LCA: Pool covers LB400 and EGST

Plastipack Ltd

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Glossary

ADP-fossil – Abiotic depletion for fossil resources potential

ADP-mineral & metals – Abiotic depletion potential for non-fossil resources

AP – Acidification potential, accumulated exceedance

CRU – Components for reuse

EE – Exported Energy

EGST – EnergyGuard ™ Selective Transmission

EI – Environmental Impact

EoL – End-of-Life

EP-freshwater – Eutrophication potential, fraction of nutrients reaching freshwater end compartment

EP-marine – Eutrophication potential, fraction of nutrients reaching marine end compartment

EP-terrestrial – Eutrophication potential terrestrial

FW – Net use of fresh water

GHG – Greenhouse Gases

GLO - Global

GWP – Global Warming Potential

GWP-biogenic – Global warming potential, biogenic

GWP-fossil – Global warming potential, fossil fuels

GWP-luluc – Global warming potential, land use and land use change

GWP-total – Global warming potential, total

HDPE – High density polyethylene

HH – Human Health

HWD – Hazardous waste disposed

Kg – Kilogram

Kg.km – Kilogram kilometre

LB400 – Light Blue 400

LCA – Life Cycle Assessment

LDPE – Low-density polyethylene

LLDPE – Linear low-density polyethylene

MER – Materials for energy recovery

MFR – Materials for recycling

NHWD – Non-hazardous waste disposed

NRSF – Use of non-renewable secondary fuels

ODP – Ozone layer depletion potential

PENRE – Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials

PENRM – Use of non-renewable primary energy resources used as raw materials

PENRT – Total use of non-renewable primary energy resource SM – Use of secondary material

PERE – Use of renewable primary energy excluding renewable primary energy used as raw materials

PERM – Use of renewable primary energy resources used as raw materials

PERT – Total use of renewable primary energy resources

POCP – Formation potential of tropospheric ozone

RER – Rest of Europe

RoW – Rest of World

RSF – Use of renewable secondary fuels

RWD – Radioactive waste disposed

VSC – Valpak Sustainability Consultancy

WDP – Water deprivation potential, deprivation-weighted water consumption

1. Executive Summary

1.1 Introduction

Plastipack commissioned Valpak's Sustainability Consultancy (VSC) to establish the environmental impacts of the lifecycle of two pool covers made respectively from the following GeoBubble™ materials (Plastipack's pool cover materials):

- Light Blue 400 and
- EnergyGuard ™ Selective Transmission

The environmental impacts of the sub-components that form the two pool covers LB400 and EGST are analysed separately using LCA methodology to quantify the impacts at the following life cycle stages:

- First Assembly Stage:
  - Materials: extraction of raw materials, processing and manufacture of raw materials, ancillary materials and inbound and outbound packaging materials used in the production and packaging of the GeoBubble™ material
  - Transport: Delivery of the raw materials and packaging materials to the assembly site 1 (which refers Plastipack's facility in Leonards on Sea)
  - Assembly: the energy, water ancillary materials used, the management of wastes (including waste water) and offcuts at the assembly site
- Distribution to customers: Delivery of product and packaging to assembly site 2 for welding
- Second Assembly Stage:
  - Materials: extraction of materials, processing and manufacture of inbound and outbound packaging materials used in the packaging of the end-product
  - Transport: The delivery of the packaging materials to assembly site 2 (which refers to the facility of the party purchasing Plastipack's products (referred to in this report as Plastipack customers), at which the welding and cutting take place, and distributing them to the end user)
  - Assembly: the energy used for the welding and cutting process and the treatment and disposal of waste from inbound packaging materials and product offcuts removed at the assembly site
- Distribution: the shipment of the product to the end user
- Maintenance: the water used to clean and maintain the product and the waste water produced as a result
- End-of-Life (EoL): the treatment and disposal of the product and its packaging after use.

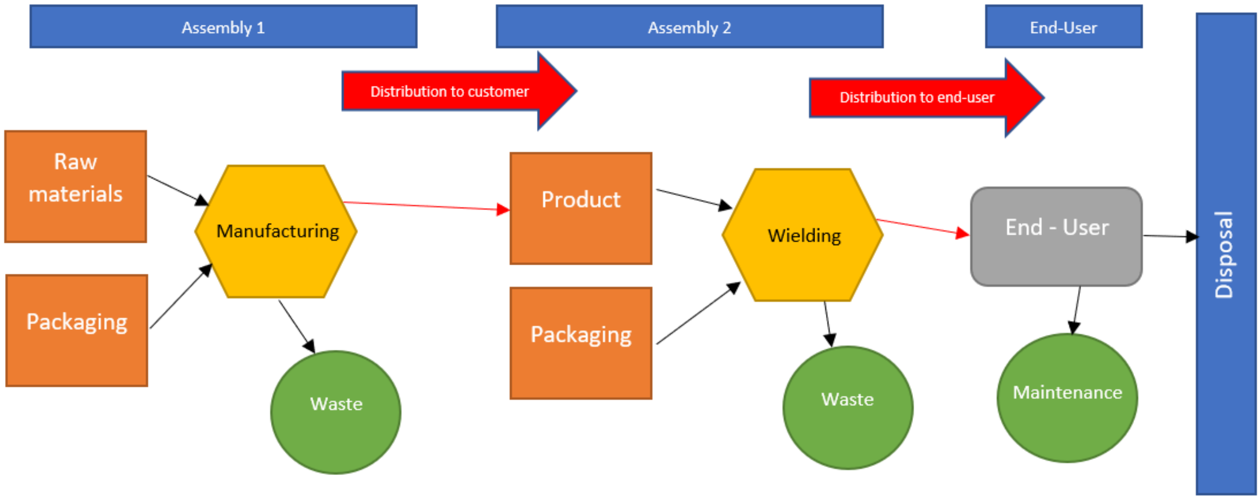
Two pool cover options are considered: the Light Blue 400 GeoBubble™ material and the EnergyGuard ™ Selective Transmission GeoBubble™ material. The overall impacts aggregated across the lifecycle stages are also quantified. The key environmental impacts of interest to Plastipack in this assessment, and for the life cycle chain stages, are:

- The carbon footprint, GHG emissions (Kg CO_2eq) per unit of pool cover
- Water deprivation potential (m^3) per unit of pool cover

1.2 Manufacturing Process

The manufacturing process has been summarised in the diagram below.

Figure 1: Plastipack Pool Cover Manufacturing Process



1.3 Key Points

The key points to note are as follows:

- The function unit is the manufacture of 1 m^2 of pool cover using GeoBubble™ material, its packaging and distribution to end users, maintenance during its expected lifespan, and EoL. The expected lifespan of LB400 is 4 years and that of EGST is 8 years.
- There are 2 pool coves considered. Per 1 m^2 of pool cover the weights of the GeoBubble ™ materials are;
    - 0.368 kg/m^2 for LB400,
    - 0.46 kg/m^2 for EGST
- The system boundary for this LCA study is cradle-to-grave and module D.
- The process specific input data provided by Plastipack is regarded as being of high quality and high accuracy, and an accurate representation (in terms of timeliness, geography and technology) for all processes used in manufacture and supply of the pool cover materials at the Plastipack production site in the UK. The production datasets at Assembly 1 site are a combination of 2022 data (for materials processes) and three-year average data (for water, fuels and off-cuts, as well as for the distribution to customers for welding). Assumptions and averages have been applied where necessary – methodologies for these is outlined in detail in this report in their respective Inventory section.

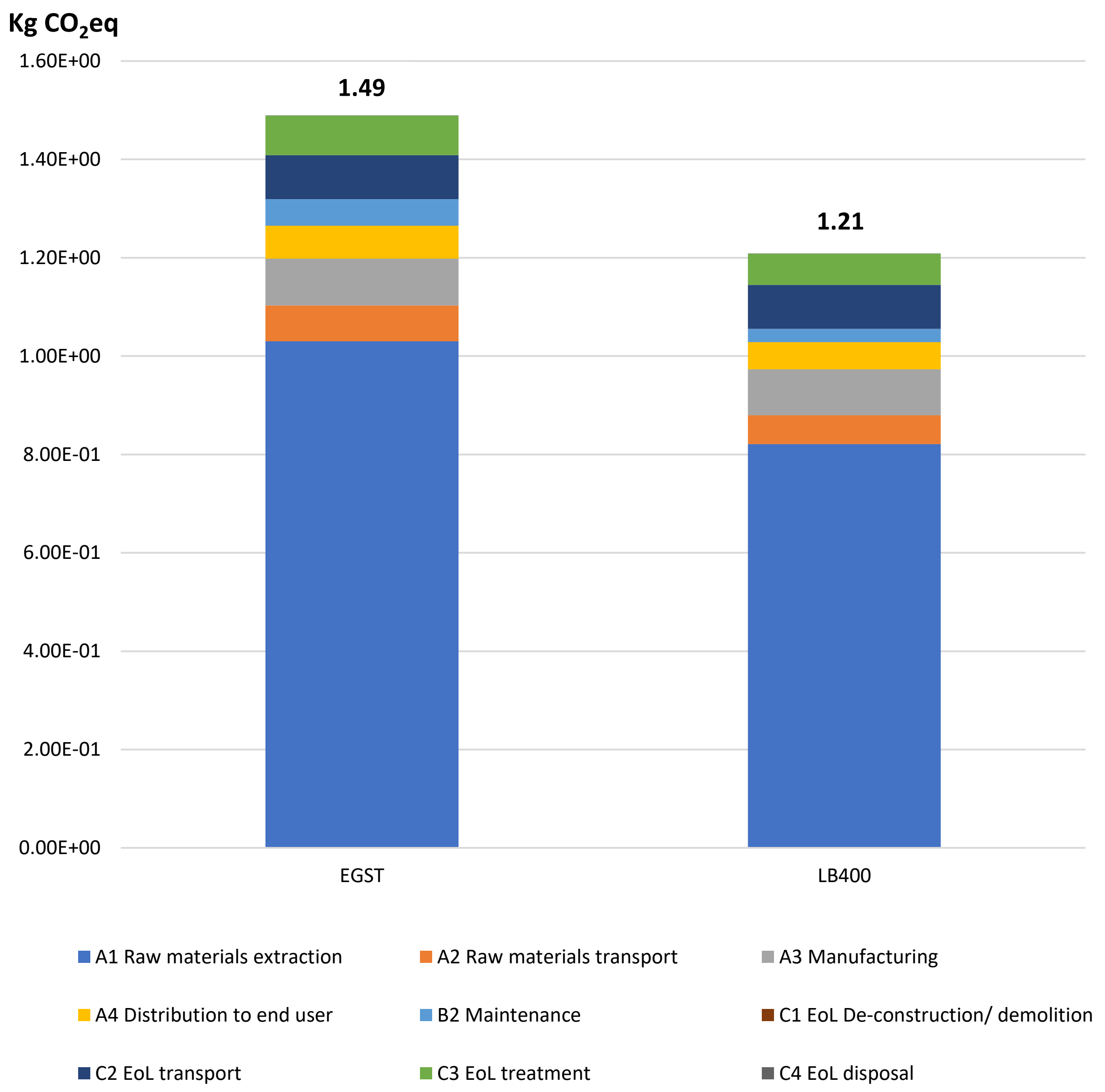
Table 1: The carbon footprints of the life cycles of LB400 and EGST pool covers

GeoBubble™ materials	Unit	Per 1 m^2 of pool cover	Per standard 32 m^2 pool cover
LB400	kg CO_2eq	1.21	38.7
EGST	kg CO_2eq	1.49	47.7

Table 2: The water deprivation potential of the life cycles LB400 and EGST pool covers

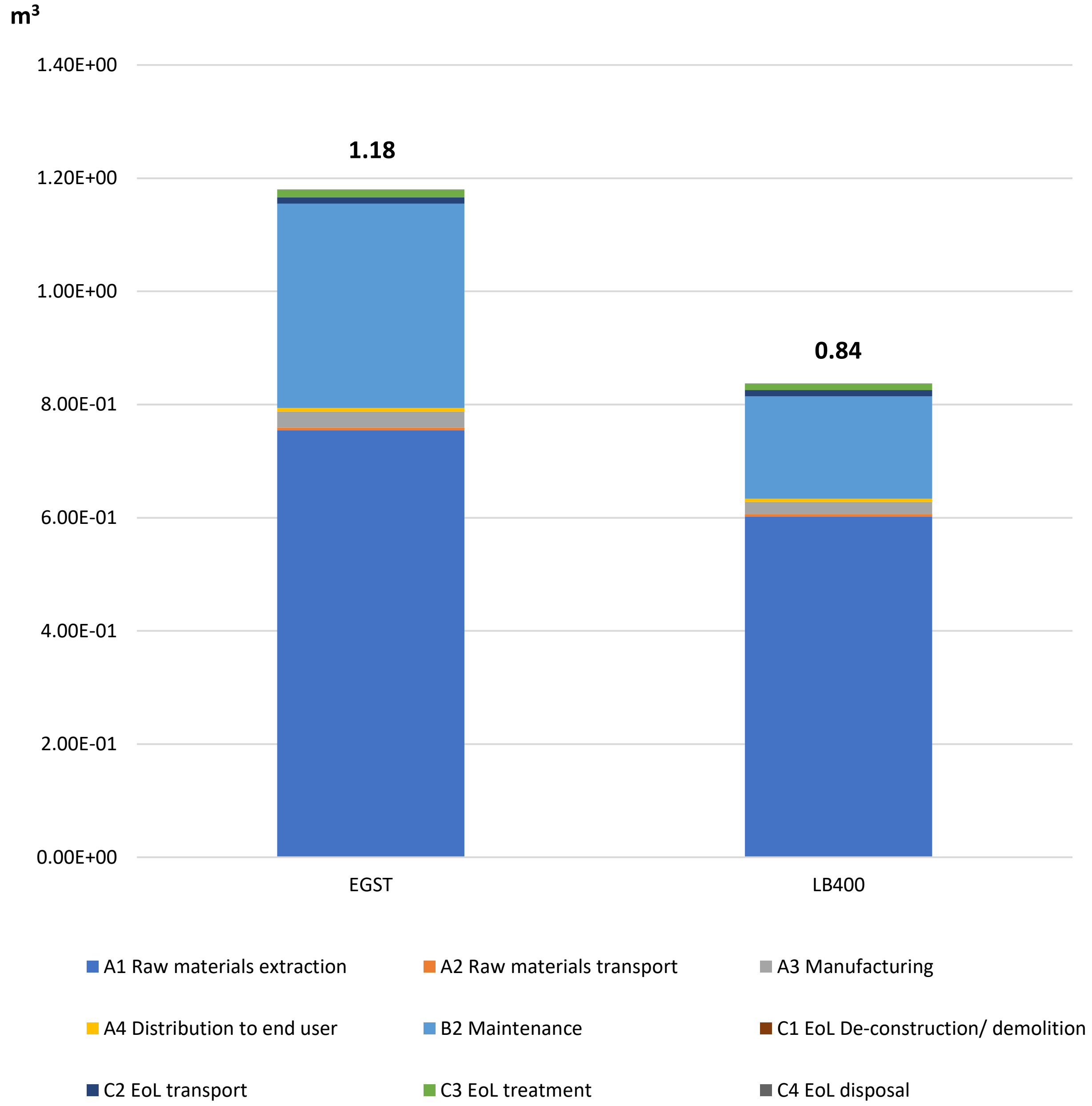
GeoBubble™ materials	Unit	Per 1 m^2 of pool cover	Per standard 32 m^2 pool cover
LB400	m^3	0.84	26.8
EGST	m^3	1.18	37.8

Figure 2: Contribution of each of the life cycle stages by EPD module to the overall carbon footprint per 1 m^2 of LB400 and EGST pool covers



- The figure shows the overall carbon footprint of one functional unit of pool cover LB400 and EGST broken down by lifecycle module. The lifecycle module A1 which represents raw materials extraction contributes the most to the overall carbon footprint of LB400 and EGST, contributing 68% and 69% to the overall footprint respectively. This can mostly be attributed to the carbon footprint of the raw materials of the pool covers. The carbon footprint for LB400 pool cover is lower than that of EGST pool cover mostly due to the weight of LB400 GeoBubble™ material weighing less than the EGST GeoBubble™ material per 1 m^2, therefore using less LDPE as a raw material.

Figure 3: Contribution of each of the life cycle stages by EPD module to the overall water deprivation potential per 1 m^2 of LB400 and EGST pool covers



- The figure shows the overall water deprivation potential of one functional unit of LB400 and EGST pool covers broken down by LCA information modules. Module A1 which represents raw materials extraction contributes the most to the overall water deprivation potential, which represents 64% and 72% of the overall water deprivation potential of the life cycles of the pool covers EGST and LB400 respectively. The water deprivation potential for LB400 pool cover is lower than EGST pool cover considered due to the weight of LB400 GeoBubble™ material weighing less than EGST GeoBubble™ material per 1 m^2, therefore using less LDPE as a raw material.

- Module D impacts are beyond the system boundary and arise from the avoided production of virgin LDPE from recycling the pool cover.

Table 3: Summary of carbon footprint and water deprivation potential avoided from recycling the pool covers LB400 and EGST and the avoided production of virgin LDPE

	Carbon footprint (kg CO_2eq)		Water Deprivation Potential (m^3)	
GeoBubble™ materials	Per 1 m^2 of pool cover	Per standard pool cover (32 m^2)	Per 1 m^2 of pool cover	Per standard pool cover (32 m^2)
LB400	0.761	24.4	0.531	17.0
EGST	0.934	29.9	0.663	21.2

2. Introduction

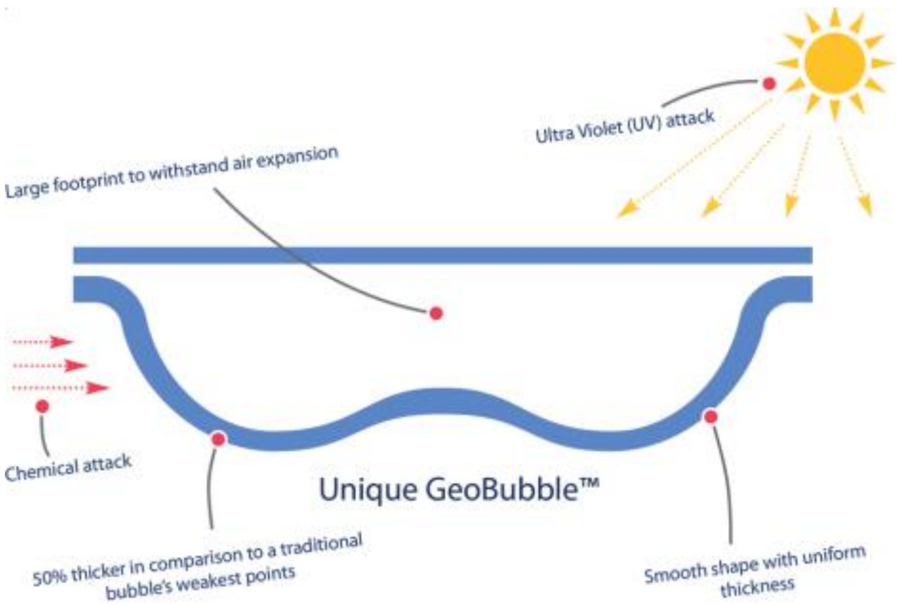
This assessment utilizes LCA modelling to quantify the environmental impacts of the manufacturing processes used to produce Light Blue 400 (LB400) and EnergyGuard ™ Selective Transmission (EGST) pool covers, as well as their transport, use, and EoL. Process-specific inventory data for each of the pool cover materials (and their supply chains), the energy, water and packaging, and the intermediate and final transport journeys has been supplied by Plastipack Ltd and used to develop a complete model the life cycle using LCA methods that is compliant with ISO standards 14040/44 for LCA. The methodology is also compliant with EN15804+A2:2019 for construction products.

The scope and boundary in this system boundary in this project is cradle-to-grave and module D. The functional unit of analysis is 1 m^2 of final product (pool cover) manufactured using the GeoBubble™ materials. The background data processes, characterisation factors and assessment methods are sourced from Ecoinvent 3.8. The LCA modelling platform is OpenLCA v2.03.

2.1 Product Description

Plastipack manufacture pool cover materials, known as GeoBubble™ materials, designed for energy and resource savings, particularly to control evaporation, reduce energy and chemical consumption. Plastipack aim to provide products with the longest possible functional life.

Figure 4: Functionality of the GeoBubble™ material



These materials, when in use, rest on the surface of water bodies such as outdoor swimming pools and industrial/ agricultural tanks or reservoirs (although it should be noted that outdoor private swimming pools, being the largest customer base of Plastipack, have been assumed in the modelling in this study). The material is comprised of two layers of polyethylene with pigments, UV and heat stabilizers added to the polymer formulation. The bottom layer goes through a vacuum forming process shortly before the two layers are laminated to produce a single material with air cells (similar to bubble wrap packaging).

Two pool covers are considered in this LCA, the LB400 pool cover and the EGST pool cover. The image below shows the standard LB400 GeoBubble™ material.

Figure 5: Standard GeoBubble™ Light Blue material

After the GeoBubble™ material is produced, it is transported in form of rolls to the customers who weld the material into pool cover length and sell it to end users.

2.2 Dangerous Substances Declaration

No substances included in the Candidate List of Substances of Very High Concern for authorization under the REACH regulations are present in the products LB400 and EGST either above the threshold for registration with the European Chemicals Agency or above 0.1%.

2.3 Methodology

To complete the LCA the following four key steps were undertaken for the LB400 and EGST pool covers:

- Goal and scope definition – A clear definition of both the goal and scope of the project, the system boundaries, and the functional unit
- Inventory analysis – Product data collection and modelling the life cycle with all the environmental inputs and outputs
- Impact assessment - Analysing the environmental impacts in terms of GHG emissions (establishing the carbon footprint) and water deprivation potential, and
- Interpretation – interpretation and discussion of results, conclusions of the study.

3. Goal and Scope

This initial stage of the LCA defines the goals and scope of the study, defines the functional unit and sets the system boundaries within which the LCA is conducted to establish the carbon footprint and water use as well as an overview of other impacts.

The goal of the analysis is to quantify the environmental impacts of LB400 and EGST pool covers using LCA modelling methods to establish the carbon footprint, water use, and other impacts based on the impact assessment method EN15804 + A2:2019 for constructions products (the indicator for total global warming potential / GWP Total measured as kg CO_2eq and the indicator for water deprivation potential is Water Usage, AWARE).

