphate (calcium phosphate is sparingly soluble, but the solubility increase with decrease in pH) might encourage algal growth (ie an algal bloom). Thrown into the sea, it is unlikely to have a significant effect given the dilution – although you could argue that were enough added at the right locations it might be beneficial by beginning to mitigate (buffer) the effects of the acidification of rain and the oceans (carbonic acid being formed from the elevated levels of CO2).	Scattering ashes can damage soils, harm plantlife, alter the pH balance and alter the ecology, but can also benefit soils. There might be instances where a thin scatter on acid/clay soils would help, given the calcium content and high pH, which will help break up the clay aggregates, but would also have to consider the negative effects of high pH and generally high salt levels in the ash. In short, it partly depends upon the nature of the soil receiving and partly on the rate at which the ashes are added – where dumped in a pile, this is likely to be detrimental, where thinly scattered, this is likely to be beneficial. It will most definitely alter the pH and have some impact on the ecology – more so in an acid environment than in an alkaline environment.
100 years	-			-	-

* Location-based type of carbon footprint measurement. A location-based method reflects the average emissions intensity of grids on which energy consumption occurs (using mostly grid-average emission factor data).
**Market-based type of carbon footprint measurement. A market-based method reflects emissions from electricity that companies have purposefully chosen, in this case, choice of renewable energy, calculated using carbon emission factors for your specific electricity supply fuel mix as published on your supplier's website for electricity supplied in the period April 2021 to March 2022.

Most significant environmental impacts that are out of scope: Funeral (including transport to the location), headstones and flowers, visiting the columbarium, energy and materials used in the upkeep of the crematorium, energy and materials used in the upkeep of the columbarium

Methods and processes for final disposal. Cremation.

Potential for improvement

Publish accurate figures for energy consumption for the whole cremation process.

Using electrical cremation that uses energy supplier that procures 100% renewable energy.

The use of biofuel could reduce up to 99.9% of the emissions associated with Natural Gas Cremation but currently, there is no widely available technology that would allow the complete replacement of natural gas with biofuel within the gas cremation. Investment and development in this technology would be beneficial.

Suitable air pollution control equipment, which could include temperature controls, dust control, carbon injection, fabric filtration, air tightness of combustion chambers and casings.

Avoidance of use of PVC, metals and chlorinated compounds in coffins and fittings.

Operational controls, inspection and preventive maintenance.

Optimise the operation to reduce the number of heating and cooling cycles.

Only measured carbon dioxide equivalent. Data for other 'out the chimney' emissions could not be obtained. We recommend this is added to the next phase of assessment for a more accurate result.

Methods and processes for final disposal. Resomation.

Results	Air	Water	Land
B6: Operational	20 $kgCO_2e$	The effluent generated in the process must be treated and disposed accordingly. Impact of chemicals used in the process are not assessed.	-
10 years	-	Throwing ashes in water is largely a question of volume - if the ashes of person are put into a small pond, it would substantially change the chemistry, adding principally calcium phosphates, potassium and sodium and few trace metals. The effect would be to make the water more turbid, alkaline and the phosphate (calcium phosphate is sparingly soluble, but the solubility increase with decrease in pH) might encourage algal growth (ie an algal bloom). Thrown into the sea, it is unlikely to have a significant effect given the dilution – although you could argue that were enough added at the right locations it might be beneficial by beginning to mitigate (buffer) the effects of the acidification of rain and the oceans (carbonic acid being formed from the elevated levels of CO2).	Scattering ashes can damage soils, harm plantlife, alter the pH balance and alter the ecology, but can also benefit soils. There might be instances where a thin scatter on acid/clay soils would help, given the calcium content and high pH, which will help break up the clay aggregates, but would also have to consider the negative effects of high pH and generally high salt levels in the ash. In short, it partly depends upon the nature of the soil receiving and partly on the rate at which the ashes are added – where dumped in a pile, this is likely to be detrimental, where thinly scattered, this is likely to be beneficial. It will most definitely alter the pH and have some impact on the ecology – more so in an acid environment than in an alkaline environment.
100 years	-	-	-

Most significant environmental impacts that are out of scope: Funeral (including transport to the location), headstones and flowers, visiting, energy and materials used in the upkeep of the resomatorium, energy and materials used in the upkeep of the columbarium.

Methods and processes for final disposal. Resomation.

Potential for improvement

The use of electricity from renewable sources could reduce the total emissions in up to 99%, as the emissions associated with electricity could go down to zero and only emissions associated with alkaline solution would remain.

The provision of an on-site effluent treatment plant to avoid transferring the impact and cost of treatment to a public utility company.

Publish accurate figures for energy, water and chemicals consumption for the whole process.

Operational controls, inspection and preventive maintenance.

Key findings:

Methods and processes for final disposal.

- The carbon emissions associated with natural burial are minimal, especially considering that the digging could be done manually, without the use of machines and any fuel (e.g. diesel).
- Immediate carbon emissions associated with traditional burial are small, the key contribution (4.1 kgCO_2e) coming from the digging done by a machine that uses fuel (e.g. diesel). However, when we look at the impact on the environment for the longer period of 100 years, there is a seepage of nutrient-and carbon-rich fluid into soils, with possible impact on groundwater as well as more CO_2e emission and there is only a small positive contribution to biomass.
- Natural Gas Cremation is the process with the highest carbon footprint for the energy consumption stage of lifecycle.
- Carbon emissions associated with Resomation are low. However, the impact associated with chemicals used and effluent disposal were not analysed in this report, as there is no data available in the public domain.

The Bigger Picture.

Impacts that generate carbon emissions after funeral

Although it is mentioned that some activities are out of scope, in order to provide a clearer view of the results and to inform the importance of considering post-funeral and other factors, emissions related to visiting memorial places of significance have been estimated.

Important examples include granite stone (raw material and extraction, 60 kg), bringing flowers and travelling 10km to site (or 20km return) with an average car over 20 year period. 2 scenarios were created in which the frequency of visiting changes.

1. In the first scenario, a family visits the memorial place once a month over the first 5 years, then this is reduced to twice a year between years 6 and 20.
2. In the second one, a family visits the memorial place 3 times a year over 20 years.

Environmental impacts that are out of the scope

- Maintenance of the location
- Engraving of the stone has not been accounted for but it is considered to be de-minimus.