The methodology incorporates specific information on GeoBubble™ materials (and their supply chains), the energy, water and packaging, and the intermediate and final transport journeys supplied by Plastipack Ltd. This is combined with environmental impact factors and LCIA methods sourced by VSC, from the add-on EN15804 version of Ecoinvent 3.8 database to develop a complete model of the life cycle using LCA methods that are compliant with ISO standards 14040/44.

3.1 Functional Unit

The functional unit in this LCA study is:

The manufacture of 1 m^2 of pool cover and its packaging at Plastipack's production site, its distribution to customers (second assembly) around the world, its welding and packaging, its distribution to the end user, its maintenance, and its EoL (including EoL of packaging).

All of the stages after arrival of unit of pool cover material to second assembly is modelled such that the customer and end user are situated in France. This is due to the fact that 52% of final products are shipped to France.

3.2 System Boundary

The boundaries considered in this study to establish the environmental impacts of the pool covers are described in Figure 6.

3.3 Peer review statement

This study has not been externally peer reviewed.

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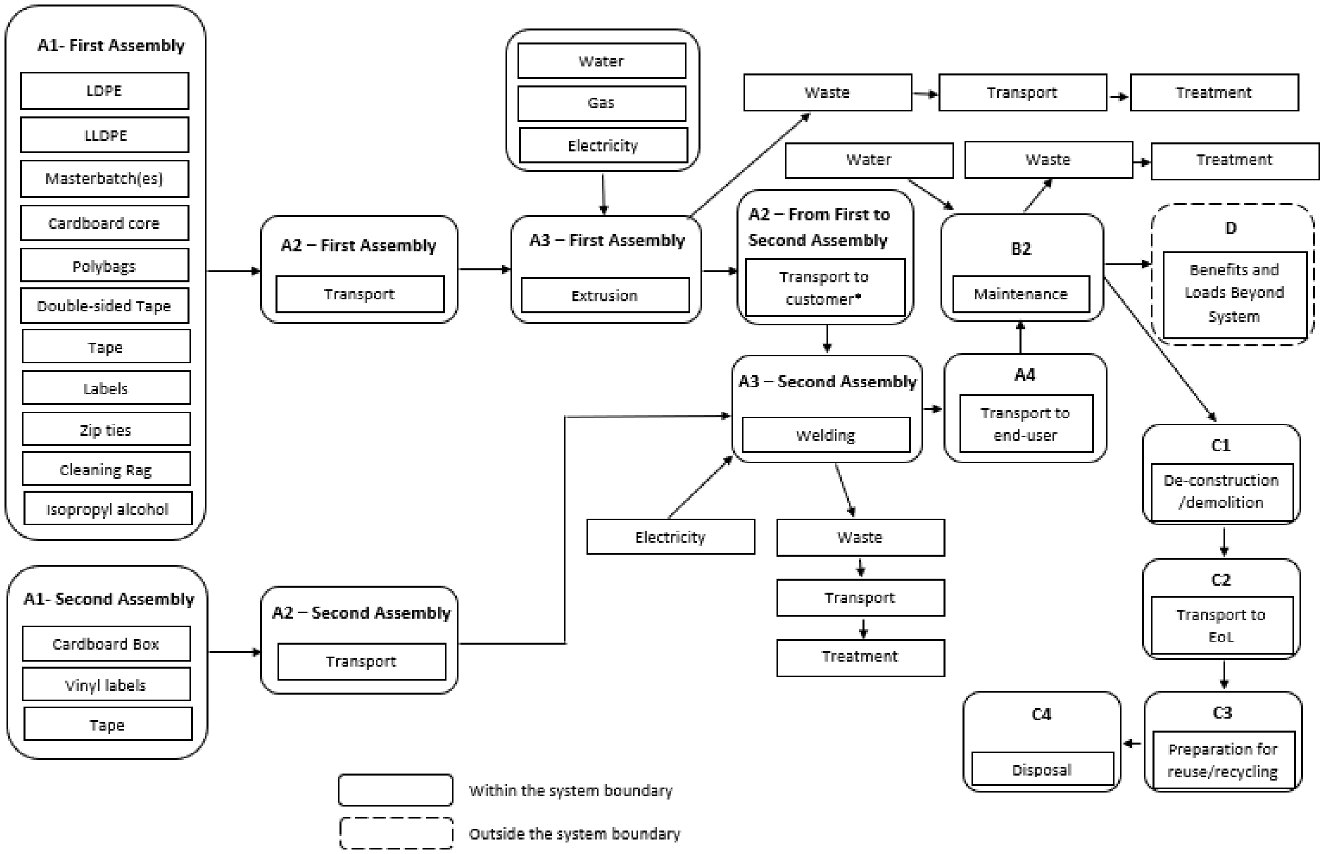
Figure 6: The system boundary for the life cycle assessment of the pool covers LB400 and EGST



*Transport to customer refers to transport to pool cover distributors for welding

Table 4: System Boundaries included in the life cycle assessment of pool covers LB400 and EGST

Stage	Description
A1	The extraction and processing of raw materials (and packaging) used to manufacture the pool cover materials at Plastipack ltd. For example, this covers the environmental impacts caused by the extraction and processing of low-density polyethylene, linear low-density polyethylene, masterbatch(es), as well as ancillary materials (cleaning rags and isopropyl alcohol), and cardboard, nylon, paper and plastic packaging materials. The extraction and processing of packaging used at the customer's welding site. For example, this covers the cardboard, paper and plastic packaging materials at the customer's welding site.
A2	The transport of raw materials, ancillary materials and packaging from supplier locations to Plastipack's manufacturing site in the UK. The transport of pool cover materials and packaging to the welding site. The transport of packaging from supplier locations to customer's welding site.
A3	The energy, fuels and water used and wastes (as well as the fate of the wastes) generated in the processes required to manufacture the pool cover material at Plastipack's manufacturing site in the UK. The energy and wastes (as well as the fate of the wastes) generated in the process required to weld the pool cover materials at customer site.
A4	The transport of the pool covers (final product) to the end user.
B2	Maintenance of the pool cover. It assumed that it is rinsed with tap water twice a year.
C1	It is assumed there are no environmental impacts associated with the removal of the pool cover material at EoL.
C2	It is assumed that (on average) the transport to the household waste recycling centre from the end user of the pool cover is a journey of 8.35 km by average car.
C3	It is assumed that the pool cover is recycled due to its LDPE content. It is assumed that the cardboard packaging component is recycled by the end-user
C4	It is assumed that the packaging tape and label shipped with the pool cover goes to general waste.
D	The main benefit beyond the system boundary arises from the avoided impacts of the production of virgin LDPE.

4. Inventory

This section details the inventory data information and assumptions as well as the materials (raw materials and packaging), energy, fuels, water, and wastes associated with the production of the pool covers at first assembly and second assembly. The inventory data also encompasses the transport journeys of materials and packaging to first assembly, the transport journey from first assembly to second assembly, the distribution to end user, the maintenance of a unit (1 m^2) of product and its EoL.

The inventory data is mostly composed of data provided by Plastipack for the year 2022 or in some cases using a 3-year average (instances of this are specified below). Some data has required assumption conducted by Valpak using information provided by Plastipack. The source of inventory data will be specified at every stage of the process.

4.1 Inventory data information and assumptions

4.1.1 First assembly

The materials data used and information on the supply chains at the first assembly stage are supplied by Plastipack for the year 2022. This information has been used to create assumptions on the composition of Masterbatches. The weight of raw materials at the beginning of the manufacturing process per 1 m^2 has been calculated by Valpak using information provided by Plastipack. This information includes the percentage of each raw material used per 1 m^2 and the offcuts at the first assembly stage and the second assembly stage. The packaging and ancillary materials data used per 1 m^2 has been provided by Plastipack. The journey distances between the suppliers and the production site are sourced by Plastipack. The waste data from inbound packaging is supplied by Plastipack for the year 2022, whereas the polymer waste is supplied by Plastipack using a 3-year average. Plastipack has shared the company that they have employed for waste management services. This information is used by Valpak to find the closest of the waste management services' location to Plastipack to determine the transport distance of waste from first assembly to general waste/recycling facilities. The distance from Plastipack to the waste/recycling facilities is provided through the use of google maps. Plastipack confirmed that their pallets are part of a return scheme, and therefore only the environmental impact of their transport, and not production, has been included in this analysis. The transport data of polymer waste to external manufacturers has been sourced by Plastipack.

The first assembly site-specific production data such as fuels (electricity and gas) and water used in the manufacturing process is supplied by Plastipack using a three-year average.

4.1.2 Transport to customer

The information on destination countries of GeoBubble™ material has been provided by Plastipack using a 3-year average. This information has been used by Valpak to model four different processes for the journey distances from Plastipack to customer making up 96% of all transport journeys to customers (as 96% of sales were made to destinations with transport data), in order to be reflective of the different journey types to different destinations. Each of the proportions of total purchases to the four journeys each are scaled to 96% to account for 100% of transport journeys. The proportions are then applied to the weight of 1 m^2 of GeoBubble™ material to capture the different transport modes and their relative contributions to the average.

4.1.3 Second Assembly

The materials used at the second assembly stage have been determined through assumptions conducted by Plastipack and the associated inbound packaging materials have been determined through assumptions conducted by Plastipack and Valpak. The waste data has been sourced by Plastipack with the additional assumption that the inbound packaging determined by Valpak becomes waste at the end of the second assembly stage. The electricity used in the second assembly stage has been sourced by Plastipack. The journey distances between the suppliers and the production site; production site and the general waste/ recycling facilities are unavailable. Market processes from Eco-invent 3.8 for materials have been used to account for journey distances of materials with no available information on transport distance.

4.1.4 Transport to end user

The journey distance to end users has been assumed at 250 km on average by Plastipack.

4.1.5 Maintenance

The information on the maintenance of the pool cover has been provided by Plastipack, including the average water use per pool cover rinse, the number of rinses the pool cover undergoes per year and the average lifespan for pool covers LB400 and EGST in years. This information has been used by Valpak to calculate the water used in a pool cover's life span for its maintenance.

4.1.6 EoL

The fate of the pool cover has been provided by Plastipack. It is assumed there are no environmental impacts associated with the removal of the pool cover material at EoL. It is assumed that the pool cover would be recycled at the closest household waste recycling centre to the end user's home. The weight of 1 m^2 of end-product is provided by Plastipack. The packaging is assumed to be collected through general waste/recycling household collections. No information on journey distances for treatment/disposal have been provided by Plastipack. An average distance from end user to household waste recycling centre has been estimated by Valpak using a combination of information from the internet, mapping on Google Maps and calculations. Further detail on these assumptions is provided in Section 4.11: End-of-Life.

4.2 Raw Materials

4.2.1 LB400

The materials data used at the first assembly stage are supplied by Plastipack for the year 2022. This information includes the percentage of each raw material used per 1 m^2. 1 m^2 of end-product of LB400 material weighs 0.368 kg. There are three main raw materials inputted to produce LB400 pool cover material: LDPE (88%), LLDE (10%), and Masterbatch MB020 (2%) which constitutes of additives encapsulated in an LDPE carrier containing coloured pigments and UV stabiliser.

The end-product unit weight is summarised below.

Table 5: Composition of 1 m^2 of final product of LB400

Material	**Unit**	**Total**
LDPE	kg	0.324
LLDPE	kg	0.0368
Coloured Masterbatch MB020	kg	0.00736
Total	**kg**	0.368

Before reaching the end-product stage, the pool cover material goes through an extrusion process at first assembly (production of pool cover material), which incurs some raw material wastage, and a welding process at second assembly that leaves behind offcuts. For this reason, calculations have been conducted by Valpak to account for the offcuts and obtain the weight of raw materials inputted at the first stage of the manufacturing process. The data regarding the offcuts at the first assembly stage and the second assembly stage have been provided by Plastipack. The result of the calculations indicate that the total inputted weight of raw materials is 0.393 kg per 1 m^2 of LB400. The table below showcases the calculations conducted to obtain this result.

Table 6: The calculation conducted to determine the initial weight of raw materials inputted per 1 m^2 of LB400

Raw material weight per m^2	**Unit**	0.393
First assembly offcuts and wastage	kg	0.00213
Offcuts and Wastage (% of raw materials)	%	0.5
Unit weight after First Assembly	kg	0.391
Second Assembly Offcuts and Wastage	kg	0.0288
Offcuts and Wastage (% of the product of First Assembly)	%	5.88
Product after Second Assembly	kg	0.368
Weight of 32 m^2 product	kg	11.8

The table below showcases the weight of each component of the raw materials inputted at the initial stage of manufacturing.

Table 7: Composition and weight of 1 m^2 of LB400 at initial stage of manufacturing

Material	**Unit**	**Total**
LDPE	kg	0.346
LLDPE	kg	0.0391
Coloured Masterbatch	kg	0.00786
Total	**kg**	0.393

4.2.2 EGST

The materials data used at the first assembly stage are supplied by Plastipack for the year 2022. This information includes the percentage of each raw material used per 1 m^2. 1 m^2 of end-product of EGST pool cover material weighs 0.46 kg. There are five main raw materials inputted to produce the pool cover material: LDPE (84.51%), LLDE (10%), and Masterbatch MB014 (2.325%), MB035 (2.68%) and MB030 (0.495%) which constitute of additives encapsulated in an LDPE carrier containing coloured pigments and UV stabiliser.

The end-product unit weight is summarised below.

Table 8: Composition and weight of 1 m^2 of final product of EGST

Material	**Unit**	**Value**
LDPE	kg	0.389
LLDPE	kg	0.0460

Masterbatch MB014	kg	0.0107
Masterbatch MB035	kg	0.0123
Masterbatch MB030	kg	0.00228
Total	**kg**	0.460

Similarly to LB400, before reaching the end-product stage, the EGST pool cover material goes through an extrusion process at first assembly (production of pool cover material) which incurs some raw material wastage, and a welding process at second assembly that leaves behind offcuts. For this reason, calculations have been conducted by Valpak to account for the offcuts and obtain the weight of raw materials inputted at the first stage of the manufacturing process. The data regarding the offcuts at the first assembly stage and the second assembly stage have been provided by Plastipack. The result of the calculations indicate that the total inputted weight of raw materials is 0.491 kg per 1 m^2 of EGST. The table below showcases the calculations conducted to obtain this result.

Table 9: The calculation conducted to determine the initial weight of raw materials inputted per 1 m^2 of EGST

Raw material weight per m^2	**Unit**	0.491
First assembly offcuts and wastage	kg	0.00213
Offcuts and Wastage (% of raw materials)	%	0.433
Unit weight after first assembly	kg	0.489
Second Assembly Offcuts and Wastage	kg	0.0288
Offcuts and Wastage (% of the product of first assembly)	%	5.88
Product after Second Assembly	kg	0.460
Weight of 32 m^2 product	kg	14.7

The table below showcases the weight of each component of the raw materials inputted at the initial stage of manufacturing.

Table 10: Composition and weight of 1 m^2 of EGST at initial stage of manufacturing

Material	**Unit**	**Total**
LDPE	kg	0.415
LLDPE	kg	0.0491
Masterbatch MB014	kg	0.0114
Masterbatch MB035	kg	0.0132
Masterbatch MB030	kg	0.00243
Total	**kg**	0.491

4.2.3 Masterbatches

The composition of the masterbatches have not been disclosed in their entirety by the masterbatch manufacturers to Plastipack or Valpak, due to the commercially sensitive nature of the manufacturing process. Information provided by Plastipack and obtained through web research on the main components within the masterbatches has enabled the creation of assumptions and the generic modelling of the masterbatch for the LCA. The masterbatches MB020 and MB035 are coloured masterbatches. They are composed of LDPE carrier containing inorganic pigments and a set level of UV stabilisers. It is believed that the components in these masterbatches excluding the LDPE consist of equal parts organic chemical and inorganic chemical. The MB030 and MB014 masterbatches consist of LDPE carrier containing UV absorber and UV booster respectively. It is believed that the components in these masterbatches excluding the LDPE are mainly organic chemicals. Research on masterbatches shows that masterbatches usually contain between 40 and 65% of additives[1]. For this reason, it is assumed that the average proportion of the additive is at 52.5% and that the rest is made of LDPE carrier (47.5%). A summary of the breakdown of the masterbatch components can be found in the table below.

Table 11: The modelling of masterbatch components and their weights

Masterbatch	Component	Weight in kg
MB020	LDPE carrier	0.00373
	Organic chemical	0.00206
	Inorganic chemical	0.00206
MB035	LDPE carrier	0.00625
	Organic chemical	0.00346
	Inorganic chemical	0.00346
MB030	LDPE carrier	0.00116
	Organic chemical	0.00128
MB014	LDPE carrier	0.00543
	Organic chemical	0.00600

4.3 Ancillary Materials

The ancillary materials data used at the first assembly stage are supplied by Plastipack using a 3-year average. The table below showcases the weight of ancillary materials used in the production of 1 m^2 of end-product of pool cover material. The ancillary materials used are the same for 1 m^2 of LB400 and 1 m^2 of EGST.

1 https://www.google.co.uk/books/edition/Applied_Plastics_Engineering_Handbook/urctkFROYbkC?hl=en&gbpv=1&pg=PA439&printsec=frontcover

Table 12: Ancillary materials used in the production of 1 m^2 of LB400 and EGST

Component	**Material**	**Unit**	**Total**
Cleaning Rag	Mixed Recycled Fabric	kg	0.000113
Isopropyl Alcohol	Isopropyl Alcohol	m^3	0.0000483

4.4 Packaging

4.4.1 Inbound Packaging at First Assembly

4.4.1.1 LB400

The packaging data used per 1 m^2 has been provided by Plastipack. The table below represents the weight of all inbound packaging used at first assembly per 1 m^2 of end-product LB400. This also includes the inbound packaging of the ancillary materials. The weight of the inbound packaging is used to model and account for the production and transport of inbound packaging to first assembly site as well as the fate of the inbound packaging at its End-of-Life (transport and disposal/preparation for next life). The weight of the wooden pallets will only be used to account for its transport to first assembly and its transport back to the manufacturers they are considered to be part of return schemes. This means that the production of the pallets is not included within this product system.

Table 13: Inbound packaging at first assembly per 1 m^2 of LB400

Component	**Material**	**Unit**	**Total**
Wooden Pallet	Softwood	kg	0.00172
LDPE Bag	LDPE virgin	kg	0.0000398
LDPE Bag	LDPE – 30% recycled content	kg	0.000157
Cardboard Box	Cardboard 100% recycled	kg	0.00000294
Backing Paper	Paper	kg	0.0000588
HDPE Drum	HDPE	kg	0.00000295
Total	**-**	**kg**	0.00198

4.4.1.2 EGST

The packaging data used per 1 m^2 has been provided by Plastipack. The table below represents the weight of all inbound packaging used at first assembly per 1 m^2 of end-product EGST. This also includes the inbound packaging of the ancillary materials. The weight of the inbound packaging is used to model and account for the production and transport of inbound packaging to first assembly site as well as the fate of the inbound packaging at its End-of-Life (transport and disposal/preparation for recycling at next life). The weight of the wooden pallets will only be used to account for its transport to first assembly and its transport back to the manufacturers they are considered to be part of return schemes. This means that the production of the pallets is not included within this product system.

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Table 14: Inbound packaging at first assembly per 1 m^2 of EGST

Component	Material	Unit	Total
Wooden Pallet	Softwood	kg	0.00223
LDPE Bag	LDPE virgin	kg	0.000136
LDPE Bag	LDPE – 30% recycled content	kg	0.000197
Cardboard Box	Cardboard - 100% recycled content	kg	0.00000294
Backing Paper	Paper	kg	0.0000588
HDPE Drum	HDPE	kg	0.000002950
Total	**-**	**kg**	0.00263

4.4.2 Outbound Packaging at First Assembly

The packaging data used per 1 m^2 has been provided by Plastipack. The outbound packaging used at first assembly is the same for 1 m^2 of LB400 and EGST. This is due to the fact that the outbound packaging carries the same area of product (2 m x 102 m) and the area determines the amount of outbound packaging used. The table below summarises the materials used for packaging the pool cover materials to customers and the weight used per 1 m^2 of end-product. This information is used to account for the production of the outbound materials, the transport from manufacturers to first assembly site, the transport to second assembly site and the fate of the packaging at the second assembly site (transport and disposal/preparation for recycling at next life).

Table 15: Outbound packaging at first assembly for 1 m^2 of LB400 and EGST

Component	Materials	Unit	Total
Cardboard Core	Cardboard - 100% recycled content	kg	0.00343
Double Sided tape	Polypropylene	kg	0.0000490
Polybag	LDPE - 30% recycled content	kg	0.00392
Zip Tie	Nylon 6-6	kg	0.00000980
Labels	Polypropylene	kg	0.0000245
Tape	Polypropylene	kg	0.0000490
Total	**-**	**kg**	0.00749

4.4.3 Inbound Packaging at Second Assembly

The materials data used at the second assembly stage have been determined through assumptions conducted by Plastipack and the associated inbound packaging materials have been determined through assumptions conducted by Valpak. These assumptions look at similar packaging to second assembly packaging used at first assembly, to determine inbound packaging. An internal packaging expert at Valpak has determined that the inbound packaging for cardboard boxes would include pallets and shrink wrap. It is assumed that the pallet for the cardboard cores (first assembly) can carry the same weight in cardboard boxes. The shrink wrap used per pallet is assumed at 500 grams.[2] The inbound packaging used at second assembly is the same for 1 m^2 of LB400 and EGST. The inbound packaging does not include at this stage the packaging received from Plastipack, due to the fact that its production and its transport journeys from manufacturers to Plastipack and from Plastipack to customer have already been accounted for in other stages. The outbound packaging used around the pool cover materials in the transport journey from Plastipack to customer will be considered again in second assembly waste. The weight of the inbound packaging used per 1 m^2 of pool cover materials LB400 and EGST at second assembly is summarised in the below table.