Potential for improvement

- It is recommended that maintenance is addressed as the next stage of LCA assessment in the future.
- Bringing flowers from our own gardens or reducing the amount of flowers that we bring
- Travelling in a sustainable way – fully electric car, cycling, walking or using public transport (electric buses or trains are the least emitting options)

Scenario	Granite Stone	Flowers	Transport	Total
1	42 kgCO_2e	80 bouquets = 136.8 kgCO_2e	90 visits = 307.2 kgCO_2e	486.0 kgCO_2e
2	42 kgCO_2e	60 bouquets = 102.6 kgCO_2e	60 visits = 204.8 kgCO_2e	349.4 kgCO_2e

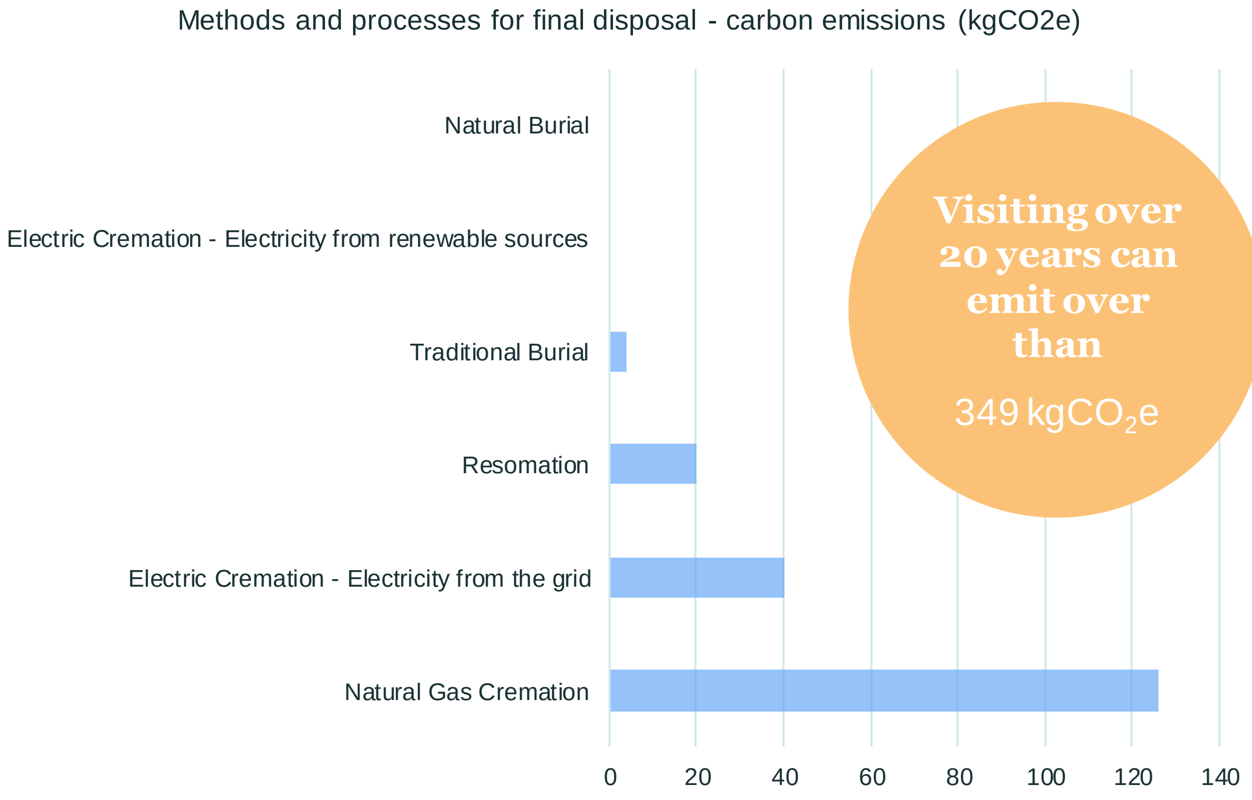
Summary - The Bigger Picture.

Natural Gas Cremation is the process with the highest carbon footprint for the operational stage of lifecycle, but when looking at the whole end to end process, visiting memorial places of significance can have a much higher impact over the years than any of the disposal methods.

These emissions are estimated and will depend on the mode of transport, distance, quantity of visits, flowers and other objects that may be taken to the place.

For example, a 20km trip emits:

- **3.4 $kgCO_2e$ by an average car**
- **1.9 $kgCO_2e$ by bus per passenger**
- **0.7 $kgCO_2e$ by train per passenger**
- **2.3 $kgCO_2e$ by an average motorbike**



Visiting over 20 years can emit over than

349 $kgCO_2e$

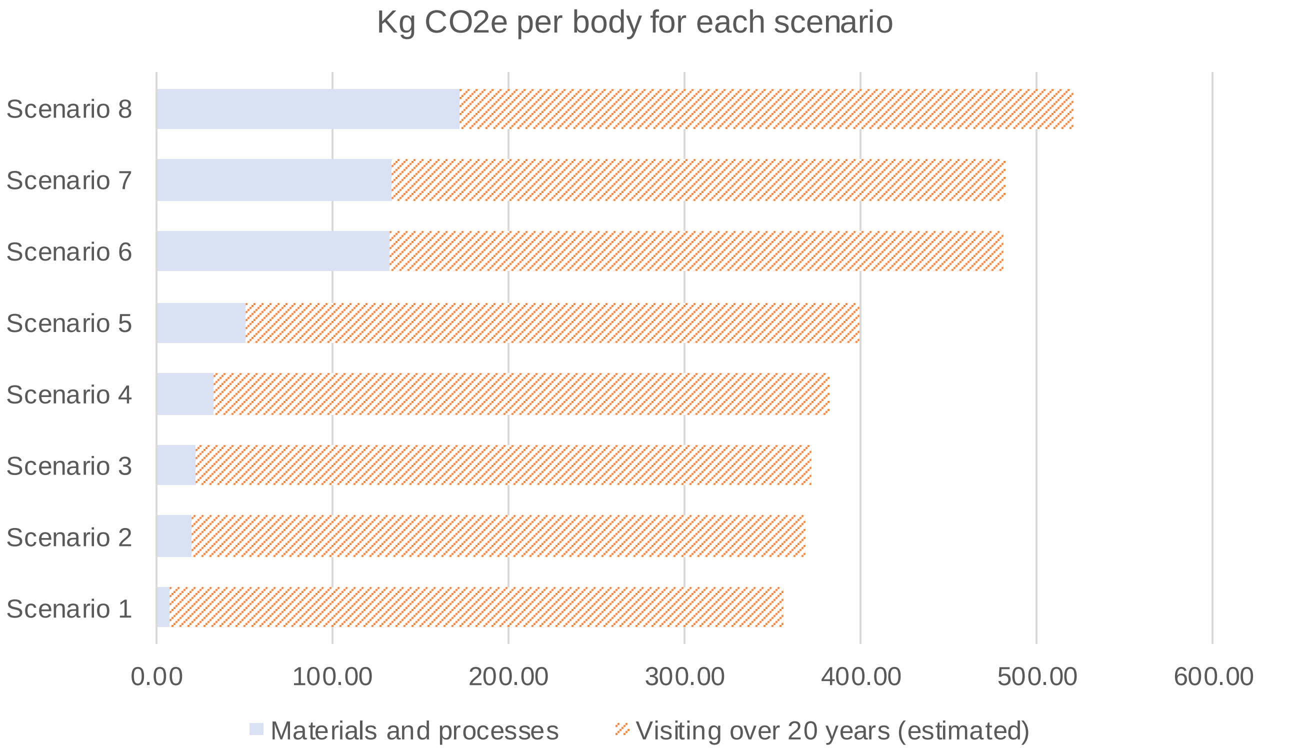
Most significant environmental impacts that are out of scope: Funeral (including transport to the location), Energy and materials used in the upkeep of the location, Land-use, Energy and materials used in the upkeep of the crematorium / resomatorium

Scenarios.

The results show that there isn't only one option. There are many variables, and how sustainable the process is will depend on the choices made.

To help visualising the different overall results, see below the total carbon emissions associated with the whole life of 8 scenarios for one body. Please refer back to the exclusions list to understand what is out of scope.

	Coffin Type	Handle Type	Lining Type	Packaging Type	Body Disposal Method
Scenario 8	Mahogany veneer	Plastic	Polythene sheet	Bubble Wrap	Cremation
Scenario 7	Cotton shroud	None	None	None	Cremation
Scenario 6	Cardboard from recycled material	Wooden	Polythene sheet	None	Cremation
Scenario 5	Mahogany veneer	Plastic	Polythene sheet	Bubble Wrap	Traditional Burial
Scenario 4	Biodegradable bag and woolen shroud	None	None	None	Resomation
Scenario 3	Bamboo	Wicker	Paper	None	Natural Burial
Scenario 2	Biodegradable bag	None	None	None	Resomation
Scenario 1	Cardboard from recycled material	Rope	Polythene sheet	None	Natural Burial



Collective impact.

The emissions may not seem significant when looking at one single body, but when analysed collectively, the impact is massive.

There were 689,629 deaths in the United Kingdom in 2020, in which, 543,293 were cremations.

This means that, collectively, we can reduce more than 400 thousands tonnes of carbon emissions by choosing consciously.

Perspective.

What do those figures mean?

100 $kgCO_2e$ per body

- Equivalent to extract, process, manufacture and transport **1 tonne** of concrete
- **11** gallons of gasoline consumed
- **12,164** smartphones charged with electricity from the grid

400,000 tCO_2e per annum in the UK

- **70,606** homes' electricity use for one year
- **900 million** miles driven by an average gasoline-powered passenger vehicle, this is equivalent to 2 million travels from London to Edinburgh
- **36 millions** of gallons of diesel consumed

Next Steps.

Next steps for the industry.

- Gather as much actual data within the industry as possible and share it as open source so more detailed comparisons and life cycle assessments can be undertaken.
- It is recommended to look at the process as a whole – from immediate emissions from coffins, accessories and mode of disposal as much as the long-term considerations such as land use and maintenance of the disposal locations impact of the visiting the final resting place and pollution to the soils.
- Educating people and the industry can change the future. It is important to ensure that people and the industry understand the impacts of their choices. By providing them with the right tools, they can choose consciously.
- There is a great opportunity for trade associations to show leadership and invest in research and encourage the transition.
- Keep informed and act ahead of requirements mandated in legislations. The requirements for measuring emissions from cremators are currently under review and new targets should be published soon.
- Consider removing certain products and processes from the funeral care supply chain if there is evidence that they have a negative environmental impact and better alternatives are readily available

Next steps for funeral directors.

- Assist the industry and consumers in making their decisions by supporting further research and making data available.
- Improve public knowledge and awareness to make evidence-based environmental choices.
- Encourage industry change and improvement by supporting carbon reduction targets.
- Support policy makers.

Next steps for policy makers.

- Use the data available to provide guidance, consistency, accountability and clarity on how an organisation must operate to be sustainable.
- Incentivise and provide the industry with the tools to reduce carbon emissions.
- Updating policies and regulations can be a long process. We need to act fast to help the industry to standardize to the best level.

Next steps for consumers.

- Funeral planning and choices shouldn’t be a taboo subject. Read about the options available, get informed and choose consciously.
- Reflect about all choices, i.e., coffin types, accessories and body disposal methods.
- Post funeral activities, like regularly visiting places for memorialization, can have a significant environmental impact - local, lower impact activities could be encouraged.

About this report.

APPENDIX

About this report – General.

Company Name	Full Circle Funerals
Project Initiator	Sarah Jones, Director, Full Circle Funerals
Funded by	This project was funded by the community through a crowdfunding campaign. Find more information here: https://www.crowdfunder.co.uk/p/what-is-the-greenest-funeral
Peer review by	Please see Appendix D – Page 70
Calculations by	Isabella Valencio, Senior Sustainability Consultant, Planet Mark David Hackett, Founding Director, Biora Ellen Huelin, Associate Director, Whitecode Katy Venables, Sustainability Consultant, Whitecode
Verification by	Rima Trofimovaite, Head of Certification, Planet Mark Jamie Beevor, Head of Technical, Planet Mark
Date	6 July 2023

Calculations.

APPENDIX

Coffins.