Table 16: Inbound packaging at second assembly for 1 m^2 of LB400 and EGST

Component	**Materials**	**Unit**	**Total**
Wooden Pallet	Softwood	kg	0.01677
Shrink wrap	LDPE	kg	0.000208
Cardboard Box	Cardboard – 100% recycled content	kg	0.0000298
Backing paper	Paper	kg	0.000313
Total	**-**	**kg**	0.0177

4.4.4 Outbound Packaging at Second Assembly

The materials data used at the second assembly stage have been determined through assumptions conducted by Plastipack. The outbound packaging used at second assembly from customer to end user is the same for 1 m^2 of LB400 and EGST. This data is used to account for the production, transport from manufacturer to customer, transport to end user, and fate (transport and disposal/preparation for recycling at next life) of outbound packaging per 1 m^2 of pool cover material. The weight of the outbound packaging used per 1 m^2 of pool cover material at second assembly is summarised in Table 17.

Table 17: Inbound packaging at second assembly for 1 m^2 of LB400 and EGST pool cover

Material	**Materials**	**Unit**	**Total**
Vinyl label	Polypropylene	kg	0.000313
Cardboard box	Cardboard – 100% recycled content	kg	0.0625
Tape	Polypropylene	kg	0.000625
Total	-	kg	0.0634

[2] https://www.melbpack.com.au/blog/how-calculate-cost-wrapping-pallet/#:~:text=First%2C%20we%20wrap%20a%20pallet,material%20used%20for%20the%20load.

4.5 Transport of Materials and packaging

4.5.1 LB400

The journey distances between the suppliers and the production site are sourced by Plastipack. The table below summarises the transport journeys from suppliers of materials and packing to Plastipack.

Table 18: Transport journeys of materials and packaging for LB400

Material supplied	Transport distance from supplier in km	Mode of Transport
LDPE	313	Tanker 28 t
LLDPE	504	Lorry 27.5 t
Wooden Pallet	504	Lorry 27.5 t
LDPE Bags	504	Lorry 27.5 t
Coloured Masterbatch MB020	29	Lorry
Wooden Pallet	29	Lorry
LDPE Bags	29	Lorry
Cardboard Core	66	Lorry
Wooden Pallet	66	Lorry
Double Sided Tape	77	Van
Cardboard Box	77	Van
Backing Paper	77	Van
Tape	77	Van
Cardboard Box	77	Van
Polybags	79	Lorry
Wooden Pallet	79	Lorry
Zip Ties	3	Van
LDPE Bags	3	Van
LDPE Bags	3	Van
Cardboard Box	3	Van
Labels	184	Van
Backing Paper	184	Van
Cardboard Box	184	Van

Cleaning Rags	7	Van
LDPE Bags	7	Van
Isopropyl Alcohol	279	Van
HDPE Drums	279	Van

There is no available information on transport of packaging from supplier to customer in second assembly. The production of the packaging has been allocated market activity processes on the LCA database to account for the transport journeys.

4.5.2 EGST

The journey distances between the suppliers and the production site are sourced by Plastipack. The table below summarises the transport journeys from suppliers of raw materials to Plastipack.

Table 19: Transport journeys of materials and packaging for EGST

Supplied Material	**Transport distance from supplier in km**	**Mode of Transport**
LDPE	313	Tanker 28 t
LLDPE	504	Lorry 27.5 t
Wooden Pallet	504	Lorry 27.5 t
LDPE Bags	504	Lorry 27.5 t
Masterbatch MB014	29	Lorry
Wooden Pallet	29	Lorry
LDPE Bags	29	Lorry
Masterbatch MB035	29	Lorry
Wooden Pallet	29	Lorry
LDPE Bags	29	Lorry
Masterbatch MB030	29	Lorry
Wooden Pallet	29	Lorry
LDPE Bags	29	Lorry
Cardboard Core	66	Lorry
Wooden Pallet	66	Lorry
Double Sided Tape	77	Van

Cardboard Box	77	Van
Backing Paper	77	Van
Tape	77	Van
Cardboard Box	77	Van
Polybags	79	Lorry
Wooden Pallet	79	Lorry
Zip Ties	3	Van
LDPE Bags	3	Van
LDPE Bags	3	Van
Cardboard Box	3	Van
Labels	184	Van
Backing Paper	184	Van
Cardboard Box	184	Van
Cleaning Rags	7	Van
LDPE Bags	7	Van
Isopropyl Alcohol	279	Van
HDPE Drums	279	Van

There is no available information on transport of packaging from supplier to customer in second assembly. The production of the packaging has been allocated market activity processes on the LCA database to account for the transport journeys.

4.6 Fuels and Water

The site-specific production data such as fuels (electricity and gas) and water used in the first manufacturing process is supplied by Plastipack using a three-year average. The second assembly site-specific data for fuels is supplied by Plastipack using informed assumptions.

The table below summarises the fuels and water used at first assembly site and second assembly site per 1 m^2 of pool cover material. The fuels and water used are the same for 1 m^2 of LB400 and EGST.

Table 20: Fuels and water used per 1 m^2 of pool cover material

First Assembly	Unit	Total
Electricity	kWh	0.261
Gas	kWh	0.00141

Water	kg	0.134
Second Assembly	-	-
Electricity	kWh	0.000434

4.7 Waste at First and Second Assembly

4.7.1 LB400

The waste data from inbound packaging is supplied by Plastipack for the year 2022, whereas the polymer waste and ancillary material waste is supplied by Plastipack using a 3-year average. The waste produced from first assembly as well as any transport distance to waste facilities provided are summarised below. The waste of isopropyl alcohol and the transport of this waste are not considered as this solvent is assumed to evaporate completely at room temperature[3]. The waste of the LDPE bags used as the inbound packaging for cleaning rags and its transport are not included as the bags are re-used on site. The weight of the offcuts in the table below only includes the weights of those that are transported and recycled off-site. The weight of the rest of the offcut is re-used on site and included in other pool cover products and for this reason the fate of this waste is perceived as out of scope.

Table 21: First assembly waste and fate of waste for LB400

Component	Material	Unit	Total	Fate of waste	Distance from first assembly
LDPE - offcuts	LDPE	kg	0.00172	Recycling – known manufacturer	363 km
LLDPE - offcuts	LLDPE	kg	0.000195	Recycling – known manufacturer	363 km
Masterbatch MB020 - offcuts	Additives encapsulated in an LDPE carrier containing coloured pigments and UV stabiliser	kg	0.0000391	Recycling – known manufacturer	363 km
Cleaning Rag	Mixed Recycled Fabric	kg	0.00000682	General waste – known waste service provider	2 km
Isopropyl Alcohol	Isopropyl Alcohol	kg	0.00000292	N/A	-
Wooden Pallets	Softwood	kg	0.000524	Return scheme	504 km
Wooden Pallets	Softwood	kg	0.000157	Return scheme	29 km
Wooden Pallets	Softwood	kg	0.000915	Return scheme	66 km
Wooden Pallets	Softwood	kg	0.000123	Return scheme	79 km

3 https://www.researchgate.net/publication/328783685_Evaluating_the_vapour_evaporation_from_the_surface_of_pure_organic_solvents_and_their_mixtures

LDPE Bag	LDPE virgin	kg	0.0000393	Recycling – known waste service provider	2 km
LDPE Bag	LDPE – 30% recycled content	kg	0.000157	Recycling – known waste service provider	2 km
Cardboard Box	Cardboard 100% recycled	kg	0.00000294	Recycling – known waste service provider	2 km
Backing Paper	Paper	kg	0.0000588	General waste – known waste service provider	2 km
HDPE Drum	HDPE	kg	0.000000178	Recycling – known waste service provider	2 km
Waste water	Waste water	kg	0.134	Waste water treatment	-

Plastipack confirmed that their pallets are part of a return scheme, and therefore only the environmental impact of their transport, and not production, has been included in this analysis The transport data of polymer waste to external manufacturers has been sourced by Plastipack. Plastipack has shared the company that they have employed for waste management services. This information is used by Valpak to find the closest of the waste management services' location to Plastipack to determine the transport distance of waste from first assembly to general waste/recycling facilities. The distance from Plastipack to the waste/recycling facilities is provided through the use of google maps and comes to 2 km.

The waste data has been sourced by Plastipack with the additional assumption that the inbound packaging determined by Valpak becomes waste at the end of the second assembly stage. The waste produced at second assembly is summarised as well as the fate of the waste. There is no information on the transport distances between the customer and the waste treatment facilities. The disposal and preparation for treatment of waste have been allocated market activity processes on the LCA database to account for the transport journeys.

Table 22: Second assembly waste and fate of waste for LB400

Component	**Material**	**Unit**	**Total**	**Fate of waste**
GeoBubble™ offcuts	Polyethylene and masterbatch additives	kg	0.0230	Recycling
Cardboard Core	Cardboard - 100% recycled content	kg	0.00343	Recycling
Double Sided tape	Polypropylene	kg	0.0000490	General waste
Polybag	LDPE - 30% recycled content	kg	0.00392	Recycling
Zip Tie	Nylon 6-6	kg	0.00000980	General waste
Labels	Polypropylene	kg	0.0000245	General waste
Tape	Polypropylene	kg	0.0000490	General waste
Wooden Pallet	Softwood	kg	0.0171	No information available
Shrink wrap	LDPE	kg	0.000214	Recycling

Cardboard Box	Cardboard – 100% recycled content	kg	0.0000298	Recycling
Backing paper	Paper	kg	0.000313	General waste

It is assumed that the wooden pallet is reused on site.

4.7.2 EGST

The waste produced from first assembly as well as any transport distance to waste facilities provided are summarised below. The waste of isopropyl alcohol and the transport of this waste are not considered as this solvent is assumed to evaporate completely at room temperature[4]. The waste of the LDPE bags used as the inbound packaging for cleaning rags and its transport are not included as the bags are re-used on site. The weight of the offcuts in the table below only includes the weights of those that are transported and recycled off-site. The weight of the rest of the offcuts is re-used on site and included in other pool cover products and for this reason the fate of this waste is perceived as out of scope.

Table 23: First assembly waste and fate of waste for EGST

Component	Material	Unit	Total	Fate of waste
LDPE - offcuts	LDPE	kg	0.00199	Recycling – known manufacturer – 363 km
LLDPE - offcuts	LLDPE	kg	0.000236	Recycling – known manufacturer – 363 km
Masterbatch MB014 - offcuts	Additives encapsulated in an LDPE carrier containing coloured pigments and UV stabiliser	kg	0.0000548	Recycling – known manufacturer – 363 km
Masterbatch MB035 - offcuts	Additives encapsulated in an LDPE carrier containing coloured pigments and UV stabiliser	kg	0.0000632	Recycling – known manufacturer – 363 km
Masterbatch MB030 - offcuts	Additives encapsulated in an LDPE carrier containing coloured pigments and UV stabiliser	kg	0.0000117	Recycling – known manufacturer – 363 km
Cleaning Rag	Mixed Recycled Fabric	kg	0.00000682	General waste – known waste service provider
Wooden Pallets	Softwood	kg	0.000524	Return scheme – 504 km
Wooden Pallets	Softwood	kg	0.000540	Return scheme – 29 km
Wooden Pallets	Softwood	kg	0.000915	Return scheme – 66 km
Wooden Pallets	Softwood	kg	0.000123	Return scheme – 79 km

[4]https://www.researchgate.net/publication/328783685_Evaluating_the_vapour_evaporation_from_the_surface_of_pure_organic_solvents_and_their_mixtures

LDPE Bag	LDPE virgin	kg	0.000135	Recycling – known waste service provider
LDPE Bag	LDPE – 30% recycled content	kg	0.000197	Recycling – known waste service provider
Cardboard Box	Cardboard 100% recycled	kg	0.00000294	Recycling – known waste service provider
Backing Paper	Paper	kg	0.0000588	General waste – known waste service provider
HDPE Drum	HDPE	kg	0.000000178	Recycling – known waste service provider

Plastipack confirmed that their pallets are part of a return scheme, and therefore only the environmental impact of their transport, and not production, has been included in this analysis. The transport data of polymer waste to external manufacturers has been sourced by Plastipack. Plastipack has shared the company that they have employed for waste management services. This information is used by Valpak to find the closest of the waste management services' location to Plastipack to determine the transport distance of waste from first assembly to general waste/recycling facilities. The distance from Plastipack to the waste/recycling facilities is provided through the use of google maps and comes to 2 km.

The waste produced at second assembly is summarised as well as the fate of the waste. There is no information on the transport distances between the customer and the waste treatment facilities. The disposal and preparation for treatment of waste have been allocated market activity processes on the LCA database to account for the transport journeys.

Table 24: Second assembly waste and fate of waste for EGST

Component	**Material**	**Unit**	**Total**	**Fate of waste**
GeoBubble™ Offcuts	Polyethylene and masterbatch additives	kg	0.0288	Recycling
Cardboard Core	Cardboard - 100% recycled content	kg	0.00343	Recycling
Double Sided tape	Polypropylene	kg	0.0000490	General waste
Polybag	LDPE - 30% recycled content	kg	0.00392	Recycling
Zip Tie	Nylon 6-6	kg	0.00000980	General waste
Labels	Polypropylene	kg	0.0000245	General waste
Tape	Polypropylene	kg	0.0000490	General waste
Wooden Pallet	Softwood	kg	0.0171	No information available
Shrink wrap	LDPE	kg	0.0002144	Recycling
Cardboard Box	Cardboard – 100% recycled content	kg	0.0000298	Recycling

Backing paper	Paper	kg	0.000313	General waste

It is assumed that the wooden pallet is reused on site.

4.8 Distribution to customer

The information on destination countries of GeoBubble™ pool cover material has been provided by Valpak using a 3-year average. The table below summarises the transport journeys from Plastipack to the customers by country, such that each country presented contributes to the purchase of at least 1% of total GeoBubble™ units produced by Plastipack. This table summarises 96% of all transport journeys between Plastipack and customers. The final 4% represents destination countries which contribute to less than 1% of purchase volume each and with no specific transport distances available, and have been excluded from the average in order to prevent the overcomplication of analysis.

Table 25: Destination countries of GeoBubble™ pool cover materials

Origin	Destination	Transport mode/type	% of total M^2 3-year average	Notes / Comments
Plastipack Limited	UK	Lorry	9%	Plastipack to Destination 31km
Plastipack Limited	France	Road Train + Ferry	52%	Plastipack to Dover 70km, Dover to Calais (Ferry) 50km, Calais to Destination 790km
Plastipack Limited	Spain	Road Train + Ferry	10%	Plastipack to Dover 70km, Dover to Calais (Ferry) 50km, Calais to Destination 1842km
Plastipack Limited	Germany	Lorry + Ferry	7%	Plastipack to Dover 70km, Dover to Calais (Ferry) 50km, Calais to Destination 668km
Plastipack Limited	Italy	Lorry + Ferry	1%	Plastipack to Dover 70km, Dover to Calais (Ferry) 50km, Calais to Destination 1050km
Plastipack Limited	Portugal	Lorry + Ferry	2%	Plastipack to Dover 70km, Dover to Calais (Ferry) 50km, Calais to Destination 2004km
Plastipack Limited	Belgium	Lorry + Ferry	2%	Plastipack to Dover 70km, Dover to Calais (Ferry) 50km, Calais to Destination 241km
Plastipack Limited	Austria	Lorry + Ferry	1%	Plastipack to Dover 70km, Dover to Calais (Ferry) 50km, Calais to Destination 1181km
Plastipack Limited	Sweden	Lorry + Ferry	1%	Plastipack to Dover 70km, Dover to Calais (Ferry) 50km, Calais to Destination 1926km
Plastipack Limited	Hungary	Lorry + Ferry	1%	Plastipack to Dover 70km, Dover to Calais (Ferry) 50km, Calais to Destination 1563km
Plastipack Limited	Poland	Lorry + Ferry	1%	Plastipack to Dover 70km, Dover to Calais (Ferry) 50km, Calais to Destination 1155km
Plastipack Limited	Czech Republic	Lorry + Ferry	1%	Plastipack to Dover 70km, Dover to Calais (Ferry) 50km, Calais to Destination 1217km

Plastipack Limited	Bulgaria	Lorry + Ferry	1%	Plastipack to Dover 70km, Dover to Calais (Ferry) 50km, Calais to Destination 2423km
Plastipack Limited	South Africa - Cape Town	Container/ Cargo Ship	5%	By road 514m, By Cargo Ship 12,111km
Plastipack Limited	Australia	Container/ Cargo Ship	2%	By road 246km, By Cargo Ship 20,518km
Plastipack Limited	New Zealand	Container/ Cargo Ship	1%	By road 248km, By Cargo Ship 23,438km

The transport journeys of the distribution to customers have been summarised through these four main processes.

Table 26: Transport routes of pool cover materials to customers

Destination	Proportion of purchases to total	Lorry	Road-Train	Ferry	Sea container	Lorry	Road train
Route 1: UK	9%	31 km	-	-	-	-	-
Route 2: Continental Europe excluding France and Spain	18%	70 km	-	50 km	-	1065 km	-
Route 3: France and Spain	62%	-	70 km	50 km	-	-	965 km
Route 4: Rest of World	7%	70 km	-	-	14936 km	362 km	-

The information available on transport destination to customers covers 96% of total transport destinations – the final 4% being for known countries to which less than 1% of purchase volume was sold each and without available journey distances.

Table 27: Scaling of weight of 1 m^2 of pool cover material and associated packaging by proportion of pool cover material that gets transported to destination country

Destination	Percentage of total M^2 3-year average	Scaling transport distances to cover 100%	Weight of 1 m^2 of LB400 pool cover and associated packaging	Weight of 1 m^2 of EGST pool cover and associated packaging
Route 1: UK	9%	9%	0.0375	0.0467

Route 2: Continental Europe excluding France and Spain	18%	19%	0.0755	0.0940
Route 3: France and Spain	62%	65%	0.257	0.320
Route 4: Rest of World	7%	7%	0.0284	0.0354
Total	**96%**	**100%**	**0.399**	**0.496**

The proportions of purchase volumes by destination have been scaled to 96% to account for 100% of purchase volumes. The weight of 1 m^2 of LB400 and EGST materials and associated packaging is multiplied by the scaled proportions of purchased volumes by destination, and then multiplied by the leg distances of each route, to provide a proportionate impact assessment of the transport to customers of on 1 m^2 of LB400 and EGST materials whilst accounting for the variety in destination.

The materials transport weight by distance for each route is as follows.

Table 28: Weight by transport distance of GeoBubble™ material per leg per transport route

	Destination	Lorry kg.km	Road-Train kg.km	Ferry kg.km	Sea container kg.km	Lorry kg.km	Road train kg.km
LB400	Route 1: UK	1.16	-	-	-	-	-
	Route 2: Continental Europe excluding France and Spain	5.28	-	3.77	-	80.4	-
	Route 3: France and Spain	-	18.0	12.9	-	-	248
	Route 4: Rest of World	1.99	-	-	425	10.3	-
EGST	Route 1: UK	1.45	-	-	-	-	-
	Route 2: Continental Europe excluding France and Spain	6.58	-	4.70	-	100.1	-
	Route 3: France and Spain	-	22.4	16.0	-	-	309

	Route 4: Rest of World	2.48	-	-	529	12.8	-

4.9 Distribution to end user

The transport to end user is stated by Plastipack to be undergone in a van, and the journey distance estimated at 250 km on average.

4.10 Maintenance

The data for the maintenance of pool covers has been provided by Plastipack. The maintenance of a pool cover occurs twice a year and consists of 10 minutes of water passing through a hosepipe used to clean the pool cover. 15 litres of water used per minute for 10 minutes per cleaning cycle. This means that 150 L of water is used to clean 32 m^2 of pool cover, and 150 L/32 m^2 = 4.69 L used per m^2 of pool cover.

The average lifespan (provided by Plastipack) of the LB400 material is 4 years and that of EGST is 8 years. This information is used to calculate the water used for the maintenance of the GeoBubble™ materials throughout their lifespan. The maintenance of the pool cover includes the use of water and the treatment of this waste water once used.

Table 29: Water used for the maintenance of 1 m^2 of pool covers during its lifespan

	LB400	EGST
In Litres	37.5	75.0
In Kg	37.4	74.8

4.11 End-of-Life

It is assumed there are no environmental impacts associated with the removal of the pool cover material at EoL.

As the pool cover consists mostly of LDPE, this is widely recyclable at household waste recycling centres. It is assumed that the pool cover will be transported to the household waste recycling centre by the end user and accepted for recycling by the recycling centre as this type of material would not be collected by household waste collection services. There is no available information on journey distances from end user to household waste recycling centre for the pool cover. The cardboard box is assumed to be recycled through household packaging collection services. For the cardboard box, the recovery rate of cardboard is applied for France, which is 81.6% as of 2021[5], which is the most recent year for which data is available. The tape and the label are assumed to be placed in general waste and collected by household general waste services.

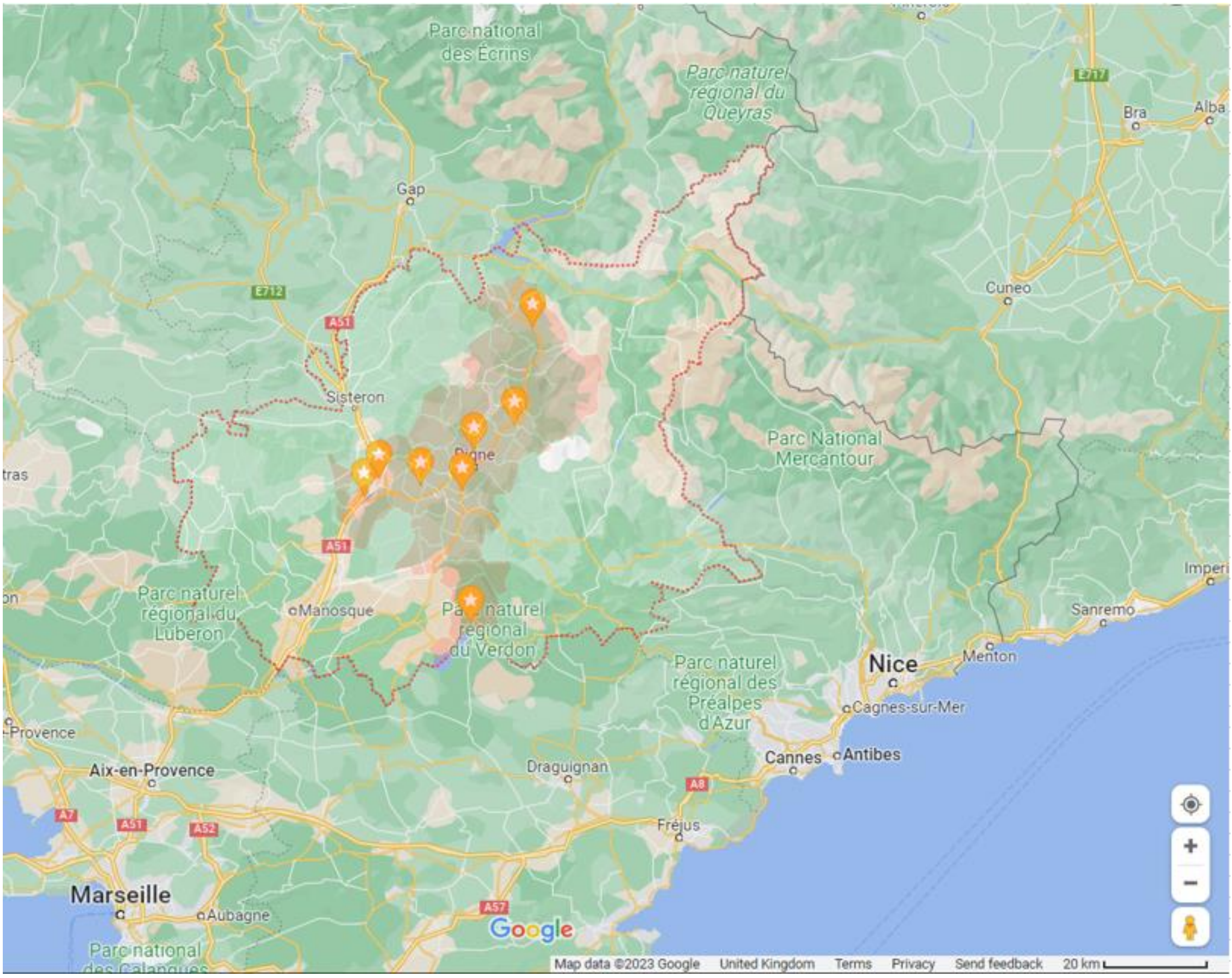
Valpak has formulated assumptions for the journey distance from end user to household waste recycling centre for the pool cover in France.

Online research revealed no available information on the average distance from households to household waste recycling centres in France. To create an informed assumption on the transport distance between household and household waste recycling centres in France, an urban agglomeration has been chosen to map out the average distance. The mapping process utilises Google Maps. The South-east of France has been chosen as the region to map on as it is the region with the highest concentration (39%) of private pools in France[6]. From this, Alpes de Haute Provence is chosen randomly within that area to focus on. This province's geographical

[5] https://www.statista.com/statistics/769494/pcr-recovery-rate-france/#:~:text=In%202021%2C%20the%20recovery%20rate,to%20less%20than%2080%20percent.
[6] https://www.propiscines.fr/piscine-actualite/la-france-compte-pres-de-25-millions-de-piscines-privees#:~:text=Sud%2DEst%20%3A%20la%20plus%20forte%20concentration%20r%C3%A9gionale%20de%20piscines&text=Le%20Nord%2DOuest%20(avec%20le,hors%2Dsol%20(56%25).

borders are dotted in red in the image of the map presented. The Provence-Alpes agglomeration, shaded in red, has been chosen from this Provence to simplify the mapping process. This agglomeration has been chosen within that area due to the availability of information on tips within that agglomeration on the internet. Information on the tips that accept all bulky items has been researched and presented on the map with yellow pins[7]. It is assumed that these tips accept pool covers for recovery. The maximum distance from a household within that agglomeration to a household waste recycling centre within that agglomeration has been approximated at 16.7 km. The average distance has been calculated to be 8.35 km. This average distance has been used as the distance from the end user to the nearest household waste recycling centre to dispose of the pool cover for recycling.

Figure 7: Map showing the Alpes de Haute Provence region, the Provence-Alpes agglomeration and sampling points.



4.12 Life Cycle Impact Factors

Environmental impact factors for the energy, water, fuels, materials, and waste used to manufacture the pool covers are sourced from a modified version of the Ecoinvent 3.8 database, based on the impact assessment method EN15804+A2:2019 for construction products. OpenLCA Nexus[8] provides version 2 of its EN15804 add-on using modified Ecoinvent 3.8 data for producing Environmental Product Declarations (EPDs) compliant with the EN15804+A2:2019 standard for construction products.

[7] https://www.provencealpesagglo.fr/decheteries/
[8] https://nexus.openlca.org/

The data within the EN15804 add-on has been critically reviewed and verified by experts to be compliant with EN15804+A2:2019[9]. For the carbon footprints the environmental indicator used is, total global warming potential, GWP Total, measured as in terms of kg CO_2eq.

Table 30 shows the Ecoinvent LCA datapoints used for materials, fuels, water, transport and waste to model the environmental impacts of the production of the pool covers LB400 and EGST.

Table 30: Processes used for materials, fuels, water, transport and waste used in the production of GeoBubble™ materials and the associated processes (including Module D)

Component	Processes used in the LCA modelling of GeoBubble™ materials
Chemical, inorganic	Chemical production, inorganic | chemical, inorganic | EN15804 - GLO
Chemical, organic	Chemical production, organic | chemical, organic | EN15804 - GLO
Electricity, low voltage	Market for electricity, low voltage | electricity, low voltage | EN15804 - GB
Electricity, low voltage	Market for electricity, low voltage | electricity, low voltage | EN15804 - FR
EUR-flat pallet	EUR-flat pallet production | EUR-flat pallet | EN15804 - RER
Extrusion, co-extrusion	Extrusion, co-extrusion of plastic sheets | extrusion, co-extrusion | EN15804 - RoW
Extrusion, plastic film	Extrusion, plastic film | extrusion, plastic film | EN15804 - RER
Extrusion, plastic film	Market for extrusion, plastic film | extrusion, plastic film | EN15804 - GLO
Fibre and fabric waste, polyester	Fibre and fabric waste, polyester, Recycled Content cut-off | fibre and fabric waste, polyester | EN15804 - GLO
Heat, central or small-scale, natural gas	Market for heat, central or small-scale, natural gas | heat, central or small-scale, natural gas | EN15804 - Europe without Switzerland
Injection moulding	Injection moulding | injection moulding | EN15804 - RER
Isopropanol	Isopropanol production | isopropanol | EN15804 - RER
Nylon 6-6	Nylon 6-6 production | nylon 6-6 | EN15804 - RER
Packaging film, low density polyethylene	Packaging film production, low density polyethylene | packaging film, low density polyethylene | EN15804 - RER
Packaging film, low density polyethylene	Market for packaging film, low density polyethylene | packaging film, low density polyethylene | EN15804 - GLO
Paper, woodfree, coated	Paper production, woodfree, coated, at integrated mill | paper, woodfree, coated | EN15804 - RER
Paper, woodfree, coated	Market for paper, woodfree, coated | paper, woodfree, coated | EN15804 - RER
Polyethylene, high density, granulate	Polyethylene production, high density, granulate | polyethylene, high density, granulate | EN15804 - RER

[9] https://nexus.openlca.org/ws/files/23889.

Polyethylene, linear low density, granulate	Polyethylene production, linear low density, granulate | polyethylene, linear low density, granulate | EN15804 - RER
Polyethylene, low density, granulate	Polyethylene production, low density, granulate | polyethylene, low density, granulate | EN15804 - RER
Polypropylene, granulate	Polypropylene production, granulate | polypropylene, granulate | EN15804 - RER
Polypropylene, granulate	Market for polypropylene, granulate | polypropylene, granulate | EN15804 - GLO
Tap water	Market for tap water | tap water | EN15804 - Europe without Switzerland
Transport, freight, lorry >32 metric ton, EURO6	Transport, freight, lorry >32 metric ton, EURO6 | transport, freight, lorry >32 metric ton, EURO6 | EN15804 - RER
Transport, freight, lorry 16-32 metric ton, EURO6	Transport, freight, lorry 16-32 metric ton, EURO6 | transport, freight, lorry 16-32 metric ton, EURO6 | EN15804 - RER
Transport, freight, lorry 16-32 metric ton, EURO6	Transport, freight, lorry 16-32 metric ton, EURO6 | transport, freight, lorry 16-32 metric ton, EURO6 | EN15804 - RoW
Transport, freight, lorry 3.5-7.5 metric ton, EURO6	Transport, freight, lorry 3.5-7.5 metric ton, EURO6 | transport, freight, lorry 3.5-7.5 metric ton, EURO6 | EN15804 - RER
Transport, freight, sea, container ship	Transport, freight, sea, container ship | transport, freight, sea, container ship | EN15804 - GLO
Transport, freight, sea, ferry	Transport, freight, sea, ferry | transport, freight, sea, ferry | EN15804 - GLO
Transport, passenger car	Transport, passenger car | transport, passenger car | EN15804 - RER
Waste graphical paper	Market for waste graphical paper | waste graphical paper | EN15804 - GB
Waste graphical paper	Market for waste graphical paper | waste graphical paper | EN15804 - FR
Waste paperboard	Market for waste paperboard | waste paperboard | EN15804 - FR
Waste paperboard, sorted	Waste paperboard, sorted, Recycled Content cut-off | waste paperboard, sorted | EN15804 - GLO
Waste paperboard, sorted	Treatment of waste paperboard, unsorted, sorting | waste paperboard, sorted | EN15804 - Europe without Switzerland
Waste paperboard, sorted	Market for waste paperboard, sorted | waste paperboard, sorted | EN15804 - GLO
Waste paperboard, unsorted	Market for waste paperboard, unsorted | waste paperboard, unsorted | EN15804 - Europe without Switzerland
Waste plastic, mixture	Market for waste plastic, mixture | waste plastic, mixture | EN15804 - FR
Waste polyethylene	Market for waste polyethylene | waste polyethylene | EN15804 - FR
Waste polyethylene, for recycling, sorted	Waste polyethylene, for recycling, sorted, Recycled Content cut-off | waste polyethylene, for recycling, sorted | EN15804 - GLO

Waste polyethylene, for recycling, sorted	Treatment of waste polyethylene, for recycling, unsorted, sorting | waste polyethylene, for recycling, sorted | EN15804 - Europe without Switzerland
Waste polyethylene, for recycling, unsorted	Market for waste polyethylene, for recycling, unsorted | waste polyethylene, for recycling, unsorted | EN15804 - Europe without Switzerland
Waste polypropylene	Market for waste polypropylene | waste polypropylene | EN15804 - FR
Waste textile, soiled	Treatment of waste textile, soiled, municipal incineration | waste textile, soiled | EN15804 - RoW
Waste water maintenance	Treatment of wastewater, from residence, capacity 1.1E10l/year | wastewater, from residence | EN15804 - RoW

5. Data Validation

This section describes the quality of the data used, and the steps taken to increase the accuracy and validity of data used in this study.

5.1 Quality of Data

In general, the quality of data used is judged based on the principle that primary process specific data used to model the manufacture of the pool cover materials LB400 and EGST at the production site must be of higher quality than background data processes (the latter are provided by the Ecoinvent 3.8 datasets used, they are processes upstream in the supply chain of Plastipack's main specific production processes and are not readily influenceable by Plastipack).

5.1.1 Temporal Representativeness

Comprehensive process specific input data of high quality, granularity and temporal representativeness has been provided by Plastipack regarding the Assembly 1 manufacturing processes for the pool cover materials LB400 and EGST and the supply chains for materials and fuels at the production site. The datasets for the raw material processes are for 2022, and a 3-year average is used for fuels, water and pool cover material offcuts and are therefore very recent and highly representative of actual processes used at Assembly 1. Comprehensive process specific input data of high quality and granularity has been provided by Plastipack regarding the transport to customers of the pool cover materials, including 3-year average of the proportion of GeoBubble™ materials sold by destination country and descriptions of transport journeys. For the Assembly 2 process-specific inputs, the data on electricity used has been provided by Plastipack, based on a 3-year usage average that has been allocated to a unit of analysis using data on total production of pool cover materials per annum.

5.1.2 Geographical representativeness

Environmental impact factors used are representative of the location of the production sites, and supplier locations in the supply chains for materials used to produce the Plastipack pool cover materials.

Comprehensive process specific input data of high quality, granularity and geographical representativeness has been provided by Plastipack regarding the Assembly 1 manufacturing processes for the pool cover materials LB400 and EGST and the supply chains for materials and fuels at the production site. Processes from EN15804 add-on database of geographical representativeness have been applied to every stage of the life cycle of the pool covers. The production of raw materials and use of water, fuels and waste treatment service (including transport) which are mostly based in the UK, have been modelled using UK/GB specific processes when possible (there are just 2 instances of GB specific processes), where not an option, Europe (excluding Switzerland), Europe average processes, Rest of World average processes and Global average processes are used (see table 30). The transport to customers to Assembly 2 uses high-level data encompassing 96% of transport journeys to customers, which account for destination countries with greater than 1% of purchase volumes, and with known transport distances. For transport journeys to customers in Europe, Europe average processes are used and when not an option, Global average processes are used. For transport journeys to customers outside of Europe, Rest of World average processes are used. Assembly 2 activities, maintenance and End-of-Life of the pool covers are modelled to be based in France, as 52% of total purchasing volumes are destined to France. Processes representative of France from EN15804 add-on database are used for Assembly 2 activities, maintenance and End-of-Life of the pool covers when possible and when not an option are replaced by Europe excluding Switzerland, Europe average processes, or Global processes.

5.1.3 Technological representativeness

Environmental impact factors used are representative of the current technological developments. The modelling of the masterbatches, the extrusion of plastic packaging, the maintenance stage and transport processes are represented by processes in line with the current technologies. The End-of-Life scenario for the pool cover accounts for the current technological abilities of recycling 'LDPE rich' plastic materials, however it assumes well-established systems for the recycling of bulky LDPE rich plastic in France. Disposal technologies and methods are considered representative of current practices.

5.2 Data limitations and Assumptions

The composition of masterbatches was assumed using generic components (LDPE, organic chemical, inorganic chemical). This is due to the fact that there was limited available information on the proportions of the composition of masterbatches coupled with the lack of specific processes to model the components available on the EN15804 add-on database.

Distances from Assembly 1 stage to waste treatment facility are sourced from Google maps. These journey distances are approximations because the specific routes actually taken on delivery journeys between production site and waste site, in 2022 is not available. There is no information available on Google maps on the nature of the site (whether it is an office-site or a waste facilities site) for the recycling company used, therefore the closest site has been chosen as the destination.

Comprehensive process specific input data of high quality and granularity has been provided by Plastipack regarding the transport to customers of the pool cover materials, including 3-year average of the proportion of GeoBubble™ materials sold by destination country and descriptions of transport journeys. This high-level data is provided to 96% of transport journeys to customers, which account for destination countries with greater than 1% of purchase volumes, and with known transport distances. VSC scales this dataset to be representative of 100% of transport journeys to customers and adds on environmental impact factors and methods from the EN15804 add-on database. The transport to customers specific input data provided by Plastipack is regarded as high quality and high accuracy.

Assumptions have been used to model for the Assembly 2 processes. The data on packaging is provided by Plastipack using sector-specific knowledge. Inbound packaging for the cardboard box, in lieu of measured weights, has been determined by VSC through discussion with a Valpak packaging expert combined with research to determine the appropriate weights of the packaging. To this dataset, VSC added data environmental impact factors and methods from the EN15804 add-on database. Representative environmental impacts factors are used that include market activity of the processes to account for the lack of information available on distances from supplier to Assembly 2 and Assembly 2 to waste disposal/treatment site. The Assembly 2 specific input data provided by Plastipack is regarded as adequate.

The distribution to end user and the maintenance of pool covers LB400 and EGST are calculated based on assumptions provided by Plastipack using sector-specific knowledge. The distribution to end user and the maintenance of pool covers specific input data provided by Plastipack is regarded as adequate.

For the End-of-Life of product, it is known that the processes providing the environmental impacts are calculated based on assumptions and theoretical models, therefore the quality of the data should be regarded as poor. As such, it is acknowledged here that the impacts are uncertain.

In summary, the data is judged overall to be of high quality and an accurate representation (in terms of timeliness, geography, and technology) for all processes used in manufacture of the pool coversLB400 and EGST.

5.3 Completeness of Environmental Impacts

All process flows have been quantified in terms of their environmental impacts. Environmental impact factors are sourced from the Ecoinvent 3.8 database, as modified for compliance with the EN15804+A2:2019 standard for producing Environmental Product Declarations (EPDs). The data within it has been critically reviewed and verified to be compliant with EN15804[10]. Carbon emissions from all sources (fuels, materials, production, transport, water and waste) are quantified in terms of their environmental impacts.

[10] https://nexus.openlca.org/ws/files/23889.

6. Discussion of results

The environmental impacts and other impacts of one functional unit of the pool covers LB400 and EGST from cradle-to-grave are presented below.

Table 31: Environmental impacts of 1 m^2 of LB400 and EGST pool covers

Indicator	**EGST**	**LB400**	**Unit**
Environmental Impacts			
EI acidification	5.77E-03	4.58E-03	molc H+ eq
EI climate change, GWP biogenic	0.00E+00	0.00E+00	kg CO_2 eq
EI climate change, GWP fossil	1.49E+00	1.20E+00	kg CO_2 eq
EI climate change, GWP land transformation	8.72E-04	6.93E-04	kg CO_2eq
EI climate change, GWP total	1.49E+00	1.21E+00	kg CO_2 eq
EI depletion of abiotic resources - ADPE elements	1.05E-05	8.59E-06	kg Sb-Eq
EI depletion of abiotic resources - ADPF fossil fuels	4.26E+00	3.33E+00	MJ
EI eutrophication, freshwater	3.73E-04	2.74E-04	kg P eq
EI eutrophication, marine	2.70E-03	1.71E-03	kg N eq
EI eutrophication, terrestrial	1.20E-02	9.57E-03	molc N eq
EI ozone depletion	7.98E-08	6.63E-08	kg CFC11 eq
EI photochemical ozone formation	5.53E-03	4.46E-03	kg NMVOC eq
EI water use, AWARE	1.18E+00	8.37E-01	m^3

A comparison of environmental impacts of one functional unit of LB400 and EGST pool covers shows that EGST has higher values for all environmental impacts and other impacts considered in the table due to differences in product weight (and therefore raw materials inputted).

The LCA results show that the majority of impacts can be attributed to the production of LDPE. For example, for both LB400 and EGST pool covers, the production of LDPE contributed to 51%-58% of freshwater eutrophication.

Similarly, in the cases of the carbon footprint and water deprivation potential, raw materials extraction and in particular, the production of LDPE contributes the most to these impacts of the pool covers' lifecycles.

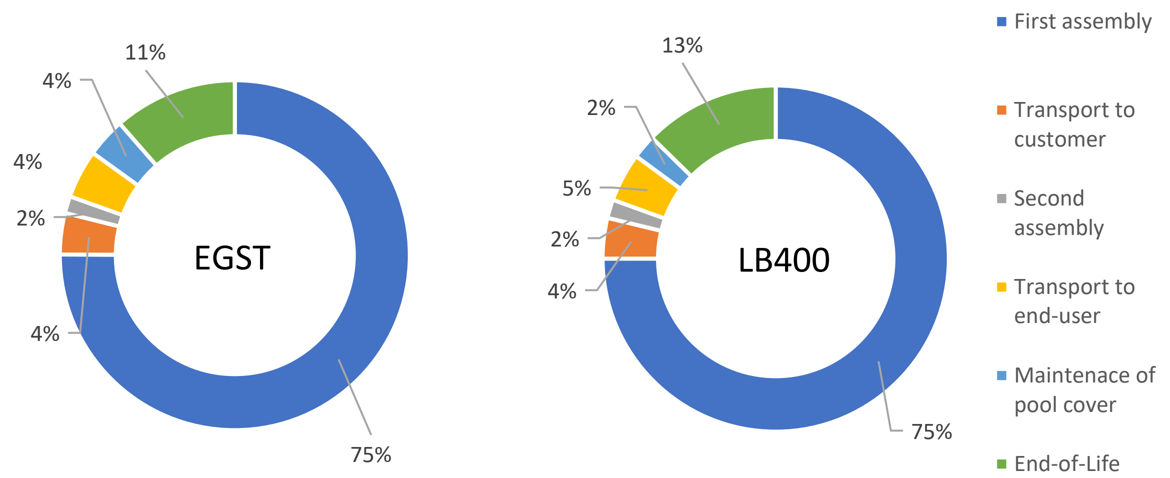
The

6.1 Carbon Footprint

This section reports the quantified carbon footprints for each of the pool covers. The carbon footprints reported are inclusive of the carbon emissions caused by End-of-Life processes of product at the End-of-Life. The carbon footprints of the LCA of 1 m^2 of LB400 and EGST pool covers are 1.21 kg CO_2eq and 1.49 kg CO_2eq respectively. The carbon footprints of the LCA of a standard 32 m^2 pool cover of LB400 and EGST are 38.7 kg CO_2eq and 47.7 kg CO_2eq respectively.