Coffin	Description	Total kgCO2e	Source
Mahogany Veneer with chipboard sides and MDF base	Veneer 0.01395m3, MDF base 0.0169m3, chipboard 24kg	36.72	Based on standard coffin size and thickness of materials
Vinyl wrapped MDF	Vinyl 0.01kg, MDF 0.054565m3	32.28	Based on standard coffin size and thickness of materials
Elm Veneer with chipboard sides and MDF base	Veneer 0.01395m3, MDF base 0.0169m3, chipboard 24kg	31.83	Based on standard coffin size and thickness of materials
Oak Veneer with chipboard sides and MDF base	Veneer 0.01395m3, MDF base 0.0169m3, chipboard 24kg	31.06	Based on standard coffin size and thickness of materials
Oak Veneer with chipboard sides and base	Veneer 0.01395m3, chipboard 35kg	30.78	Based on standard coffin size and thickness of materials
Wicker (British willow)	14.82kg	28.18	UK willow coffin supplier – details on request
Bamboo (from Vietnam)	15kg	22.43	Assumption based on coffin size https://www.inbar.int/resources/search/?resource-type=all&keyword=lca
woollen textile with cardboard sides and MDF base	Woollen textile 27kg, Cardboard 0.074m3, MDF 0.0169m3	14.88	Based on standard coffin size and thickness of materials
Cardboard with MDF base	Cardboard 0.074m3, MDF 0.0169m3	14.63	Based on standard coffin size and thickness of materials
woollen shroud (100% sheep's wool) optional for resomation	Emission factor: 20 kgCO2e/kg Weight of the bag: 0.66kg	13.20	Based on average emission factor extracted from Ecoinvent, emissions factors vary from 10 to 25 kgCO2e/kg
Solid Oak	0.067169m3	11.57	Based on standard coffin size and thickness of materials
Solid Pine	0.067169m3	10.51	Based on standard coffin size and thickness of materials
Cardboard from recycled material	Total volume of material 0.11 m^3 Density 90 km/m^3	7.1	Based on standard coffin size and thickness of materials, average cardboard density and recycled cardboard emission factor
Cotton shroud (100% standard cotton)	Weight of the bag: 0.66kg	7.5	Assumption based on the bag size - 0.2mm thick and this worked out at 0.66kg of cotton in total assuming standard body size
Biodegradable bag	Emission factor: 11.8 kgCO2e/kg Weight of the bag: 0.023 kg Dimensions: 812.8mm x 2235.2 mm (no thickness info)	0.27	Based on standard bag size sourced from: https://www.classicplasticscorp.com/classic-pva.html PVA Emission factor from: https://www.aquapakpolymers.com/ https://www.ecocostsvalue.com/data/

Material thickness.

Material	Thickness
Base/sides/lid MDFchipboard	15mm
Veneer	5mm
Solid wood	18mm
Cardboard	22mm
Vinyl wrap	0.06mm
Cotton/linen	0.2mm
Wool	5mm
polythene sheet	0.075mm
Paper	0.05mm

Linings.

Coffin	Description	Total kgCO2e	Source
polythene sheet	0.29kg and thickness 0.075mm	0.72	Based on standard coffin size and thickness of materials
Paper	0.16kg and thickness 0.05mm	0.19	Based on standard coffin size and thickness of materials
Linen	0.33kg and thickness 0.2mm	0.39	Based on standard coffin size and thickness of materials

Handles.

Coffin	Description	Total kgCO2e	Source
Plastic	0.04kg	3.41	Industry knowledge (Luke Lambert through Sarah Jones)
Brass	0.215kg	0.92	Industry knowledge (Luke Lambert through Sarah Jones)
Rope	0.12kg	0.47	Online
Wood	0.18kg	0.35	Online
Wicker	0.18kg	0.34	Online

Packaging.

Coffin	Description	Total kgCO2e	Source
Bubble Wrap	2kg	5.74	Assumption based on material required to package standard coffin
Cardboard	2kg	1.17	Assumption based on material required to package standard coffin

Methods and processes for final disposal.

Process	Consumption	Emission Factor	Total kgCO2e	Source
Natural Gas Cremation	600 kWh of Natural Gas	0.21 kgCO2e/kWh	126	Emission factor: BEIS 2022 Consumption: the ICCM list of crematorium which lists England, Wales, Scotland, Northern and Republic of Ireland, Isle of Man and the Channel Islands was used. All companies from this list were contacted and 11 responses were received. This allowed an average value of 600kWh per cremation to be used. Crematoriums who responded with usage data: Croydon, Isle of Man, Lambeth, Leeds, NE Lincs, Woodlands, North Devon, Stockton, Maidstone, Park Grove, Wealden, Kings Lynn.
Electric Cremation - Electricity from the grid	190 kWh of Electricity and Transmission and Distribution	0.21107 kgCO2e/kWh	40	Emission factor: BEIS 2022 Consumption: Very few crematoriums are currently electrically powered however new crematoriums are being encouraged to be planned as electrically powered to take advantage of the decarbonising grid. The carbon emissions for electric cremation was taken from ‘ A comparison of gas and electric cremator emissions in the UK’ Ben Copeland , April 2021
Electric Cremation - Electricity from renewable sources	190 kWh of Electricity and Transmission and Distribution	0 kgCO2e/kWh	0	Emission factor: BEIS 2022 Consumption: same as above
Resomation	1800 litres of water supply	0.149 kgCO2e/m^3	0.2682	Emission factor: BEIS 2022 Consumption: Industry knowledge (Howard Pickard, LBBC Group)
	1800 litres of wastewater	0.272 kgCO2e/m^3	0.4896	Emission factor: BEIS 2022 Consumption: Actual data provided by Howard Pickard, LBBC Group
	90 kWh of Electricity and Transmission and Distribution	0.21107 kgCO2e/kWh	18.9963	Emission factor: BEIS 2022 Consumption: Body disposal in Portugal: Current practices and potential adoption of alkaline hydrolysis and natural burial as sustainable alternatives
	Single-use plastic bag for transportation of the body	2.6 kgCO2e/kg	0.06	Emission factor: BEIS 2022 Weight: 0.023 kg

Methods and processes for final disposal.

Process	Consumption	Emission Factor	Total kgCO2e	Source
Traditional burial	Diesel, assumed for a standard excavator uses 7 L/per hour, assumed digging takes 1 h in summer and 2-3h in winter = average of 1.5h is used Total litres of fuel used = 7*2=14L Size of the grave is assumed 36" wide by 8' long and approximately 4 – 5' deep.	2.75857 kgCO_2e/L	4.1	Emission factor: BEIS 2022 Specification Maximum Digging Depth 4.21m Machine Height 2.83m Machine Weight 8250kg Tank Capacity 103 litres Fuel Consumption 7 L/per hour

Visiting the final resting place.