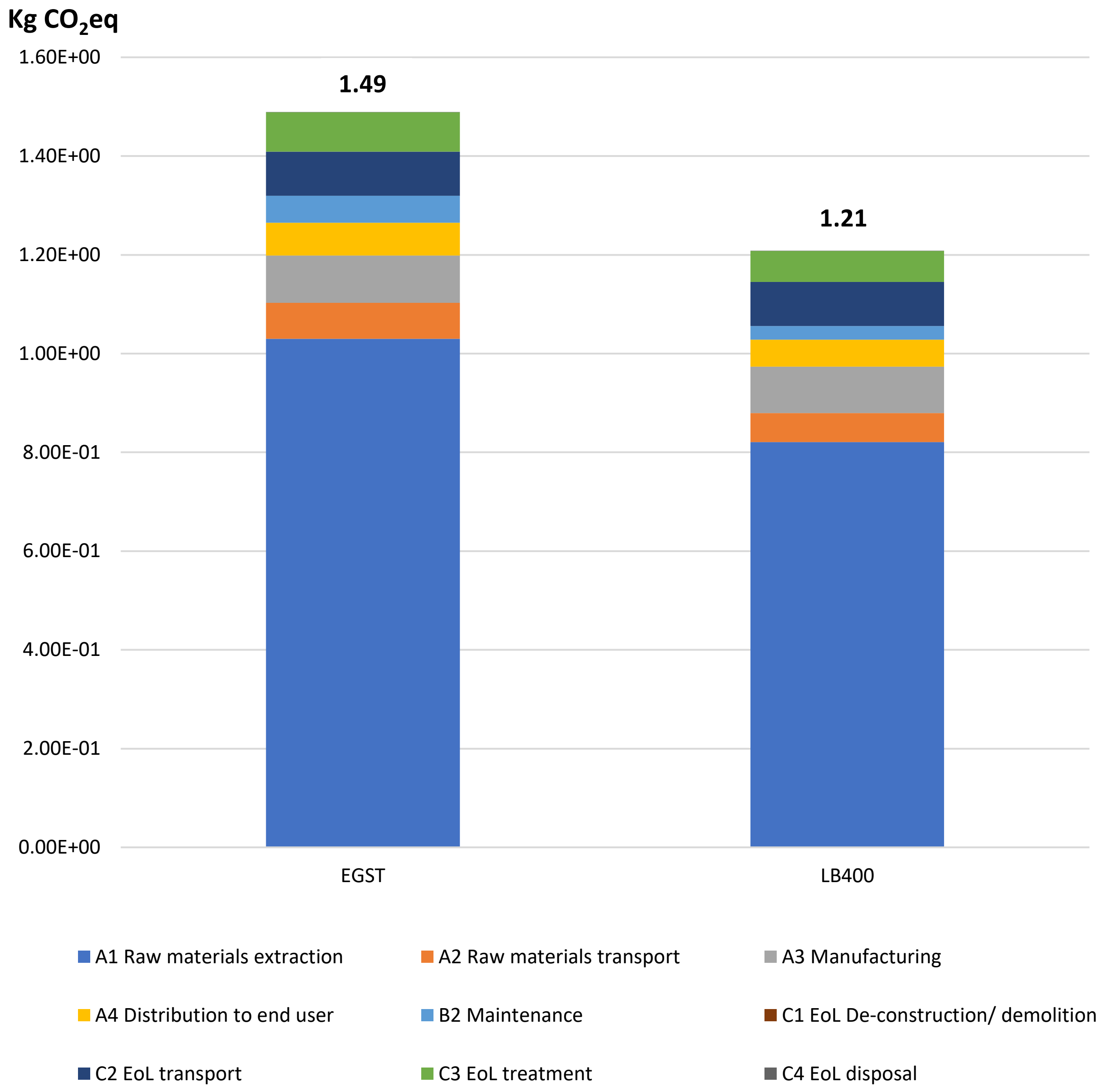
The figure below shows the contribution of each lifecycle stage to the overall carbon footprint for LB400 and EGST pool covers.

Figure 8: Contribution of each of the life cycle stages to the overall carbon footprint for LB400 and EGST pool covers



For both LB400 and EGST pool covers, the first assembly stage contributes to most to the carbon footprint of the life cycle per functional unit, which is 75% for EGST and LB400. The second biggest contributor to the overall carbon footprint of the pool covers is the End-of-Life stage, which contributes 11% of overall footprint for EGST and 13% for LB400. The model for the End-of-Life of the pool covers assumes that the end user drives to the household waste recycling centre to recycle the pool cover.

Figure 9: Contribution of each of the life cycle stages by EPD module to the overall carbon footprint per 1 m^2 of LB400 and EGST pool covers



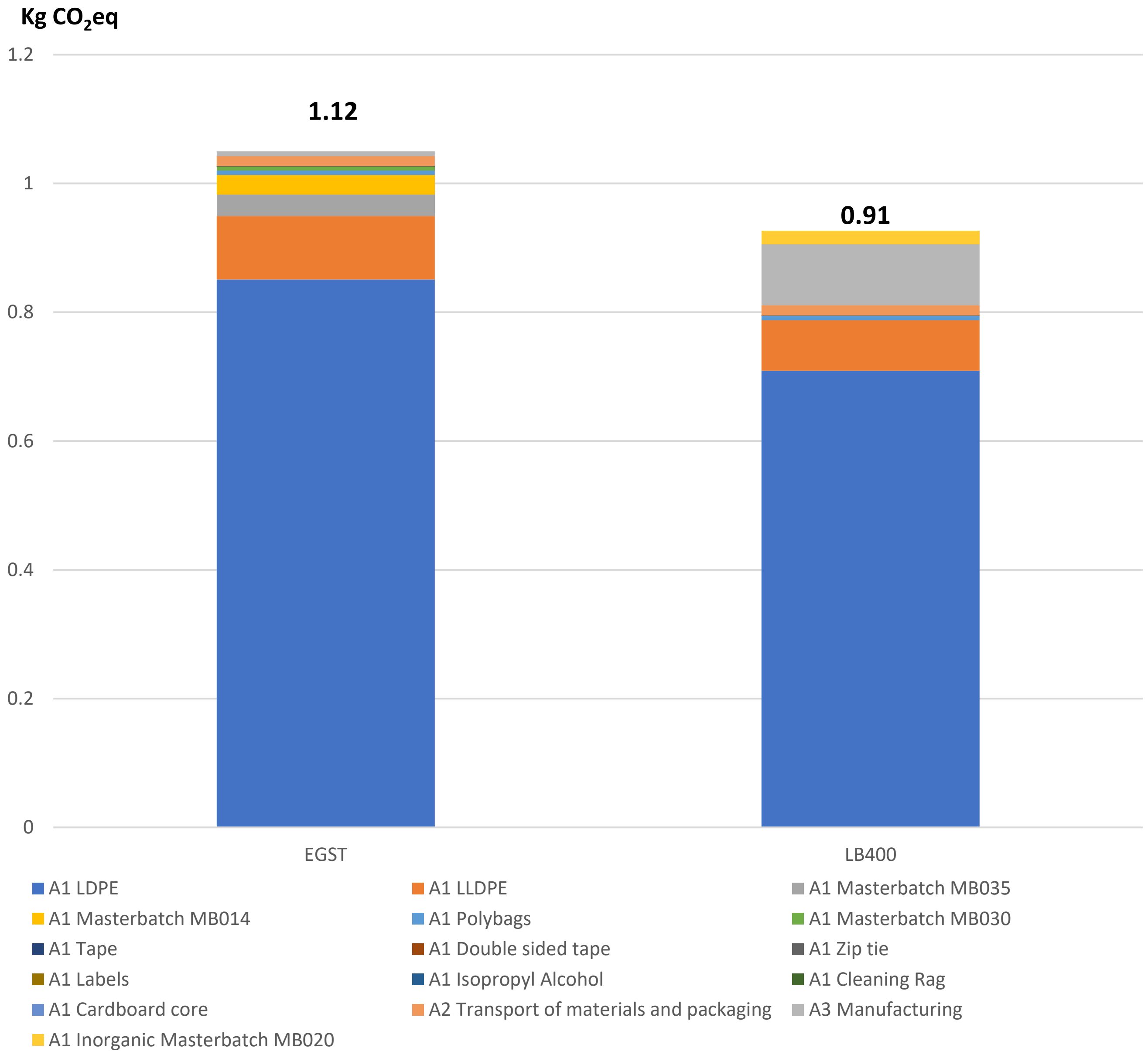
The figure shows the overall carbon footprint of one functional unit of pool cover LB400 and EGST broken down by lifecycle module. The lifecycle module A1 which represents raw materials extraction contributes the most to the overall carbon footprint of LB400 and EGST, contributing 68% and 69% to the overall footprint respectively. This can mostly be attributed to the carbon footprint of the raw materials of the pool covers. The carbon footprint for LB400 pool cover is lower than that of EGST pool cover mostly due to the weight of LB400 GeoBubble™ material weighing less than the EGST GeoBubble™ material per 1 m2, therefore using less LDPE as a raw material.

The table below shows the carbon footprint used per 1 m^2 of LB400 and EGST pool covers in one life cycle.

Table 32: Contribution of life cycle stages of LB400 and EGST pool covers to overall carbon footprint

EPD module	**EGST (**kg CO_2eq)	**LB400 (**kg CO_2eq)
A1 Raw materials extraction	1.03E+00	8.21E-01
A2 Raw materials transport	7.28E-02	5.87E-02
A3 Manufacturing	9.56E-02	9.36E-02
A4 Distribution to end user	6.67E-02	5.51E-02
B2 Maintenance	5.42E-02	2.71E-02
C1 EoL De-construction/ demolition	0.00E+00	0.00E+00
C2 EoL transport	8.94E-02	8.94E-02
C3 EoL treatment	8.02E-02	6.32E-02
C4 EoL disposal	6.63E-04	6.63E-04

Figure 10: The contribution of materials, transport and manufacturing process to carbon footprint of 1 m^2 of LB400 and EGST pool covers in first assembly



The above figure shows the contribution of materials, transport and manufacturing process to first assembly carbon footprint. For both EGST and LB400 pool covers, the most significant contributor to first assembly carbon footprint is LDPE. The second most significant contributor to first assembly carbon footprint is LLDPE for EGST and the manufacturing process for LB400.

The table below shows the carbon footprint of materials, transport and manufacturing process at first assembly.

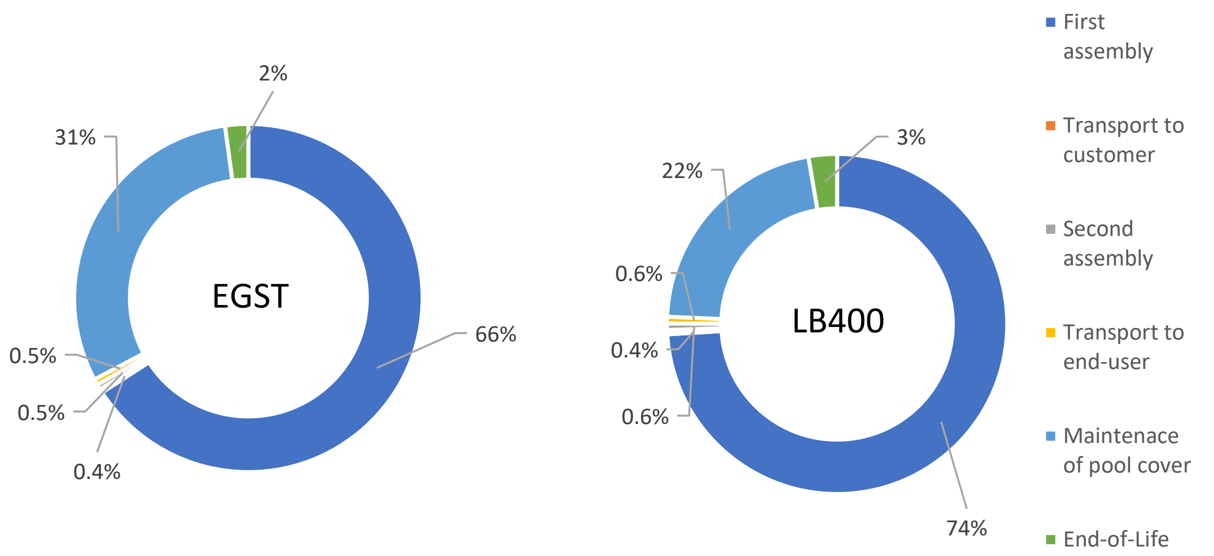
Table 33: Breakdown of First Assembly Carbon Footprint for EGST and LB400

Component	**EGST (**kg CO_2eq)	**LB400 (**g CO_2eq)
A1 LDPE	8.43E-01	7.03E-01
A1 LLDPE	9.76E-02	7.81E-02
A1 Masterbatch MB035	3.37E-02	N/A
A1 Masterbatch MB014	2.97E-02	N/A
A1 Polybags	7.11E-03	7.11E-03
A1 Masterbatch MB030	6.33E-03	N/A
A1 Tape	1.16E-04	1.16E-04
A1 Double sided tape	1.67E-04	1.67E-04
A1 Zip tie	9.33E-05	9.33E-05
A1 Labels	7.26E-05	7.26E-05
A1 Isopropyl Alcohol	1.05E-04	1.05E-04
A1 Cleaning Rag	1.36E-06	1.36E-06
A1 Cardboard core	-1.52E-03	-1.52E-03
A2 First Assembly	1.57E-02	1.29E-02
A3 First Assembly	8.41E-02	8.39E-02
A1 Inorganic Masterbatch MB020	N/A	2.01E-02

6.2 Water Deprivation Potential

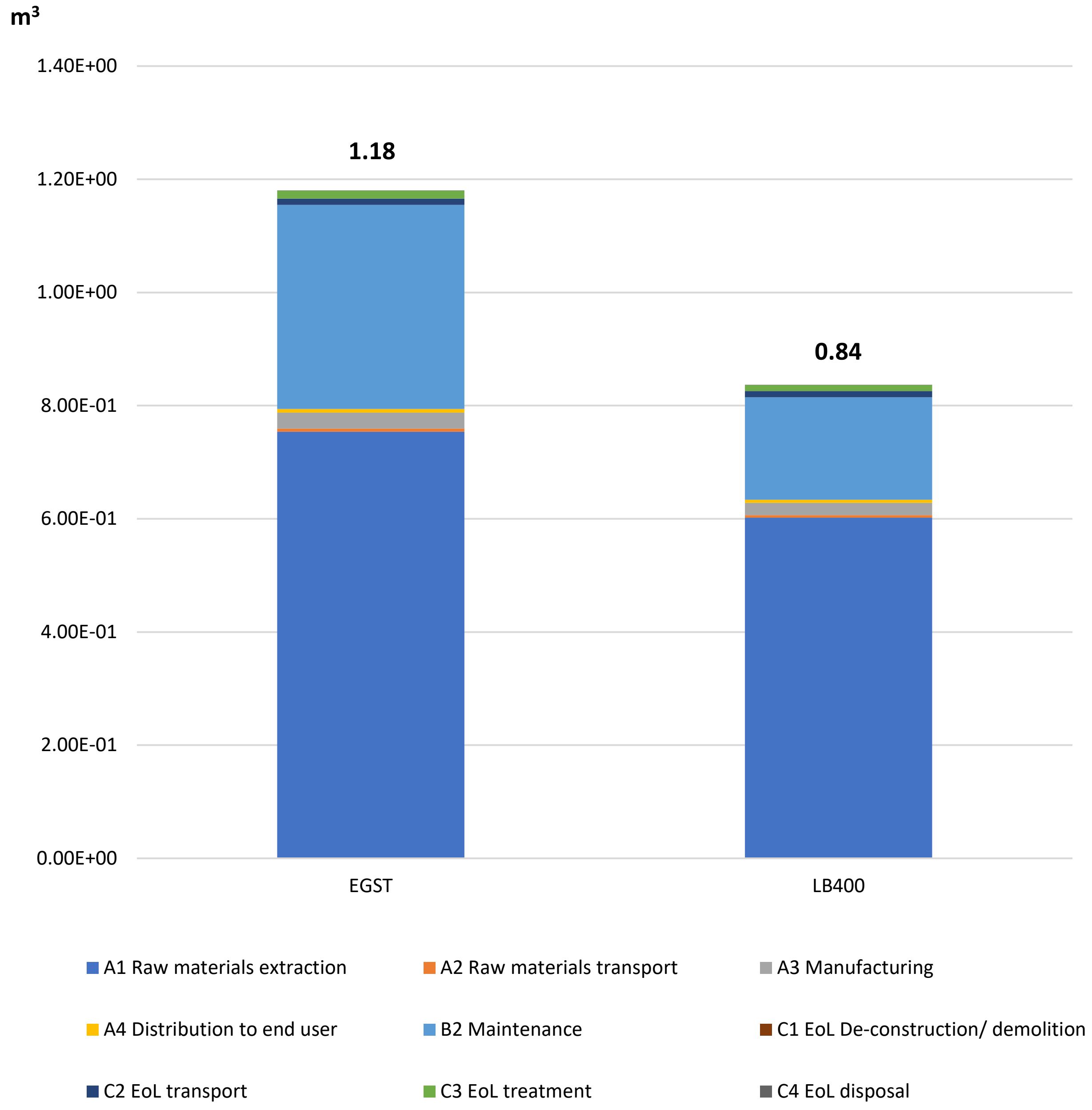
This section reports the quantified water deprivation potential for LB400 and EGST pool covers. The water deprivation potential of the LCA of 1 m^2 of LB400 and EGST are 0.84 m^3 and 1.18 m^3 respectively. The water deprivation potential of the LCA of a standard 32 m^2 pool cover of LB400 and EGST are 26.8 m^3 and 37.8 m^3 respectively. The figure below shows the contribution of each lifecycle stage to the overall water deprivation potential for LB400 and EGST.

Figure 11: Contribution of each of the life cycle stages to the overall water deprivation potential of LB400 and EGST pool cover



For both LB400 and EGST, the majority of water deprivation potential can be attributed to the first assembly stage (74% and 66% respectively). For both LB400 and EGST, the second largesy contributor to the overall water deprivation potential is the maintenance phase. The water deprivation potential in the second assembly stage, transport to customer,transport to end user and End-of-Life stage make up 4.36% and 3.53% of the overall water deprivation potential in the life cycles of LB400 and EGST respectively.

Figure 12: Contribution of each of the life cycle stages by EPD module to the overall water deprivation potential per 1 m^2 of LB400 and EGST pool covers



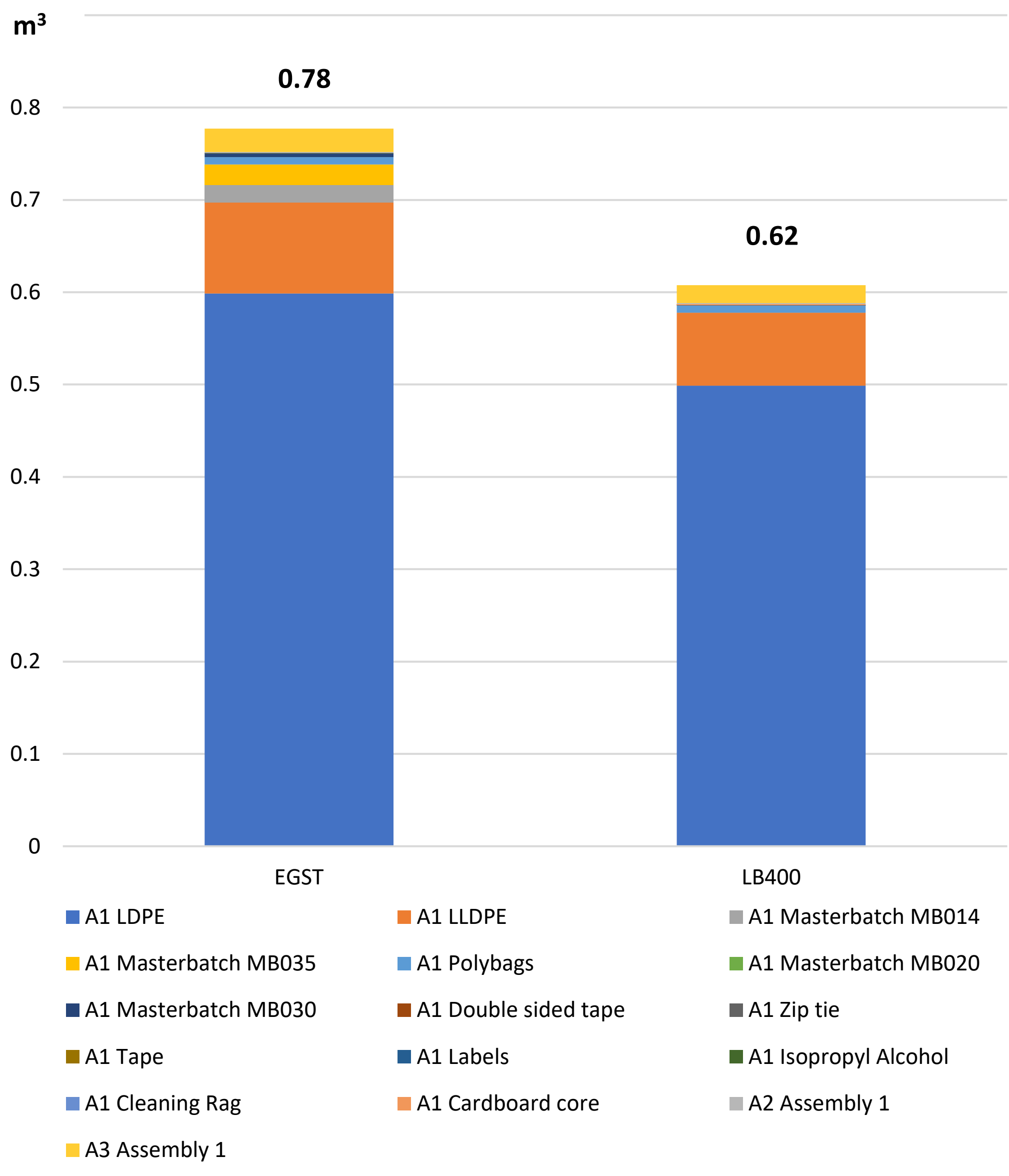
The figure shows the overall water deprivation potential of 1 m^2 of LB400 and EGST pool covers broken down by LCA information modules. Module A1 which represents raw materials extraction, contributes the most to the overall water deprivation potential of EGST and LB400 pool covers, accounting for 64% and 72% of the overall water deprivation potential of the life cycles respectively. The water deprivation potential for LB400 pool cover is lower than EGST pool cover considered due to the weight of LB400 GeoBubble™ material weighing less than EGST GeoBubble™ material per 1 m^2, therefore using less LDPE as a raw material. The maintenance of the pool covers, which consists of rinsing the pool cover twice a year, is the second largest contributor to the water deprivation potential of the life cycles of LB400 and EGST pool covers. The model for the maintenance stage of the pool covers is for the duration of their expected lifespans, this is 4 years for LB400 and 8 years for EGST.

The table below shows the amount of water deprivation potential per 1 m^2 of LB400 and EGST in one life cycle.

Table 34: Contribution of life cycle stages of LB400 and EGST pool covers to overall water deprivation potential

EPD module	**EGST (m^3)**	**LB400 (m^3)**
A1 Raw materials extraction	7.54E-01	6.02E-01
A2 Raw materials transport	5.43E-03	4.38E-03
A3 Manufacturing	2.80E-02	2.18E-02
A4 Distribution to end user	6.45E-03	5.32E-03
B2 Maintenance	3.61E-01	1.81E-01
C1 EoL De-construction/ demolition	0.00E+00	0.00E+00
C2 EoL transport	1.11E-02	1.11E-02
C3 EoL treatment	1.37E-02	1.10E-02
C4 EoL disposal	4.51E-04	4.51E-04

Figure 13:The contribution of materials, transport and manufacturing process to the water deprivation potential of 1 m^2 of LB400 and EGST in first assembly



The figure shows that LDPE, LLDPE and masterbatches contribute the most to water deprivation potential in first assembly for EGST and LB400.

The table below breaks down the water deprivation potential contributions from materials, materials transport, and manufacturing process in first assembly for LB400 and EGST.

Table 35: Water deprivation potential contributions at first assembly from 1 m^2 of LB400 and EGST materials

Components	**EGST (m^3)**	**LB400 (m^3)**
A1 LDPE	5.99E-01	4.99E-01
A1 LLDPE	9.87E-02	7.90E-02
A1 Masterbatch MB014	1.85E-02	N/A
A1 Masterbatch MB035	2.25E-02	N/A
A1 Masterbatch MB020	N/A	1.34E-02
A1 Masterbatch MB030	3.95E-03	N/A
A1 Polybags	7.77E-03	7.77E-03
A1 Double-sided tape	1.96E-04	1.96E-04
A1 Zip tie	1.02E-04	1.02E-04
A1 Tape	9.13E-05	9.13E-05
A1 Labels	6.66E-05	6.66E-05
A1 Isopropyl Alcohol	3.95E-05	3.95E-05
A1 Cleaning Rag	1.08E-06	1.08E-06
A1 Cardboard core	0.00E+00	0.00E+00
A2 First Assembly	1.26E-03	1.04E-03
A3 First Assembly	2.52E-02	1.94E-02

6.3 Biogenic carbon in GeoBubble™ material and Packaging

6.3.1 LB400

The following table showcases the biogenic carbon present in the 1 m^2 of LB400 pool cover.

Table 36: Biogenic carbon in 1 m^2 of LB400 pool cover

Material	Biogenic carbon kg C
LDPE	0.00
LLDPE	0.00
Masterbatch MB020	0.00
Total	**0.00**

The following table showcases the biogenic carbon present in the packaging (after second assembly) of 1 m^2 of LB400 pool cover.

Table 37: Biogenic carbon in the packaging (after second assembly) of 1 m^2 of LB400 pool cover

Packaging Material	Biogenic carbon kg C
Polypropylene	0.00
Cardboard	0.00753
Polypropylene	0.00
Total	**0.00753**

6.3.2 EGST

The following table showcases the biogenic carbon present in the 1 m^2 of EGST pool cover.

Table 38: Biogenic carbon 1 m^2 of EGST pool cover

Material	Biogenic carbon kg C
LDPE	0.00
LLDPE	0.00
Masterbatch MB014	0.00
Masterbatch MB035	0.00
Masterbatch MB030	0.00
Total	**0.00**

The following table showcases the biogenic carbon present in the packaging (after second assembly) of 1 m^2 of EGST pool cover.

Table 39: Biogenic carbon in the packaging (after second assembly) of 1 m^2 of EGST pool cover

Packaging Material	Biogenic carbon kg C
Polypropylene	0.00
Cardboard	0.00753
Polypropylene	0.00
Total	**0.00753**

6.4 Mandatory and voluntary impacts according to EN15804

6.4.1 LB400

Table 40: Results of the mandatory environmental impact category indicators according to EN 15804 for the life cycle of 1 m^2 of LB400 pool cover

Indicators	Unit	A1-A3	A4	B2	C1	C2	C3	C4
GWP biogenic	kg CO_2 eq.	-2.76E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.25E-03	5.11E-03
GWP-fossil	kg CO_2 eq.	9.65E-01	5.50E-02	2.68E-02	0.00E+00	8.93E-02	6.93E-02	2.05E-03
GWP-LULUC	kg CO_2 eq.	5.47E-04	3.27E-05	2.76E-05	0.00E+00	4.27E-05	4.22E-05	2.33E-07
GWP-Total	kg CO_2 eq.	9.73E-01	5.51E-02	2.71E-02	0.00E+00	8.94E-02	6.32E-02	6.63E-03
ODP	kg CFC11 eq.	3.46E-08	1.20E-08	1.66E-09	0.00E+00	1.67E-08	1.42E-09	3.73E-11
AP	molc H^+ eq.	3.72E-03	1.58E-04	2.21E-04	0.00E+00	3.70E-04	1.15E-04	3.54E-06
EP – freshwater	kg P eq.	2.01E-04	5.14E-06	4.75E-05	0.00E+00	1.23E-05	8.13E-06	5.65E-08
EP – marine	kg N eq.	7.22E-04	2.93E-05	7.92E-04	0.00E+00	8.72E-05	7.09E-05	9.53E-06
EP – terrestrial	molc N eq.	7.41E-03	3.17E-04	5.42E-04	0.00E+00	9.43E-04	3.48E-04	1.32E-05
POCP	kg NMVOC eq.	3.81E-03	1.19E-04	1.06E-04	0.00E+00	3.16E-04	1.00E-04	5.80E-06
ADP – minerals and metals*	kg Sb eq.	6.49E-06	3.28E-07	2.95E-07	0.00E+00	1.09E-06	3.89E-07	1.15E-09
ADP – fossil*	MJ	2.72E+00	8.49E-02	1.74E-01	0.00E+00	2.25E-01	1.22E-01	1.18E-03
WDP*	m^3	6.28E-01	5.32E-03	1.81E-01	0.00E+00	1.11E-02	1.10E-02	4.51E-04

GWP-biogenic = Global warming potential biogenic, GWP-fossil = Global warming potential fossil fuels, GWP-LULUC= Global warming potential land use and land use change, GWP – Total = Total global warming potential, ODP = Ozone layer depletion potential, AP = Acidification potential, EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment, EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment, EP-terrestrial = Eutrophication potential terrestrial, POCP = Formation potential of tropospheric ozone, ADP – minerals and metals = Abiotic depletion potential for non-fossil resources, ADP – fossil = Abiotic depletion for fossil resources potential, WDP = Water deprivation potential.

* *Disclaimer: The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator*

Table 41: Results of the mandatory indicator on resource use according to EN15804 for the lifecycle of 1 m² of LB400 pool cover

Indicators	Unit	A1-A3	A4	B2	C1	C2	C3	C4
PENRT	MJ	3.34E+01	8.34E-01	4.22E-01	0.00E+00	1.29E+00	2.57E-01	3.98E-03
PENRE	MJ	5.85E+00	1.11E-01	2.85E-01	0.00E+00	2.57E-01	1.57E-01	1.35E-03
PENRM	MJ	2.76E+01	7.23E-01	1.37E-01	0.00E+00	1.03E+00	9.93E-02	2.63E-03
PERE	MJ	8.37E-01	1.28E-02	2.44E-02	0.00E+00	2.13E-02	1.76E-02	1.20E-04
PERM	MJ	3.63E-01	4.50E-03	7.28E-03	0.00E+00	7.90E-03	7.56E-03	3.59E-05
PERT	MJ	1.20E+00	1.73E-02	6.55E-02	0.00E+00	2.92E-02	2.52E-02	1.56E-04
FW	m^3	1.47E-02	1.27E-04	9.75E-03	0.00E+00	2.73E-04	2.61E-04	1.06E-05
SM	kg	1.15E-01	1.28E-03	9.68E-03	0.00E+00	2.40E-03	4.61E-01	1.38E-05
NRSF	MJ	2.08E-02	1.83E-03	4.61E-03	0.00E+00	5.12E-04	5.49E-04	2.48E-06
RSF	MJ	2.41E-02	3.98E-04	2.01E-03	0.00E+00	2.67E-04	5.18E-04	1.44E-06

PENRT = Total use of non-renewable primary energy resources, PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials, PENRM = Use of non-renewable primary energy resources used as raw materials, PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials, PERM = Use of renewable primary energy resources used as raw materials, PERT = Total use of renewable primary energy resources FW = Use of net fresh water, SM = Use of secondary materials, NRSF = Use of non-renewable secondary fuels, RSF = Use of renewable secondary fuels.

Table 42: Results of the mandatory indicators on waste according to EN15804 for the lifecycle of 1 m² of LB400 pool cover

Indicators	Unit	A1-A3	A4	B2	C1	C2	C3	C4
HW	kg	1.02E+00	2.69E-02	6.12E-02	0.00E+00	6.58E-02	4.18E-02	3.43E-04
NHW	kg	1.01E-01	2.62E-02	9.31E-03	0.00E+00	3.16E-02	4.07E-02	1.25E-02
RW	kg	1.57E-03	2.15E-05	6.79E-05	0.00E+00	2.57E-05	2.21E-05	1.18E-07

HW = Hazardous waste, NHW = Non-hazardous waste, RW = Radioactive waste.

Table 43:Results of other mandatory indicator according to EN15804 for the lifecycle of 1 m^2 of LB400 pool cover

Indicators	Unit	A1	A4	B2	C1	C2	C3	C4
GWP-GHG[11]	kg CO_2 eq.	9.01E-01	5.45E-02	2.66E-02	0.00E+00	8.81E-02	6.84E-02	6.76E-03

Table 44: Results of additional voluntary output flow indicator for the lifecycle of 1 m^2 of LB400 pool cover

Indicators	Unit	A1-A3	A4	B2	C1	C2	C3	C4
CFR	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EXE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFE	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	4.17E-02	1.10E-03	4.11E-03	0.00E+00	4.18E-03	1.81E-03	5.33E-06

CFR = Components for reuse. EXE = Exported energy, MFE = Materials for energy recovery, MFR=Materials for recycling.

Table 45: Results of other voluntary indicator for the lifecycle of 1 m^2 of LB400 pool cover

Indicators	Unit	A1-A3	A4	B2	C1	C2	C3	C4
Ionising radiation, HH	kBq U-235 eq	1.69E-01	4.57E-03	6.76E-03	0.00E+00	5.95E-03	2.29E-03	1.69E-05
Land use	Pt	1.47E+00	4.35E-01	4.69E-02	0.00E+00	5.25E-01	5.18E-02	4.77E-03
Human toxicity, non-cancer effects	CTUh	2.36E-08	1.32E-09	4.45E-09	0.00E+00	2.99E-09	2.09E-09	2.06E-10
Ecotoxicity, freshwater	CTUe	1.22E-01	1.95E-02	5.05E-02	0.00E+00	5.88E-02	2.10E-02	2.65E-04
Particulate matter, HH	Disease inc.	3.07E-08	2.57E-09	1.81E-09	0.00E+00	4.62E-09	2.84E-09	6.95E-11
Human toxicity, cancer effects	CTUh	2.68E-10	2.47E-11	1.05E-10	0.00E+00	6.90E-11	7.47E-11	1.54E-12

[11] This indicator accounts for all greenhouse gases except biogenic carbon dioxide uptake and emissions and biogenic carbon stored in the product. As such, the indicator is identical to GWP-total except that the CF for biogenic CO_2 is set to zero.

6.4.2 EGST

Table 46:Results of the mandatory environmental impact category indicators according to EN 15804 for the lifecycle of 1 m^2 of EGST pool cover

Indicators	Unit	A1 – A3	A4	B2	C1	C2	C3	C4
GWP biogenic	kg CO_2 eq.	-2.76E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.25E-02	5.11E-03
GWP-fossil	kg CO_2 eq.	1.19E+00	6.67E-02	5.35E-02	0.00E+00	8.93E-02	8.63E-02	2.05E-03
GWP-LULUC	kg CO_2 eq.	6.70E-04	3.97E-05	5.51E-05	0.00E+00	4.27E-05	5.25E-05	2.33E-07
GWP-Total	kg CO_2 eq.	1.20E+00	6.67E-02	5.42E-02	0.00E+00	8.94E-02	8.02E-02	6.63E-03
ODP	kg CFC11 eq.	4.34E-08	1.46E-08	3.32E-09	0.00E+00	1.67E-08	1.76E-09	3.73E-11
AP	molc H^+ eq.	4.62E-03	1.92E-04	4.41E-04	0.00E+00	3.70E-04	1.43E-04	3.54E-06
EP - freshwater	kg P eq.	2.50E-04	6.23E-06	9.49E-05	0.00E+00	1.23E-05	1.01E-05	5.65E-08
EP - marine	kg N eq.	8.94E-04	3.56E-05	1.58E-03	0.00E+00	8.72E-05	8.82E-05	9.53E-06
EP - terrestrial	molc N eq.	9.17E-03	3.85E-04	1.08E-03	0.00E+00	9.43E-04	4.32E-04	1.32E-05
POCP	kg NMVOC eq.	4.72E-03	1.45E-04	2.12E-04	0.00E+00	3.16E-04	1.24E-04	5.80E-06
ADP - minerals and metals*	kg Sb eq.	7.93E-06	3.98E-07	5.90E-07	0.00E+00	1.09E-06	4.82E-07	1.15E-09
ADP – fossil*	MJ	3.43E+00	1.03E-01	3.49E-01	0.00E+00	2.25E-01	1.51E-01	1.18E-03
WDP*	m^3	7.87E-01	6.45E-03	3.61E-01	0.00E+00	1.11E-02	1.37E-02	4.51E-04

GWP-biogenic = Global warming potential biogenic, GWP-fossil = Global warming potential fossil fuels, GWP-LULUC= Global warming potential land use and land use change, GWP - Total = Total global warming potential, ODP = Ozone layer depletion potential, AP = Acidification potential, EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment, EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment, EP-terrestrial = Eutrophication potential terrestrial, POCP = Formation potential of tropospheric ozone, ADP - minerals and metals = Abiotic depletion potential for non-fossil resources, ADP - fossil = Abiotic depletion for fossil resources potential, WDP = Water deprivation potential.

**Disclaimer: The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator*

Table 47: Results of the mandatory indicators on resource use according to EN15804 for the lifecycle of 1 m^2 of EGST pool cover

Indicators	Unit	A1 – A3	A4	B2	C1	C2	C3	C4
PENRT	MJ	4.11E+01	1.01E+00	8.43E-01	0.00E+00	1.29E+00	3.18E-01	3.98E-03
PENRE	MJ	7.08E+00	1.35E-01	5.70E-01	0.00E+00	2.57E-01	1.95E-01	1.35E-03
PENRM	MJ	3.40E+01	8.77E-01	2.74E-01	0.00E+00	1.03E+00	1.23E-01	2.63E-03
PERE	MJ	9.76E-01	1.56E-02	4.88E-02	0.00E+00	2.13E-02	2.18E-02	1.20E-04
PERM	MJ	4.05E-01	5.46E-03	1.46E-02	0.00E+00	7.90E-03	9.38E-03	3.59E-05
PERT	MJ	1.38E+00	2.10E-02	1.31E-01	0.00E+00	2.92E-02	3.12E-02	1.56E-04
FW	m^3	1.84E-02	1.54E-04	1.95E-02	0.00E+00	2.73E-04	3.25E-04	1.06E-05
SM	kg	1.39E-01	1.55E-03	1.94E-02	0.00E+00	2.40E-03	5.63E-01	1.38E-05
NRSF	MJ	2.53E-02	2.22E-03	9.23E-03	0.00E+00	5.12E-04	6.80E-04	2.48E-06
RSF	MJ	2.96E-02	4.83E-04	4.03E-03	0.00E+00	2.67E-04	6.33E-04	1.44E-06

PENRT = Total use of non-renewable primary energy resources, PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials, PENRM = Use of non-renewable primary energy resources used as raw materials, PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials, PERM = Use of renewable primary energy resources used as raw materials, PERT = Total use of renewable primary energy resources FW = Use of net fresh water, SM = Use of secondary materials, NRSF = Use of non-renewable secondary fuels, RSF = Use of renewable secondary fuels.

Table 48: Results of the mandatory indicators on waste according to EN15804 for the lifecycle of 1 m^2 of EGST pool cover

Indicators	Unit	A1-A3	A4	B2	C1	C2	C3	C4
HW	kg	1.27E+00	3.27E-02	1.22E-01	0.00E+00	6.58E-02	5.17E-02	3.43E-04
NHW	kg	1.25E-01	3.18E-02	1.86E-02	0.00E+00	3.16E-02	5.06E-02	1.25E-02
RW	kg	1.80E-03	2.60E-05	1.36E-04	0.00E+00	2.57E-05	2.73E-05	1.18E-07

HW = Hazardous waste, NHW = Non-hazardous waste, RW = Radioactive waste.

Table 49: Results of the other mandatory indicators according to EN15804 for the lifecycle of 1 m^2 of EGST pool cover

Indicators	Unit	A1- A3	A4	B2	C1	C2	C3	C4
GWP-GHG[12]	kg CO_2 eq.	1.11E+00	6.61E-02	4.12E-02	0.00E+00	8.81E-02	8.51E-02	6.76E-03

[12] This indicator accounts for all greenhouse gases except biogenic carbon dioxide uptake and emissions and biogenic carbon stored in the product. As such, the indicator is identical to GWP-total except that the CF for biogenic CO_2 is set to zero.

Table 50: Results of the additional voluntary output flow indicator for the lifecycle of 1 m^2 of EGST pool cover

Indicators	Unit	A1-A3	A4	B2	C1	C2	C3	C4
CFR	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EXE	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFE	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	kg	5.13E-02	1.34E-03	8.21E-03	0.00E+00	4.18E-03	2.23E-03	5.33E-06

CFR = Components for reuse. EXE = Exported energy, MFE = Materials for energy recovery, MFR=Materials for recycling.

Table 51: Other voluntary indicator results for 1 m^2 of EGST pool cover

Indicators	Unit	A1-A3	A4	B2	C1	C2	C3	C4
Ionising radiation, HH	kBq U-235 eq	1.91E-01	5.54E-03	1.35E-02	0.00E+00	5.95E-03	2.84E-03	1.69E-05
Land use	Pt	1.82E+00	5.28E-01	9.39E-02	0.00E+00	5.25E-01	6.43E-02	4.77E-03
Human toxicity, non-cancer effects	CTUh	2.89E-08	1.61E-09	8.89E-09	0.00E+00	2.99E-09	2.59E-09	2.06E-10
Ecotoxicity, freshwater	CTUe	1.57E-01	2.36E-02	1.01E-01	0.00E+00	5.88E-02	2.61E-02	2.65E-04
Particulate matter, HH	Disease inc.	3.78E-08	3.12E-09	3.62E-09	0.00E+00	4.62E-09	3.54E-09	6.95E-11
Human toxicity, cancer effects	CTUh	3.46E-10	3.00E-11	2.11E-10	0.00E+00	6.90E-11	9.28E-11	1.54E-12

6.5 Benefits and Loads Beyond the System Boundary

Module D encompasses the savings from the recycling of the pool cover which assumes the avoided production of virgin LDPE.

The benefits and loads beyond the system boundary use processes from the eco-invent 3.8 EN15804 add-on to translate the savings from the avoided production of virgin LDPE into measurable environmental impacts avoided and other impacts avoided.

Table 52: Results of the mandatory environmental impact category indicators according to EN 1580 for the benefits and loads beyond the system boundary of 1 m² of LB400 and EGST materials

Indicators	Unit	LB400	EGST
GWP biogenic	kg CO_2 eq.	0.00E+00	0.00E+00
GWP-fossil	kg CO_2 eq.	-7.47E-01	-9.34E-01
GWP-LULUC	kg CO_2 eq.	-3.70E-04	-4.62E-04
GWP-Total	kg CO_2 eq.	-7.61E-01	-9.34E-01
ODP	kg CFC11 eq.	-1.17E-08	-1.46E-08
AP	molc H^+ eq.	-2.79E-03	-3.49E-03
EP - freshwater	kg P eq.	-1.69E-04	-2.11E-04
EP - marine	kg N eq.	-5.19E-04	-6.49E-04
EP - terrestrial	molc N eq.	-5.22E-03	-6.52E-03
POCP	kg NMVOC eq.	-3.17E-03	-3.96E-03
ADP - minerals and metals*	kg Sb eq.	-4.85E-06	-6.06E-06
ADP – fossil*	MJ	-2.07E+00	-2.59E+00
WDP*	m^3	-5.31E-01	-6.63E-01

GWP-biogenic = Global warming potential biogenic, GWP-fossil = Global warming potential fossil fuels, GWP-LULUC= Global warming potential land use and land use change, GWP - Total = Total global warming potential, ODP = Ozone layer depletion potential, AP = Acidification potential, EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment, EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment, EP-terrestrial = Eutrophication potential terrestrial, POCP = Formation potential of tropospheric ozone, ADP - minerals and metals = Abiotic depletion potential for non-fossil resources, ADP - fossil = Abiotic depletion for fossil resources potential, WDP = Water deprivation potential.

* *Disclaimer: The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator*

Table 53: Results of the mandatory indicator results on resource use according to EN15804 for the benefits and loads beyond the system boundary of 1 m^2 of LB400 and EGST materials

Indicators	Unit	LB400	EGST
PENRT	MJ	-2.79E+01	-3.49E+01
PENRE	MJ	-4.13E+00	-5.16E+00
PENRM	MJ	-2.38E+01	-2.98E+01
PERE	MJ	-5.16E-01	-6.45E-01
PERM	MJ	-1.53E-01	-1.91E-01
PERT	MJ	-6.69E-01	-8.36E-01
FW	m^3	-1.24E-02	-1.55E-02
SM	kg	-4.44E-02	-5.55E-02
NRSF	MJ	-1.64E-02	-2.05E-02
RSF	MJ	-2.28E-02	-2.85E-02

PENRT = Total use of non-renewable primary energy resources, PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials, PENRM = Use of non-renewable primary energy resources used as raw materials, PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials, PERM = Use of renewable primary energy resources used as raw materials, PERT = Total use of renewable primary energy resources FW = Use of net fresh water, SM = Use of secondary materials, NRSF = Use of non-renewable secondary fuels, RSF = Use of renewable secondary fuels.

Table 54:Results of the mandatory indicator results on waste according to EN15804 for the benefits and loads beyond the system boundary of 1 m^2 of LB400 and EGST materials

Indicators	Unit	LB400	EGST
HW	kg	-8.49E-01	-1.06E+00
NHW	kg	-2.12E-02	-2.65E-02
RW	kg	-9.10E-04	-1.14E-03

HW = Hazardous waste, NHW = Non-hazardous waste, RW = Radioactive waste.