Scenario 1 - a family visits the memorial place once a month over the first 5 years, then this is reduced to twice a year between years 6 and 20.

Process	Consumption	Emission Factor	Total kgCO2e	Source
Transport	Assumed 20 km travelled (return) once a month years 1 to 5, then twice a year from year 6 to 20	Average car unknown fuel: 0.17067 $kgCO_2e$/km	3.4134 $kgCO_2e$ per travel 307.206 $kgCO_2e$ over 20 years	Emission factor: BEIS 2022 Estimation: Planet Mark
Granite stone	Assumed 60 kg stone	Granite Stone: 0.7 $kgCO_2e$/kg	42 $kgCO_2e$	Emission Factor: OneClick – ICE Estimation: https://www.cem.va.gov/hmm/types.asp
Flowers	15 stems mixed outdoor UK grown flowers, grown and sold locally	5 Kenyan roses + 3 Dutch lily + 3 Kenyan gypsophila – 31.132 Kg Co2 5 Dutch roses + 3 Dutch lily + 3 Kenyan gypsophila – 32.252 Kg CO2 5 outdoor grown UK snapdragons + 3 UK lily + 3 UK alstroemeria – 3.287 Kg CO2 15 stems mixed outdoor UK grown flowers, grown and sold locally (eg to Booths supermarket, Lancashire) – 1.71 Kg CO2 1.71 $kgCO_2e$ per bouquet	136.8 $kgCO_2e$ for 80 bouquets over 20 years	https://www.flowersfromthefarm.co.uk/learning-resources/the-carbon-footprint-of-flowers/

Visiting the final resting place.

Scenario 2 - a family visits the memorial place 3 times a year over 20 years.

Process	Consumption	Emission Factor	Total kgCO2e	Source
Transport	Assumed 20 km travelled (return) 3 times over 20 years	Average car unknown fuel: 0.17067 kgCO_2e/km	3.4134 kgCO_2e per travel 204.8 kgCO_2e over 20 years	Emission factor: BEIS 2022 Estimation: Planet Mark
Granite stone	Assumed 60 kg stone	Granite Stone: 0.7 kgCO_2e/kg	42 kgCO_2e	Emission Factor: OneClick – ICE Estimation: https://www.cem.va.gov/hmm/types.asp
Flowers	15 stems mixed outdoor UK grown flowers, grown and sold locally	5 Kenyan roses + 3 Dutch lily + 3 Kenyan gypsophila – 31.132 Kg Co2 5 Dutch roses + 3 Dutch lily + 3 Kenyan gypsophila – 32.252 Kg CO2 5 outdoor grown UK snapdragons + 3 UK lily + 3 UK alstroemeria – 3.287 Kg CO2 15 stems mixed outdoor UK grown flowers, grown and sold locally (eg to Booths supermarket, Lancashire) – 1.71 Kg CO2 1.71 kgCO_2e per bouquet	102.6 kgCO_2e for 60 bouquets over 20 years	https://www.flowersfromthefarm.co.uk/learning-resources/the-carbon-footprint-of-flowers/

Sources.

APPENDIX

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Peer review.

APPENDIX

Peer review.

The people and companies listed below were part of the peer review, which took place in December/2022 and January/2023. Some of the people that were part of the peer review did not want to have their names disclosed and were, therefore, excluded from the list below.

1. Clare Montagu (Poppy's Funerals)
2. Fran Hall (Good Funeral Guide)
3. Gemma (Association of Green Funeral Directors - AGFD)
4. Howard Pickard (LBBC)
5. James Leedam (Leedam Natural Burial)
6. Jamieson Hodgson (Memoria Ltd)
7. Ken West and Ann West (Natural Burial Ground)
8. Mark Binnersley (Content & copywriting for fintech & funerals)
9. Mark Pawlett (Cranfield University)
10. Rosie Inman-Cook (Natural Death Centre)
11. Simon Holden (Faunus Group Ltd)
12. William Wainman (Association of Green Funeral Directors – AGFD, CCSA and Ecoffins)
13. Yuli Somme (Bellacouche)

Summary of the feedback received.

- We have received a total of 237 comments. All comments were assessed and taken into consideration where possible.
- Comments may not have been addressed due to 2 main reasons: out of scope or change in the meaning of what is written.
- Suggestions in the copy, formatting, colour and word choices were assessed. Unless they would change the meaning of the phrase, the update was made.
- Clarifications around sources, calculations, exclusions and constants were added throughout the report.
- The way ‘visiting a specific place for memorial purposes’ is presented in the report was updated following feedback received.
- Land impact from the disposition of cremated remains (ashes) was updated.
- Figures that could be misled out of context were removed.
- Next pages summarise the feedback received that was partially or not addressed in the report.

Summary of the feedback received (i).

Peer Review comment	Planet Mark comment
Requests to add the following materials: - Lining types: callico and polyester trimmings - Pillows, wadding - Coffin types: pure cardboard coffin, eco2 coffin range created by Ecoffins, American Style Caskets, Banana and Pandanus Coffins, - Coffin covers - Wrapping: eco-friendly (biodegradable) bubble wrap and cotton bags which are recycled by returning them to the coffin company.	These were out of scope, but they can be considered in future evaluations. Banana and pandanus coffins were researched but no data could be found and therefore calculations could not be done.
1 - Carbon emission results for visiting a specific place for memorial purposes' do not accurately reflect reality. Cars will be replaced by electric cars in less than 20 years and this is not reflected in the calculations. The frequency of visits is not quantified. 2 - I think one further thing we could clarify in the report is that visitation emissions are based on current transport impacts and are likely to reduce as the transport network becomes greener with EVs, improved public transport options etc. And perhaps it could be mentioned that it is incumbent on the funeral industry to factor travel into future infrastructure, eg building green burial options in more populated areas. Many of the privately owned crematoria seem to be out in the sticks too! 3 - Most of us will have trips to the countryside for recreation and as tourists visiting natural places which enhance wellbeing and this might include visiting a burial site as part of that visit. Why focus on these relatively local visits, when most of the population appear to be comfortable with the idea of regular plane trips for holidays? Also, there are figures that show that visits to graves decline as the years go by, so I wonder if this is quantifiable or even valuable. 4 - I feel that comparisons between private fossil fuel vehicles and electric ones, in years to come, will prove to have a very similar footprint as we develop more sophisticated systems which include the whole life analysis of things (the damaging mining of lithium and other earth minerals needed for batteries, etc) Public transport will always be preferred. Electric bikes will most likely always be the best. But that is my assumption; these things need rigorous analyses by those qualified to do so. 5 - Although much attention is given to carbon emissions from dispositions, coffins etc, the single biggest producer of CO2 on the day of the funeral is almost always the fuel used to get the deceased, their family, friends and relatives. etc to the place where the ceremony, wake (and even possibly a memorial service at some stage afterwards) are held. Some of these people might be flying in from abroad or travelling long distances throughout the UK. Most crematoria, cemeteries and natural burial grounds are located outside city and town centres and may not be accessible to public transport. Some people do not share vehicles, and some may even arrive and depart by taxi, which is even less fuel-efficient. So why has this elephant in the room been excluded? There needs to be some method by which a family can at least estimate the carbon footprint of this aspect of the funeral. This might embolden them to think about encouraging guests to car share etc.	The way visiting is presented in the report was updated and the carbon emissions associated with each mode of transport for each singular travel was included, so that the public can estimate their emissions based on their habits. However, Planet Mark estimation for visiting over 20 years considers the use of an average vehicle. This section was included to provided the audience an overview/estimation of how big the emissions related to visiting can be.