Table 55:Results of the other mandatory indicators according to EN15804 for the benefits and loads beyond the system boundary for 1 m² of LB400 and EGST materials

Indicators	Unit	LB400	EGST
GWP-GHG[13]	kg CO_2 eq.	-6.90E-01	-8.63E-01

Table 56:Results of additional voluntary output flow indicator for the benefits and loads beyond the system boundary for 1 m² of LB400 and EGST materials

Indicators	Unit	LB400	EGST
CFR	kg	0.00E+00	0.00E+00
EXE	MJ	0.00E+00	0.00E+00
MFE	kg	0.00E+00	0.00E+00
MFR	kg	-3.87E-02	-4.84E-02

CFR = Components for reuse. EXE = Exported energy, MFE = Materials for energy recovery, MFR=Materials for recycling.

Table 57:Results of other voluntary indicator for the benefits and loads beyond the system boundary for 1 m² of the LB400 and EGST materials

Indicators	Unit	LB400	EGST
Ionising radiation, HH	kBq U-235 eq	-8.51E-02	-1.06E-01
Land use	Pt	-2.38E-01	-2.97E-01
Human toxicity, non-cancer effects	CTUh	-1.64E-08	-2.05E-08
Ecotoxicity, freshwater	CTUe	-5.96E-02	-7.44E-02
Particulate matter, HH	Disease inc.	-2.15E-08	-2.69E-08
Human toxicity, cancer effects	CTUh	-1.77E-10	-2.21E-10

[13] This indicator accounts for all greenhouse gases except biogenic carbon dioxide uptake and emissions and biogenic carbon stored in the product. As such, the indicator is identical to GWP-total except that the CF for biogenic CO_2 is set to zero.

The avoided production of virgin LDPE based on the scenario that the pool cover is recycled, represents a carbon footprint saving per 1 m^2 of GeoBubble ™ material, of 0.761 kg CO_2eq for LB400 and 0.934 kg CO_2eq for EGST.

The resulting carbon footprint saving per standard pool cover (32 m^2) is 24.4 kg CO_2eq for LB400 and 29.9 kg CO_2eq for EGST.

The avoided production of virgin LDPE based on the scenario that the pool cover is recycled represents a water deprivation potential saving, per 1 m^2 of GeoBubble ™ material, of 0.531 m^3 for LB400, 0.663 m^3 for EGST.

The resulting water deprivation potential saving per standard pool cover (32 m^2) is 17.0 m^3 for LB400 and 21.2 m^3 for EGST.

7. Potential resource savings through the use of GeoBubble pool covers

This section discusses the potential environmental impact savings associated with the use of GeoBubble™ materials.

The use phase of the GeoBubble™ pool cover materials reduces water, energy and chlorine used for a pool. As discussed in the product description, the pool cover is designed to save resources, particularly through energy, water and chlorine savings through properties that maximise the transfer of solar energy into the pool and preventing evaporation and the breakdown of chlorine.

This section first quantifies the energy, water and chlorine savings per unit of LB400 and EGST based on the frequency at which the pool cover is used during pool season. Then, processes from the eco-invent 3.8 EN15804 add-on are used to translate these savings into measurable environmental impacts avoided and other impacts avoided.

7.1 Energy Savings

The following section details energy use avoided (and the carbon footprint reduction associated with this) from the use of LB400 and EGST materials in a heated pool when the pool is not in use during daytime pool season. Plastipack' s case study[14] tests two identical outdoor pools for 17 days, with one covered with EGST pool cover fabricated in-house and the other uncovered. Each pool is serviced by its own 0.75kW filtration pump and heated using identical 12.5kW heat pumps, which were on timers and set to 28°C. The filtration pumps were also set by timers to be running continuously between 07:00hr and 21:00hr, whist the heat pumps ran between 08:00hr and 20:00hr. This filtration and heating pattern was selected as it most efficient for heating purposes.

The case study reveals that the EGST material helps preserve and increase the temperature of the water within the pool leading to a reduction of energy consumption by 85%. The study also showed that the uncovered pool used 193 kWh for the 17 days, which equates to an average power usage of 1.42 kW. A case study conducted by Plastipack on LB400[15] shows that the use of the pool cover can increase water temperature by 2 to 3 degrees Celsius compared to an uncovered pool. A case study on EGST by Plastipack reveals that the use of the pool cover can increase water temperature by 5 to 7 degrees Celsius compared to an uncovered pool. Using the following information, Plastipack assumes that LB400 is about half as much as energy efficient as EGST, therefore the energy saving rate of LB400 is 40%. A case study conducted by Plastipack on GeoBubble™ materials shows that the materials also act as a barrier against evaporation, reducing evaporation rate by 98%.

Plastipack estimates that a standard 4x8 pool is used 182 days a year (pool season), 8 hours a day. A summary of information relating to the energy efficiency of the GeoBubble™ pool cover materials LB400 and EGST and the assumptions on the energy efficiency of an uncovered pool is shown below.

Table 58: Energy efficiency of uncovered pool and energy saving rate of LB400 and EGST materials

Pool Cover Material	Days per pool season	Hours per day heat pump is active	Average power usage for a heat pump for 8x4 pool per hour	Uncovered pool kWh consumption per year	Energy Saving rate	Lifespan of GeoBubble™ material in years
LB400	182	8	1.42	1,820	40%	4
EGST	182	8	1.42	1,820	85%	8

[14] Plastipack ltd, 2022. "EnergyGuard Selective Transmission".
[15] Plastipack ltd, 2019. "GeoBubble™ Light Blue"

The table below shows the energy savings from the use of 1 m^2 of LB400 and EGST pool cover materials on a heated pool based on the frequency at which a pool covers is used for the daytime during pool season. The energy savings from the use of 1 m^2 of LB400 and EGST pool cover 100% of the daytime during pool season is used as a baseline to show the carbon savings as a result of the use of 1 m^2 of LB400 and EGST pool covers 50%, 25% and 10% of the daytime during pool season as continuous use of the pool cover is not a realistic use scenario, and levels of pool cover usage will vary. These percentages have been selected to show the variability in impact savings from variability in pool cover usage. The table also shows the kWh energy saving for using a pool cover for one hour in a heated pool, during the daytime of pool season.

Table 59: Summary of energy saved by 1 m^2 of LB400 and EGST pool covers based on frequency of pool cover usage

Pool Cover Material	kW saver	kWh saver 1 m^2 of pool cover when used **100%** of the time	kWh saver 1 m^2 of pool cover when used **50%** of the time	kWh 1 m^2 of pool cover when used **25%** of the time	kWh saver 1 m^2 of pool cover when used **10%** of the time
LB400	0.0178	103	51.7	25.8	10.3
EGST	0.0377	439	220	110	43.9

The energy savings from the use of 1 m^2 of GeoBubble™ pool covers in a heated pool are 51.7 and 220 kWh in the lifespan of LB400 and EGST respectively when the pool cover is used 50% of the daytime during pool season. The energy savings from the use of 1 m^2 of GeoBubble™ pool covers for its lifespan are 25.8 kWh for LB400 and 110 kWh for EGST when the pool cover is used 25% of the daytime during pool season, and 10.3 kWh and 43.9 kWh when the pool cover is used 10% of the daytime during pool season.

The energy savings from the use of 32 m^2 of GeoBubble™ pool covers in a heated pool are 1654 and 7030 kWh in the lifespan of LB400 and EGST respectively when the pool cover is used 50% of the daytime during pool season. The energy savings from the use of 32 m^2 of GeoBubble™ pool covers are 827 kWh for LB400 and 3515 kWh for EGST when the pool cover is used 25% of the daytime during pool season, and 331 kWh and 1406 kWh when pool cover is used 10% of the daytime during pool season.

7.2 Water savings

The following section covers water savings as a result of the use of pool covers materials LB400 and EGST when the pool is not in use during daytime pool season, which decreases the rate of evaporation of water in a pool. As previously stated, LB400 and EGST case studies conducted by Plastipack revealed that the GeoBubble™ materials reduce evaporation by 98%. Plastipack estimates that the evaporation rates of one square meter of pool is 1.5 meters of depth per year. This means that the daily evaporation rate is at 8 mm. This is supported by web research that shows that evaporation rates can range between 5 mm daily[16] and 1.14 cm daily (3.5 inches weekly[17]). The calculations in the table below summarise the water savings caused by GeoBubble™ materials.

Table 60: Water savings by pool cover materials LB400 and EGST

Pool Cover Material	Evaporation rates per 1 m^2 per year in meters	Evaporation reduction rate	Water saving per 1 m^2 per year when the pool cover is used **100%** of the time	Lifespan of GeoBubble™ materials in years
LB400	1.5	98%	1.47	4
EGST	1.5	98%	1.47	8

[16] https://www.compass-pools.co.uk/wp-content/uploads/2022/08/Compass-Pools-Water-Efficency-2022-3-1_compressed-1.pdf
[17] https://www.flower-mound.com/1998/Pool-Evaporation#:~:text=How%20much%20water%20does%20my,that's%203.5%20inches%20per%20week.

The table below shows the water savings for LB400 and EGST based on the frequency at which a pool cover is used for the daytime during pool season. The water savings from to the use of 1 m^2 of the pool cover 100% of the daytime during pool season is used as a baseline to show the water savings as a result of the use of the GeoBubble™ pool cover 50%, 25% and 10% of the daytime during pool season. The table also shows the water savings for using 1 m^2 of pool cover for one hour during the daytime of pool season.

Table 61: Summary of water savings by per 1 m^2 of pool cover based on frequency of pool cover usage

Pool Cover Material	Water savings m^3 per hour per 1 m^2 of pool cover	Water saving per 1 m^2 of pool cover when used **100%** of the time m^3	Water saving m^3 per 1 m^2 of pool cover when used **50%** of the time	Water saving m^3 per 1 m^2 of pool cover when used **25%** of the time	Water saving m^3 per 1 m^2 of pool cover when used **10%** of the time
LB400	3.22E-05	5.88	2.94	1.47	0.588
EGST	3.22E-05	11.76	5.88	2.94	1.18

The water savings from the use of 1 m^2 of GeoBubble™ material in its lifespan when used 50% of daytime during pool season are 2.94 m^3 of LB400 and 5.88 m^3 of EGST, equivalent to 2931 L and 5862 L respectively. The water saving from the use of 1 m^2 of GeoBubble™ material in its when used 25% of daytime during pool season are 1.47 m^3 for LB400 and 2.94 m^3 for EGST, equivalent to 1465.59 L and 2931.18 L respectively. The water saving from the use of 1 m^2 of GeoBubble™ material in its when used 10% of daytime during pool season are 0.588 m^3 for LB400 and 1.176 m^3 for EGST, equivalent to 586 and 1172 L respectively.

The water savings from the use of a 32 m^2 standard GeoBubble™ materials in its lifespan when used 50% of daytime during pool season are 94.08 m^3 of LB400 and 188.16m^3 of EGST, equivalent to 94,080 L and 188,160 L respectively. The water savings from the use of a 32 m^2 standard GeoBubble™ materials in its lifespan when used 25% of daytime during pool season are 47.04 m^3 for LB400 and 94.08 m^3 for EGST, equivalent to 47,040 L and 94,080 L respectively. The water savings from the use of a 32 m^2 standard GeoBubble™ materials in its lifespan when used 10% of daytime during pool season are 18.82 m^3 for LB400 and 37.63 m^3 for EGST, equivalent to 18,820 L and 37,630 L respectively.

7.3 Chlorine savings

The following section covers the chlorine savings that occur through the use of the pool covers LB400 and EGST when the pool is not in use during daytime pool season, which decreases the rate at which chlorine is broken down and therefore decreases the rate at which the pool will need to be replenished with chlorine. The chlorine savings will be presented in kg to represent the savings in stabilised chlorine in its granular form, and then the environmental impacts avoided are presented to showcase carbon and water savings as a result of the chlorine savings.

The use of the GeoBubble™ material also offers chlorine savings. Chlorine consumption for pools refers to the use of stabilised chlorine to inhibit algae growth in the pool.

The use of GeoBubble™ pool covers act as a physical barrier from the sun, which reduces the chlorine in the pool from easily being consumed/degraded.

The case study on LB400 conducted by Plastipack showcases that the use of the pool cover, reduced chlorine consumption by 7%[18] compared to an uncovered pool.

The case study on EGST[19] conducted by Plastipack showcases that the use of the pool cover reduced chlorine consumption by 39% compared to an uncovered pool. This chlorine savings figure is used to calculate the environmental impacts saved when the EGST pool cover is used in section 7.4.1. The published research on

[18] Plastipack ltd, 2019. “GeoBubble™ Light Blue”
[19] Plastipack ltd, 2022. “EnergyGuard Selective Transmission.”

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EGST states that the use of the pool cover can reduce chlorine consumption by 58%[20]. This is presented in Table 62 to showcase the extent of which EGST can reduce chlorine consumption.

The EGST case study compares chlorine consumption of an uncovered standard 32 m^2 pool and a pool covered with EGST over a 17-day period. The water concentration of free chlorine was kept at 4 ppm to account for the heat wave that was occurring during the test period. This is due to the fact that warmer water will significantly increase the rate at which free chlorine is depleted from a pool. Stabilised chlorine was added when free chlorine dropped below 4 ppm. The uncovered pool used 1528 grams of stabilised chlorine during the 17-day test period. The findings from this scenario are used to calculate the chlorine savings from the GeoBubble™ materials LB400 and EGST.

The table below summarises chlorine consumption by an uncovered pool during the 17-day test period. It is assumed that the pool day hours are 8 a day and the pool season is of 182 days. From this, we can calculate daily savings and savings per pool season.

Table 62: Chlorine consumption of uncovered pool kept at 4 ppm

Days of Test	Uncovered pool chlorine consumption in 17 days (kg)	Uncovered pool chlorine consumption per day (kg)	Pool hours in a day (kg)	Uncovered pool chlorine consumption per hour (kg)	Pool season days	Uncovered pool chlorine consumption per pool season
17	1.53	0.09	8	0.01	182	16.36

The table below summarises the chlorine savings through the use of 1 m^2 of LB400 and EGST pool covers 100% of the time in the lifespan of the materials based on the possible savings rates. This information will be used as a baseline to calculate the environmental impacts avoided through the chlorine savings based on how frequently the pool cover is used during pool season over the pool cover materials' respective lifetimes. The chlorine savings in kg are shown based on available data on the range of the efficiency of the pool covers as calculated in LB400 and EGST case studies.

Table 63: Chlorine savings of 1 m^2 of pool cover based on frequency of pool cover usage

Pool Cover Material	Saving rate of pool cover	Pool cover chlorine savings per hour per 1 m^2	Lifetime per pool cover	Chlorine savings per 1 m^2 of pool cover (kg) when used **100%** of the time	Chlorine savings per 1 m^2 of pool cover (kg) when used **50%** of the time	Chlorine savings per 1 m^2 of pool cover (kg) when used **25%** of the time	Chlorine savings per 1 m^2 of pool cover (kg) when used **10%** of the time
EGST	39%	0.000137	8	1.59	0.797	0.399	0.159
EGST	58%	0.000204	8	2.37	1.186	0.593	0.237
LB400	7%	0.0000246	4	0.143	0.0716	0.0358	0.0143

The savings in stabilised chlorine through the use of EGST is presented as a range based on the lowest and highest level of efficiency at which the GeoBubble™ material saves stabilised chlorine use.

[20] Waché, Rémi, et al. "Selective Light Transmission as a Leading Innovation for Solar Swimming Pool Covers." *Solar Energy*, vol. 207, 1 Sept. 2020, pp. 388–397, www.sciencedirect.com/science/article/abs/pii/S0038092X20306319, https://doi.org/10.1016/j.solener.2020.06.022. Accessed 15 Nov. 2022.

The savings in stabilised chlorine from the use of 1 m^2 of EGST are between 0.8 and 1.19 kg when used 50% of the daytime during pool season during the material's lifetime, between 0.399 and 0.593 kg when used 25% of the daytime during pool season during the material's lifetime and between 0.159 and 0.237 kg when used 10% of the daytime during pool season during the material's lifetime.

The savings in stabilised chlorine from the use of 1 m^2 of LB400 are 0.0716 kg when used 50% of the daytime during pool season during the material's lifetime, 0.0358 kg when used 25% of the daytime during pool season during the material's lifetime and 0.0143 kg when used 10% of the daytime during pool season during the material's lifetime.

The savings in stabilised chlorine for a standard 32 m^2 EGST pool cover are between 25.52 and 37.95 kg when used 50% of the daytime during pool season during the material's lifetime, between 12.76 and 18.98 kg when used 25% of the daytime during pool season during the material's lifetime and between 5.10 and 7.59 kg when used 10% of the daytime during pool season during the material's lifetime.

The savings in stabilised chlorine for a standard 32 m^2 LB400 pool cover are 2.29 kg when used 50% of the daytime during pool season during the material's lifetime, 1.15 kg when used 25% of the daytime during pool season during the material's lifetime and 0.458 kg when used 10% of the daytime during pool season during the material's lifetime.

7.4 Environmental Impacts

7.4.1 Results

The energy, water and chlorine savings from the use of 1 m^2 of GeoBubble™ materials depending on the frequency at which the pool cover used, has been calculated. To translate the energy savings into measurable impacts, the process for heat, air-water heat pump 10 kW is used from the add-on database EN15804 used from Ecoinvent 3.8. To translate the water savings into measurable impacts, the process for market for tap water in Europe has been used from the add-on database EN15804 used from Ecoinvent 3.8. To translate the chlorine savings into measurable impacts, stabilised chlorine is modelled on the add-on database EN15804 used from Ecoinvent 3.8.

The chlorine savings refer to stabilised chlorine granule savings, particularly sodium dichloroisocyanurate dihydrate CAS No.51580-86-0. The add-on database EN15804 used from Ecoinvent 3.8 does not have sodium dichlorocyanurate dihydrate or anhydrite. For this reason, the production of stabilised chlorine has been modelled. A detailed explanation on the model of the production of stabilised chlorine can be found in the Appendix.

The table below shows the eco-invent processes used to calculate the savings in this section.

Table 64: Processes used in the modelling of resource savings by pool cover use

Component	Processes used in the modelling of resource savings by pool cover use
Stabilised Chlorine	market for chlorine, gaseous | chlorine, gaseous | EN15804 - RER
Stabilised Chlorine	Market group for electricity, medium voltage | electricity, medium voltage | EN15804 - RER
Stabilised Chlorine	kerosene production, petroleum refinery operation | kerosene | EN15804 - Europe without Switzerland
Stabilised Chlorine	market for sodium hydroxide, without water, in 50% solution state | sodium hydroxide, without water, in 50% solution state | EN15804 - GLO
Stabilised Chlorine	urea production | urea | EN15804 - RER
Stabilised Chlorine	market for water, ultrapure | water, ultrapure | EN15804 - RER
Heat Pump	heat production, air-water heat pump 10kW | heat, air-water heat pump 10kW | EN15804 - Europe without Switzerland
Water	market for tap water | tap water | EN15804 - Europe without Switzerland

The baseline calculations for energy, water and chlorine savings are when the pool covers are used 100% of the daytime during pool season for the lifespan of each GeoBubble™ materials LB400 and EGST. This was then used to calculate the savings as a result of the use of 1 m^2 as well as the standard 32 m^2 GeoBubble™ pool cover 50%, 25% and 10% of the daytime during pool season. The savings per hour per 1 m^2 of pool cover material was also presented. The energy, water and chlorine savings are presented using these scenarios to show their avoided use depending on the variability of the frequency of the use of the GeoBubble™ materials.

The tables below showcase the environmental impacts and other impacts avoided from the energy, water and chlorine savings of a pool through the use of 1 m^2 of GeoBubble™ materials LB400 and EGST when used 50% of the time during daytime pool season for the lifetime of the material. The tables below look at mandatory environmental, waste and resource use indictors and mandatory output flow results as well as other voluntary environmental indicators for this scenario.

Table 65: Results of the mandatory environmental impact category indicators according to EN 1580 for the potential resource savings through the use of 1 m^2 of LB400 and EGST pool cover

		When 1 m^2 of pool cover is used throughout 50% of its lifespan	
Indicators	Unit	LB400	EGST
GWP biogenic	kg CO_2 eq.	0.00E+00	0.00E+00
GWP-fossil	kg CO_2 eq.	8.94E+00	3.88E+01
GWP-LULUC	kg CO_2 eq.	1.77E-02	7.62E-02
GWP-Total	kg CO_2 eq.	8.96E+00	3.88E+01
ODP	kg CFC11 eq.	1.54E-06	7.08E-06
AP	molc H^+ eq.	4.53E-02	1.98E-01
EP - freshwater	kg P eq.	7.67E-03	3.30E-02
EP - marine	kg N eq.	7.31E-03	3.20E-02
EP - terrestrial	molc N eq.	6.50E-02	2.85E-01
POCP	kg NMVOC eq.	1.77E-02	7.79E-02
ADP - minerals and metals*	kg Sb eq.	1.26E-04	5.50E-04
ADP – fossil*	MJ	7.60E+01	3.28E+02
WDP*	m^3	5.92E+00	2.62E+01

GWP-biogenic = Global warming potential biogenic, GWP-fossil = Global warming potential fossil fuels, GWP-LULUC= Global warming potential land use and land use change, GWP - Total = Total global warming potential, ODP = Ozone layer depletion potential, AP = Acidification potential, EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment, EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment, EP-terrestrial = Eutrophication potential terrestrial, POCP = Formation potential of tropospheric ozone, ADP - minerals and metals = Abiotic depletion potential for non-fossil resources, ADP - fossil = Abiotic depletion for fossil resources potential, WDP = Water deprivation potential.

* *Disclaimer: The results of this environmental impact indicator shall be used with care as the uncertainties of these results are high or as there is limited experience with the indicator*

Table 66: Results of the mandatory indicator results on resource use according to EN15804 for the potential resource savings through the use of 1 m² of LB400 and EGST pool cover

		When 1 m² of pool cover is used throughout 50% of its lifespan	
Indicators	Unit	LB400	EGST
PENRT	MJ	1.91E+02	8.36E+02
PENRE	MJ	1.50E+02	6.46E+02
PENRM	MJ	4.08E+01	1.90E+02
PERE	MJ	2.73E+01	1.17E+02
PERM	MJ	4.13E+00	1.78E+01
PERT	MJ	3.15E+01	1.35E+02
FW	m^3	1.38E-01	6.13E-01
SM	kg	1.93E+00	8.28E+00
NRSF	MJ	7.58E-01	3.26E+00
RSF	MJ	1.10E+00	4.72E+00

PENRT = Total use of non-renewable primary energy resources, PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials, PENRM = Use of non-renewable primary energy resources used as raw materials, PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials, PERM = Use of renewable primary energy resources used as raw materials, PERT = Total use of renewable primary energy resources FW = Use of net fresh water, SM = Use of secondary materials, NRSF = Use of non-renewable secondary fuels, RSF = Use of renewable secondary fuels.

Table 67: Results of the mandatory indicator results on waste according to EN15804 for the for the potential resource savings through the use of 1 m² of LB400 and EGST pool cover

		When 1 m² of pool cover is used throughout 50% of its lifespan	
Indicators	Unit	LB400	EGST
HW	kg	3.86E+01	1.66E+02
NHW	kg	4.84E-01	2.12E+00
RW	kg	4.58E-02	1.96E-01

HW = Hazardous waste, NHW = Non-hazardous waste, RW = Radioactive waste.

Table 68: Results of the other mandatory indicators according to EN15804 for the potential resource savings through the use of 1 m² of LB400 and EGST pool cover

		When 1 m² of pool cover is used throughout 50% of its lifespan	
Indicators	Unit	LB400	EGST
GWP-GHG[21]	kg CO_2 eq.	8.59E+00	3.73E+01

Table 69: Results of additional voluntary output flow indicator for the potential resource savings through the use of 1 m² of LB400 and EGST pool cover

		When 1 m² of pool cover is used throughout 50% of its lifespan	
Indicators	Unit	LB400	EGST
CFR	kg	0.00E+00	0.00E+00
EXE	MJ	0.00E+00	0.00E+00
MFE	kg	0.00E+00	0.00E+00
MFR	kg	1.84E+00	7.86E+00

CFR = Components for reuse. EXE = Exported energy, MFE = Materials for energy recovery, MFR=Materials for recycling.

Table 70: Results of other voluntary indicator for the potential resource savings through the use of 1 m² of LB400 and EGST pool cover

		When 1 m² of pool cover is used throughout 50% of its lifespan	
Indicators	Unit	LB400	EGST
Ionising radiation, HH	kBq U-235 eq	4.25E+00	1.83E+01
Land use	Pt	7.41E+00	3.27E+01
Human toxicity, non-cancer effects	CTUh	5.96E-07	2.58E-06
Ecotoxicity, freshwater	CTUe	1.52E+00	6.62E+00

[21] This indicator accounts for all greenhouse gases except biogenic carbon dioxide uptake and emissions and biogenic carbon stored in the product. As such, the indicator is identical to GWP-total except that the CF for biogenic CO_2 is set to zero.

Particulate matter, HH	Disease inc.	1.38E-07	6.16E-07
Human toxicity, cancer effects	CTUh	3.73E-09	1.63E-08

7.4.2 Interpretation

The avoided carbon footprint and water deprivation potential through the use of 1 m^2 of LB400 for a heated pool kept at 4 ppm are presented for an hour of daytime during pool season as well as for 10%, 25%, 50% and 75% of the daytime during pool season throughout its lifespan. The results are presented using these scenarios to show the avoided impacts depending on the variability of the frequency of the use of the pool cover materials. The results presented at a frequency of 10%, 25%, 50% and 75% include the energy, water and chlorine savings from the use of a pool cover compared to an uncovered pool. The results presented per hour only include the energy, water and chlorine savings from the use of a pool cover compared to an uncovered pool.

Table 71: Avoided carbon footprint through the use of 1 m^2 of LB400 and EGST materials on a pool

	Avoided carbon footprint (kg CO_2eq)				
Pool cover	when 1 m^2 of pool cover is used for one hour	When 1 m^2 of pool cover is used throughout 10% of its lifespan	When 1 m^2 of pool cover is used throughout 25% of its lifespan	When 1 m^2 of pool cover is used throughout 50% of its lifespan	When 1 m^2 of pool cover is used throughout 75% of its lifespan
LB400	3.08E-03	-1.79E+00	-4.48E+00	-8.96E+00	-1.34E+01
EGST	6.67E-03	-7.77E+00	-1.94E+01	-3.88E+01	-5.83E+01

The use of 1 m^2 of LB400 for an hour for a heated pool kept at 4ppm can lead to an avoided impact of 0.00308 kg CO_2eq, whereas the use of a standard 32 m^2 pool cover can lead to an avoided impact of 0.0984 kg CO_2eq.

The use of 1 m^2 of LB400 on a heated pool kept at 4ppm for 10%, 25%, 50% and 75% of the daytime during pool season throughout its lifespan (4 years) can lead to an avoided impact of 1.79 kg CO_2eq, 4.48 kg CO_2eq eq, 8.96 kg CO_2eq and 13.4 kg CO_2eq respectively, whereas the use of a standard 32 m^2 pool cover when used in these frequencies can lead to an avoided impact of 57.3 kg CO_2eq, 143 kg CO_2eq, 287 kg CO_2eq, 430 kg CO_2eq respectively.

The use of 1 m^2 of EGST for an hour can lead to an avoided impact of 0.00667 kg CO_2eq, whereas the use of a standard 32 m^2 pool cover can lead to an avoided impact of 0.213 kg CO_2eq.

The use of 1 m^2 of EGST on a heated pool kept at 4ppm for 10%, 25%, 50% and 75% of the daytime during pool season throughout its lifespan can lead to an avoided impact of 7.77 kg CO_2eq, 19.4 kg CO_2eq, 38.8 kg CO_2eq and 58.3 kg CO_2eq respectively, whereas the use of a standard 32 m^2 pool cover when used in these frequencies can lead to an avoided impact of 249 kg CO_2eq, 621 kg CO_2eq, 1243 kg CO_2eq, and 1864 kg CO_2eq respectively.

Table 72: Avoided water deprivation potential through the use of 1 m^2 of LB400 and EGST materials on a pool

	Avoided water deprivation potential (m^3)				
Pool cover	when 1 m^2 of pool cover is used for one hour	When 1 m^2 of pool cover is used throughout 10% of its lifespan	When 1 m^2 of pool cover is used throughout 25% of its lifespan	When 1 m^2 of pool cover is used throughout 50% of its lifespan	When 1 m^2 of pool cover is used throughout 75% of its lifespan
LB400	-2.03E-03	-1.18E+00	-2.96E+00	-5.92E+00	-8.87E+00
EGST	-4.50E-03	-5.25E+00	-1.31E+01	-2.62E+01	-3.94E+01

The use of 1 m^2 of LB400 for an hour for a heated pool kept at 4 ppm can lead to an avoided impact of 0.00203 m^3 in water deprivation potential, whereas the use of a standard pool cover (32 m^2) can lead to an avoided impact of 0.0650 m^3.

The use of 1 m^2 of LB400 on a heated pool kept at 4ppm for 10%, 25%, 50% and 75% of the daytime during pool season throughout its lifespan can lead to an avoided impact of 1.18 m^3 , 2.96 m^3, 5.92 m^3, 8.97 m^3 in water deprivation potential, whereas the use of a standard pool cover (32 m^2) when used in these frequencies can lead to an avoided impact of 37.9 m^3 , 94.7 m^3, 189 m^3, 284 m^3 respectively.

The use of 1 m^2 of EGST for an hour for a heated pool kept at 4ppm can lead to an avoided impact of 0.00405 m^3 in water deprivation potential, whereas the use of a standard pool cover (32 m^2) can lead to an avoided impact of 0.144 m^3.

The use of 1 m^2 of EGST on a heated pool kept at 4ppm for 10%, 25%, 50% and 75% of the daytime during pool season throughout its lifespan can lead to an avoided impact of 5.25 m^3, 13.1 m^3, 26.2 m^3, 39.4 m^3 in water deprivation potential, whereas the use of a standard pool cover (32 m^2) when used in these frequencies can lead to an avoided impact of 168 m^3, 420 m^3, 840 m^3, 1259 m^3 respectively.

8. Conclusions

The key points to note are as follows:

- The function unit is the manufacture of 1 m^2 of pool cover using GeoBubble™ material, its packaging and distribution to end users, maintenance during its expected lifespan, and EoL. The expected lifespan of LB400 is 4 years and that of EGST is 8 years.
- There are 2 pool coves considered. Per 1 m^2 of pool cover the weights of the GeoBubble ™ materials are;
  - 0.368 kg/m^2 for LB400,
  - 0.46 kg/m^2 for EGST
- The system boundary for this LCA study is cradle-to-grave and module D.
- The process specific input data provided by Plastipack is regarded as being of high quality and high accuracy, and an accurate representation (in terms of timeliness, geography and technology) for all processes used in manufacture and supply of the pool cover materials at the Plastipack production site in the UK. The production datasets at Assembly 1 site are a combination of 2022 data (for materials processes) and three-year average data (for water, fuels and off-cuts, as well as for the distribution to customers for welding). Assumptions and averages have been applied where necessary – methodologies for these is outlined in detail in this report in their respective Inventory section.

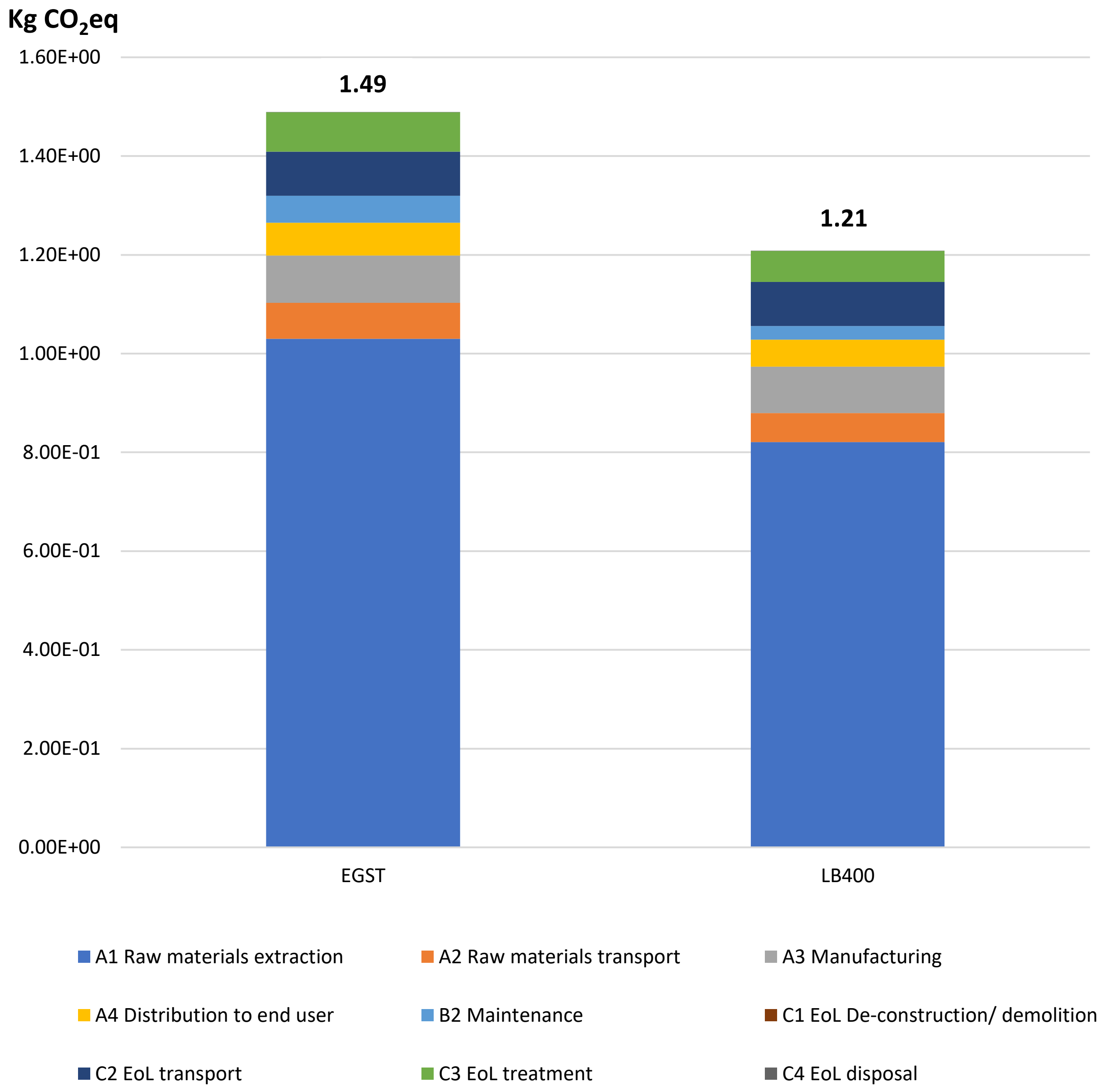
Table 73: The carbon footprints of the life cycles of LB400 and EGST pool covers

GeoBubble™ materials	Unit	Per 1 m^2 of pool cover	Per standard 32 m^2 pool cover
LB400	kg CO_2eq	1.21	38.7
EGST	kg CO_2eq	1.49	47.7

Table 74: The water deprivation potential of the life cycles LB400 and EGST pool covers

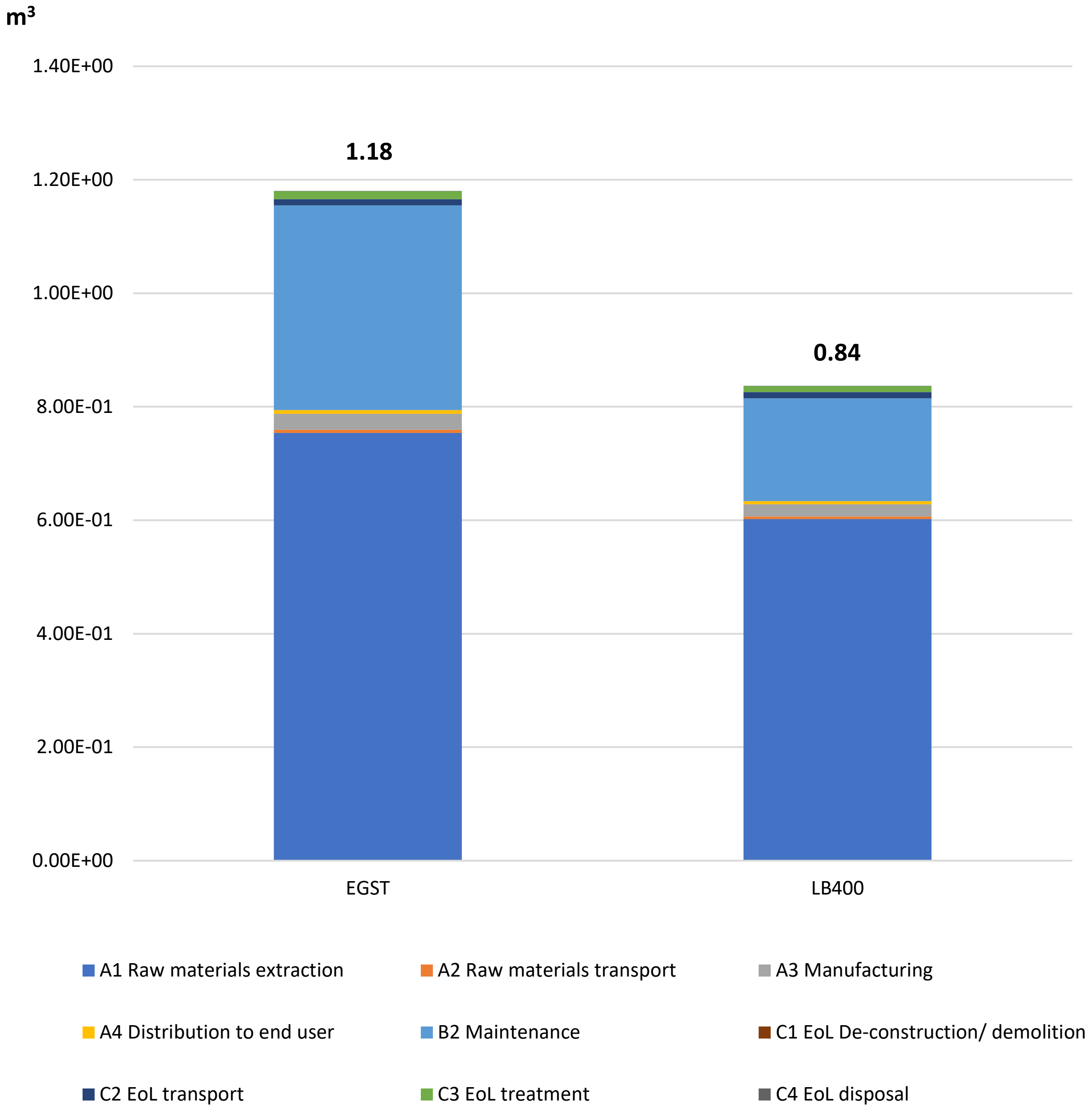
GeoBubble™ materials	Unit	Per 1 m^2 of pool cover	Per standard 32 m^2 pool cover
LB400	m^3	0.84	26.8
EGST	m^3	1.18	37.8

Figure 14: Contribution of each of the life cycle stages by EPD module to the overall carbon footprint per 1 m² of LB400 and EGST pool covers



- The figure shows the overall carbon footprint of one functional unit of pool cover LB400 and EGST broken down by lifecycle module. The lifecycle module A1 which represents raw materials extraction contributes the most to the overall carbon footprint of LB400 and EGST, contributing 68% and 69% to the overall footprint respectively. This can mostly be attributed to the carbon footprint of the raw materials of the pool covers. The carbon footprint for LB400 pool cover is lower than that of EGST pool cover mostly due to the weight of LB400 GeoBubble™ material weighing less than the EGST GeoBubble™ material per 1 m², therefore using less LDPE as a raw material.

Figure 15: Contribution of each of the life cycle stages by EPD module to the overall water deprivation potential per 1 m² of LB400 and EGST pool covers



- The figure shows the overall water deprivation potential of one functional unit of LB400 and EGST pool covers broken down by LCA information modules. Module A1 which represents raw materials extraction contributes the most to the overall water deprivation potential, which represents 64% and 72% of the overall water deprivation potential of the life cycles of the pool covers EGST and LB400 respectively. The water deprivation potential for LB400 pool cover is lower than EGST pool cover considered due to the weight of LB400 GeoBubble™ material weighing less than EGST GeoBubble™ material per 1 m², therefore using less LDPE as a raw material.

- Module D impacts are beyond the system boundary and arise from the avoided production of virgin LDPE from recycling the pool cover.

Table 75: Summary of carbon footprint and water deprivation potential avoided from recycling the pool covers LB400 and EGST and the avoided production of virgin LDPE

	Carbon footprint (kg CO_2eq)		Water Deprivation Potential (m^3)	
GeoBubble™ materials	Per 1 m^2 of pool cover	Per standard pool cover (32 m^2)	Per 1 m^2 of pool cover	Per standard pool cover (32 m^2)
LB400	0.761	24.4	0.531	17.0
EGST	0.934	29.9	0.663	21.2

9. Appendix

9.1 Modelling Process for Stabilised Chlorine

Desk research was conducted to obtain information relating to the production of sodium dichloroisocyanurate dihydrate[22][23][24]. Limited information was available on the internet relating to the production of stabilised chlorine on a large scale. For this reason, it is important to note that the model used for the production of stabilised chlorine may not be representative of how it is produced on a large scale.

The production of sodium dichloroisocyanurate dihydrate occurs in a two step process. The first consists of combining chlorine, cyanuric acid and sodium hydroxide and producing dichloroisocyanuric acid. The Ecoinvent 3.8 database does not possess a process for cyanuric acid, for this reason, desk research has been conducted to model the production of cyanuric acid. Cyanuric acid is produced by using urea as a starting material as it is the most traditional, economical, and convenient and produces high quality and good yield. The model for the production of cyanuric acid uses urea and kerosene as it produces a high yield of cyanuric acid (88.7%)[25]. The ratio of kerosene and urea is 2:1, and is heated to 180 degrees Celsius to obtain cyanuric acid. Assuming that urea and kerosene are kept at room temperature of 20 degrees Celsius, these elements must be heated 160 degrees Celsius further. To find out the energy required to heat up the solution, the specific heat capacities of both elements are used. The specific heat capacities for urea and kerosene are 1.339 (J/(g C)) and 2.01 (kJ/(kg K)) respectively. It is assumed that 50% of energy used for heating the solution is lost. The first step which consists of producing dichloroisocyanuric acid uses the proportions of the three elements by molar mass due to the lack of information on actual yield. The molar mass of chlorine is about 35 g/mole, therefore 2 Cl_2 molar mass is 140 g/mol. That of cyanuric acid is 129 g/mol and that of sodium hydroxide is approximately 40 g/mol, therefore 2 NaOH is 70 g/mol. This produces 349 g/mol, which is broken down to 198 g/mol of dichloroisocyanuric, 2 molecules of water (38 g/mol) and 2 molecules of NaCl (116 g/mol). The aqueous slurry is then separated from the solid dichloroisocyanuric acid. The energy used for the first reaction including the separation process that may include the use of a centrifuge, is accounted for using an energy proxy. The energy proxy used is from Ecoinvent 3.8, specifically the energy used for liquifying gaseous chlorine in the process for liquid chlorine, equivalent to 0.07 kWh per kg of product. The dichloroisocyanuric acid is then stabilised with sodium hydroxide in the form of an aqueous solution, such that at least two molar equivalent of water is used based on the amount of dichloroisocyanuric acid is used. The reaction temperature should remain between 0 and 5 degrees Celsius. The second step which consists of using sodium dichloroisocyanurate dihydrate uses the proportions of the three elements by molar mass due to the lack of information on actual yield. For every 197 grams of dichloroisocyanuric acid, 36 grams of water and 40 grams of sodium hydroxide are used. This solution is then filtered again and the solid sodium dichloroisocyanurate dihydrate is dried (temperature of 25 – 30 degrees Celsius) to get rid of small amounts of free water. The energy in reaction two uses the same proxy as reaction one, such that 0.07 kWh of energy is used per kg. Inputting all of the relevant flows into add-on 15804 from Ecoivent 3.8 enables the calculation of the environmental impacts avoided through chlorine savings due to the use of GeoBubble™ which inhibits the degradation of chlorine.

[22] https://patents.google.com/patent/DE3227817A1/en
[23] https://patents.google.com/patent/US3803144A/en
[24] http://jchemindustry.tju.edu.cn/EN/abstract/abstract11318.shtml
[25]https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6257242/#:~:text=There%20are%20two%20ways%20for,7%2C8%2C9%5D.