Summary of the feedback received (ii).

Peer Review comment	Planet Mark comment
The focus on 'visitation' is problematic for me in a report focusing on the actual process of body disposal. I understand the need to reference the carbon impact of bereaved people visiting the grave or cremated remains plot, however because it is so large a factor, it somehow minimises the hugely important findings about the options of coffin / lining / handles and method of disposal.	The idea is to present the bigger picture and put the carbon emissions into perspective. Every step of the journey should be taken into consideration.
Diggings for natural burial are not done by hand.	This was part of the scope of the project stablished as literature available states that diggings for natural burial are done by hand.
The calculations for the 'methods and processes of final disposition' on pages 59 and 60 do not include those for natural burial. Even though earlier in the report this is cited as being 'minimal', it surely should be shown with zero values in the chart showing the findings for comparative purposes?	The carbon emissions related to natural burial process itself, i.e., manually digging a whole in the ground, is negligible and can be assumed zero.
Shipping / transportation costs of the coffin have been excluded - is there a specific reason for that? It's something we've looked into in terms of how we advise clients - significant costs associate with importing a foreign produced coffin versus locally made willow, for example.	LCA considers the extraction of material, processing, manufacturing and transportation materials to the point of sale and transport to 100 miles location after that. Except for the imported material that is fabricated in China, which we have used actual distance.
1 - The number of excluded processes concerns me. Excluding the heating-up cycle for a series of cremations from the calculations is not right. The carbon cost of that should be apportioned. The carbon cost of pulverising the ashes should also be included for both cremation and resomation. For Resomation, the carbon cost of the chemicals used is a vital figure that should be included. There is vagueness about the disposal of effluent from the Resomation process and the carbon cost of its treatment down the line is also missing. 2 - There should be allowance made for the energy used to heat up a cremator to operating temperature divided among the average number of cremations undertaken before the cycle repeats.	We acknowledge that there is room to expand the scope of work, but in oder to be able to progress with the research, boundaries had to be stablished. The items that were out of scope in this evaluation, should be considered in future studies, and if data is available in the future, should be included. For cremation, we have used an average time provided by the crematoriums, which takes into consideration the heat up time.
There is a publicly available environmental report from TNO produced in the Netherlands that whose headlines state Burial has the biggest environmental impact of all methods – quite a contrast. I fully appreciate that there will be detail that explains this better but that is not the message that gets communicated.	Our results are based on carbon emissions (CO_2e) associated with the production of the coffins and accessories and the ones released in each of the disposal method.

Summary of the feedback received (iii).

Peer Review comment	Planet Mark comment
1 - I cannot understand the way the emissions from electric cremation is presented. It is reported that electric cremation produces 0 CO2e when using renewable electricity – this is crazy. How can this be? Even the report itself states that 'In addition to the CO2 released from the body and coffin' – does this not apply to electric cremation irrespective of the fuel source or have I missed something. That is apart from debating the wider rights or wrongs of 0 CO2 from renewable electricity. 2 - If gas cremation has a figure of 126kg CO2 How can electric cremation have a figure of only 40 kg CO2 ? The body and the coffin produce more than this when burnt, regardless of cremation type. If you are not factoring in the CO2 from the body and the coffin at this stage, it needs to clearly state this as I am confused by it. 3 - mention of electricity made from renewables: does this include nuclear, and wood chip. There are lawful questions surrounding one of the main providers of wood chip to Drax Power Station, as highlighted in a BBC Panorama documentary on 3/10/2022. The use of electricity to dispose of bodies will always be questionable when there is a viable alternative with zero emissions; natural burial. Emissions from chimneys will never be able to completely eliminate all emissions	Gas cremation uses natural gas to heat the chamber and electric cremation uses electricity. They have different emission factors and therefore they will emit different quantity of carbon in the process. Total carbon emissions presented in the report represents the emissions associated with with process itself, i.e., burning fuel. Renewable energy sources provided by the sun or wind for example are replenished by nature and emit little to no greenhouse gases or pollutants into the air. All of them don't include the CO2 released from the body and coffin - which is a constant to all the cremation processes. This is clearly stated in the report now.
It is stated that biofuel could reduce up to 99.9% of the emissions associated with Natural Gas Cremation – is a body not burnt here??	The reduction is associated with the emissions released by burning the fuels. In order to support the fair comparison between the different body disposal choices, some constants were considered across the calculations, including a non-gender-specific 70kg body (no tumors, implants, pacemakers or metals). This is a constant for all the studied cases.
126 kgCO2e for cremation - What are the sources of this information? Have they been independently verified? The ICCM and the Cremation Society have been unable to provide me with reliable figures, and those given seem low.	The ICCM list of crematorium which lists England, Wales, Scotland, Northern and Republic of Ireland, Isle of Man and the Channel Islands was contacted and 11 responses were received. This allowed an average value of 600kWh per cremation to be used. Carbon emissions were calculated using this average consumption.

Summary of the feedback received (iv).

Peer Review comment	Planet Mark comment
1 - The incomplete nature of the Resomation data should disqualify their results from being published, and certainly the scenari os provided should be reworked to include them only if full weighting is given to their complete process. 2 - The impact of Resomation could not be fully assessed because the impact associated with chemicals used in the process and the impact of treating the effluent created by the process have not been disclosed. The description of the process also failed to disclose the additional single-use plastic body bad that would be used for the collection and transportation of the body. The figures for Resomation are therefore incomplete, not comparable and as such are inadmissible.	Due to lack of publicly available data at this point, assumptions had to made and boundaries had to be set. However, we do encourage future studies on the topic.
Traditional burial - Our grave digging teams report that it takes on average 30 mins of machine time to dig and 30 mins to backfill - 1hr per grave	We have considered 1.5h on average, as digging time varies according to the site condition and time of the year.
under traditional burial you state that carbon emissions are not high. Should you add 'this is because the high carbon cost of grave maintenance and the stone memorial is yet to be assessed' as mentioned previously?	This part of the report refers to the process only.
20kgCO2e for Resomation - What is the source of this figure? Has it been independently verified?	Emissions regarding the resomation process were calculated following data publicly available in the literature. Sources and figures can be found in the appendix.
We have considered the use of resomation in detail and ultimately concluded that it would be almost as environmentally unfriendly as natural gas cremation. I have attached an extract from a report performed by Cemetery Development Services which seems to echo our view. The major issue with resomation is the heating process that is required for the water used in the process to reached the required 150 degrees centigrade. This needs to be performed by gas fuelled burners which in itself has a great deal of the same issues as gas cremation. As a result, I am afraid that the claim that resomation creates 84% less emissions than natural gas cremation would appear to be misleading – even with your caveat that chemicals used were not analysed when drafting that statement.	The emissions were calculated following data publicly available in the literature. We have adjusted the text to clarify the calculations and exclusions.
Resomation ? As far as I am aware this is not licensed in the UK, Please check for evidence, particularly a grant of planning permission. Crucially this will include approval by the EA and DEFRA for the disposal of effluent. Presenting concepts as facts can mislead everyone into thinking this is already available in the UK.	There is a company that does resomation in the UK and literature available.

Summary of the feedback received (v).

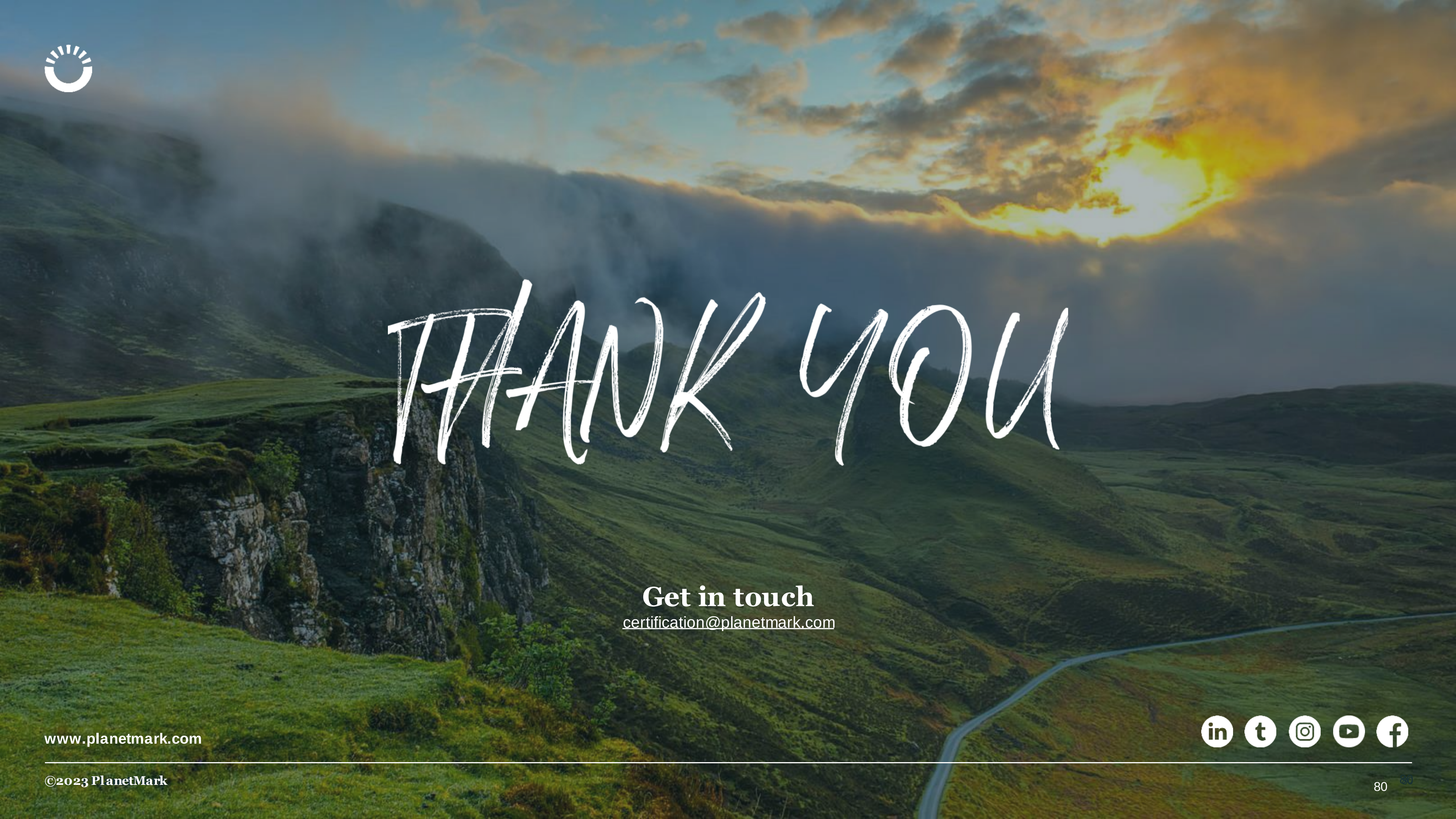
Peer Review comment	Planet Mark comment
The 70 kg body weight appears a very conservative figure these days. I am 66 kg and yet very slim. Wiki shows 85 and 72 for male and female, an average of closer to 79 kg / your choice of 70 kg seems on the low side. Further, all pacemakers have to removed anyway and metal splints are not recorded so could not be excluded without x-ray. I am not sure how you have ensured that the body has no tumours. These, in all cases of cancer, do take much longer to cremate, especially if a male. A person dying of Alzheimer's might not state that cancer was present. I don't think that using the word tumour is helpful in any way. Female bodies cremate much quicker but the report does not mention that or the helpful incendiary benefit of fat. I am surprised that you use non-embalmed bodies when the vast majority of cremations are put through the embalming process. A comparison of the two would have been interesting. Also, if questioned how have they ensured that no personal items, let alone a body bag, have been placed in the coffin? Removing the coffin lid is, surely, the only way this can be confirmed? Similarly, how did they ensure that only cotton clothes were on the body? Usually, a funeral director shroud is placed over the body and is typically made of artificial material.	These were constants adopted in order to proceed with the calculations
the figure of 60 kg of granite for the memorial seems very low. A headstone on a traditional grave (lawn grave) would weigh well above that. Is the granite imported from, say, India or China because it is prohibitively expensive to procure in the UK?	The source for the weight considered is presented in the report.
Many of these so-called mahogany coffins are actually mahogany effect (other woods stained a rich brown colour). If mahogany (or even sapele) are actually used, the sustainability of this practice needs to be questioned as both trees are endangered due to over-harvesting, and are also huge carbon sinks during their long lifespans. It is worth noting that despite this, the report appears to give them an almost identical 'Total kgCO2e' score as an oak veneer coffin which is presumably made with native grown oak harvested in the UK. This doesn't appear to be a fair representation of the difference in these materials.	The report looks into the carbon emissions associated with the material extraction and production of the coffins. Calculations consider mahogany wood
LifeArt Ltd claim to be using a material called 'enviroboard', which supposedly has many environmental benefits over other coffin materials. However, on a visit to the cardboard product supplier, Triwall in Monmouthshire, a few years ago, we were shown samples of the material that this company was using to manufacture LifeArt's coffins. The material was in fact standard cardboard – exactly the same material that Triwall were using to make all their other products.	LifeArt Life Cycle Assessment report was verified and we have no reasons to believe that the carbon emissions presented in their report are incorrect.
The report also talks quite a bit about visitation emissions but lacks any insights about the emissions caused by the manufacture and maintenance of cremation and resomation equipment.	Manufacture amd maintenance of cremation and resomation equipment as well as maintenance of cemetery, were out of scope of this report due to lack of data and resource. It is recommended that these sources are evaluated in future assessments.
When looking at the report as a whole, you can clearly see the area they struggled for data on – which is kind of a statement in its own right! The scrutiny of the caskets etc I think is very informative and useful and it is definitely the first time I've seen anyone even scratch the surface of the topic, let alone produce useful and quotable data.	-

Summary of the feedback received (vi).

Peer Review comment	Planet Mark comment
reinforce this is “scenario document” within the objectives or say no physical testing of the coffins has taken place	This is explained in the methodology and it has been made clearer after the peer review.
Page 8 – last paragraph relating to Green House Gases should have more visibility throughout the report as CO_2 / CH_4 / N_2O are critical measures	The methodology adopted was to calculate the carbon equivalent, which includes the main seven Green House Gases (GHGs) that contribute to climate change, as covered by the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). It is more relevant to show the results in carbon equivalent as these 3 gases mentioned are not the only ones causing global warming and that is why carbon dioxide equivalent (CO_2e) is used when talking about climate change.
Re coffin and accessories description: 1 - needs consistency for all coffin types regards weight / material used / country of origin (to include delivery CO_2) 2 - Imported is definitively relevant in the context of carbon, but surely some of the other woods are imported as well.	We have used the information that we had for each type of coffin, keeping them as streamlined as possible. The methodology has been updated to state that we have considered a default delivery distance of 100 miles for all coffins and accessories, unless stated in the specification.
Constants and exclusions: body would be washed even if not embalmed	Emissions related to washing the body for any type of funeral were excluded as the emissions would be de-minimus : it would be 0.421 $kgCO_2e$ per m^3 of water (including wastewater). For reference, a common shower uses 60 litres of water which would be 0.03 $kgCO_2e$

Post-Publication Feedback.

Feedback received after the report was made public in May/2023	Planet Mark comment and report updates
Association of Green Funeral Directors – AGFD, CCSA and Ecoffins During the feedback session on the 26/06/2023, insights and concerns were shared by the participants regarding the report. - One notable comment was the need to adjust the scenario considering that families typically visit the memorial place approximately three times a year, which impacts the overall carbon emissions calculation estimated for visiting the memorial place. - Another important point raised was the diverse modes of transport used by individuals when visiting memorial places. This observation highlighted the significance of accounting for the various transportation options in the analysis to provide a more comprehensive understanding of carbon emissions. - Additionally, participants pointed out that the report did not cover the carbon footprint associated with funeral events or the emissions generated during the commute to funerals. - It was also highlighted that no manufacturer or brand should be listed in the report. - Lastly, the feedback noted that some of the databases used were not listed, emphasizing the importance of transparently documenting the sources of data to enhance the report's credibility and reproducibility.	In response to the feedback received regarding visiting the memorial place, we have included a second scenario considering that a family visits it 3 times a year over 20 years. The fact that different modes of transport are used for this purpose is correct, but the objective here is to present the bigger picture, an estimated figure considering a family travelling on an average car in the UK. Although we don't have a scenario for each possible way of travelling to a funeral, we have presented the difference in carbon emissions per travel for different modes of transport. Regarding the fact that carbon emissions of funeral events and commuting not being included, this was a decision made when scoping the project, as the main goal of this report is to compare the different types of coffins and funeral processes. The report was updated to remove any mention to manufacturers and brands. Regarding the databases and emission factors not being published here, we have agreements with some of the databases used, as they are not publicly available (they are available to purchase), we can't disclose the emission factors publicly.
Greenfield Creations Ltd During the feedback call on the 29/06/2023, the primary concerns raised were the mention of a specific coffin manufacturer, as the report aimed to maintain complete impartiality. Additionally, it was highlighted the significance of clarifying that cardboard coffins can be constructed without any wooden elements, and if a wooden base is present, it is commonly made of chipboard rather than MDF.	We have updated the report, so it reflects generic cardboard coffins in the list of coffins analysed. We do acknowledge that there are other popular variations of cardboard coffins such as cardboard coffins with chipboard bases, however, due to the limitation of the scope we cannot cover all possible styles. But the current selection of coffins should give an indicator of the impact of the materials used for coffin manufacturing. We do recommend phase 2 of this project where more materials and stages could be measured.



THANK YOU

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certification@planetmark.com