# Environmental Product Statement for Solaplast

## Introduction

This Environmental Product Statement (EPS) provides a comparative quantitative description of the environmental performance of Solaplast algae-based bio-resins. Solaplast has a full third party conducted Life Cycle Assessment (LCA) from which this EPS is based.

This EPS describes the production of Solaplast resins from a 'cradle to gate' perspective - from resources extraction, raw material manufacturing up to the Solaplast resin production. Data provided in this EPS offer detailed comparable insight of Solaplast resin versus some of the conventional plastic materials it is comparable to. This document is designed to inform the user of Solaplast products on the improvement of environmental impacts associated with the use of certain types of plastics. This study presents algae blended with resins such as polystyrene (PS), high density polyethylene (HDPE), PolyLactic Acid (PLA) and ethylene vinyl-acetate (EVA) compared to the virgin base resin being used alone.

## The Company/ About Us

SOLAPLAST is a green technology company committed to the production of sustainable plastic composites. Through an uncompromising work ethic, innovation and life cycle thinking, we empower our customers to address the needs of today without compromising the needs of tomorrow. Our process allows us to provide a wide variety of environmental, economic, and humanitarian benefits.

Solaplast is a subsidiary company of ALGIX. ALGIX is committed to Life Cycle Thinking and further improving our products in order to produce more with less and to ensure sustainable resource use while alleviating the stress on the environment. Various life cycle analyses support the better performance of biobased rigid packaging, in particular in the impact categories of human health, ecosystems, climate change and fossil resources. For more information, visit www.algix.com.

## The Materials

At Solaplast, we offer a variety of algae-based resin formulations. Algix processes algae biomass, harvested from aquaculture ponds and other sources, to be blended with plastics such as polyethylene (PE), ethylene vinyl acetate (EVA), polypropylene (PP) and polystyrene (PS), to create a blended plastic filler that reduces the amount of petroleum-based plastics needed. The Algix product can also be blended with biodegradable plastics, such as poly lactic acid (PLA) and polybutylene adipate terephthalate (PBAT), to make them more cost competitive since the algae biomass is also biodegradable and cost competitive with conventional and bio-based plastics.

The use of algae and other bio-based materials instead of fossil resources in the plastics industry can help reduce Green House Gas (GHG) emissions, since the bio-based composition uses the atmospheric $CO_2$ absorbed by algae during the photosynthesis rather than carbon from fossil-based resources. Reducing GHG remains a driver for the increase seen in bio-based content of engineering materials. Solaplast not only provides a more sustainable plastic product but, dependent on the resin, in some aspects they provide improved material specifications and product performance. We accomplish all of this through our in house Custom Compounding and Research and Development activities.

Generally, Solaplast formulations typically consist of either a durable polymer or a biodegradable bio-based polymer combined with algae. Solaplast resins can be used in a vast number of ways and in a variety of applications such as packaging, agriculture/horticulture, consumer electronics, material handling, automotive, consumer goods & household appliances, personal care, and construction.

Solaplast resins often provide a drop-in replacement for thermoplastic compounds and offers the manufacturer improved mechanical properties, a more sustainable product, eligibility for government incentive programs, process cost reductions and a buffer to crude oil price fluctuations.

## The Products

Solaplast resins are comprised of a base resin and algae at 45-55% algae loading level depending on the base resin. Solaplast resins are sold as plastic resin pellets ready to be processed in injection molding, extrusion, blown films, blown molding, foaming and sheet extrusion/ thermoforming processes. Solaplast products can be sold in 50 pound foil bags, 1,500-2,000 pound cardboard Gaylords boxes or super sacks, as well as rail car upon special request. Typical mechanical properties are provided in our Technical Data Sheets for each product which can be found on our website at http://algix.com/products-services/solaplast-resin-grades/

The Life Cycle Assessment study compares the cradle-to-gate environmental impacts when the algae, sourced from aquaculture ponds and targeted algae blooms, is blended with polystyrene (PS), high density polyethylene (HDPE) and polylactide (PLA, a bio-based plastic) to the respective 100% petroleum or bio-based plastic.

## Health and Safety Information

Solaplast resins are polymeric materials not classified as hazardous for human health or the environment according to Directive 1999/45 and Regulation 1271/2008. Substances of Very High Concern (SVHC) or Substances of the 'Candidate List of Substances of Very High Concern for Authorisation' (SVHC candidate list published by the European Chemical Agency (ECHA) following REACH Regulation are not purposely used for the product of Solaplast.

## Renewable Content

The renewable content for Solaplast resins is calculated by the weight of the algae biomass added to the formulation. Solaplast resins are comprised of up to 55% algae, and if being blended with a biodegradable base resin, they can be up to 100% bio-based materials. For the purpose of the LCA study, an average bio content of 50% was used for comparison purposes. Solaplast resins can be a transformative addition to your portfolio to help you meet your sustainability goals.

## Production Process

### *Upstream Processes*
Upstream processes include the growing and harvesting of renewable, bio-based, algae resources, the extraction of non-renewable resources for the durable base resins(e.g. operation of oil platforms), the production of intermediate polymers including transport within the upstream process.

***Core Processes***
Core processes include the formulation by means of micronization of the algae biomass and extrusion compounding of the bio-based and fossil- based polymers along with any additives to form the final Solaplast resin pellets.

***Downstream Processes***
Downstream processes include the distribution from the production facility to the place where the conversion takes place, the conversion process, the use phase and the packaging.

**Environmental Data – LCA/ Charts**

The Algix process includes harvesting from an algae pond, dewatering, milling and compounding the algae with plastic, resulting in the masterbatch. The masterbatch consists of roughly 50% dry algae and 50% petroleum-based (or bio-based) plastic. The masterbatch is then combined with additional plastic at a 50:50 ratio before it is extruded into film or sheet and thermoformed. The amount of algae blended into the plastic is referred to as the loading level. For the resin comparison, 50% algae loaded is used for comparison to the virgin base resin. For the thermoformed product comparative analysis, the loading level of the thermoformed package is roughly 25% algae filler. The thermoformed package is then distributed, used and disposed of. The impacts evaluated by the LCA are defined and outlined in Figure 11.

The inputs to the Algix process include:
- Raw algae
- Material inputs for harvesting
- Electricity
- Material inputs for milling and compounding
- Water
- Petroleum or bio-based plastic

The outputs from the Algix process include:
- Masterbatch or thermoformed plastic product
- Plastic scrap from extrusion and thermoforming
- Water evaporation
- Wastewater

The life cycle's examined are "Cradle-To-Gate" and "Cradle-To-Grave" Analysis. The boundary conditions for these two analysis are shown below:

Figure 1: Cradle to Gate:

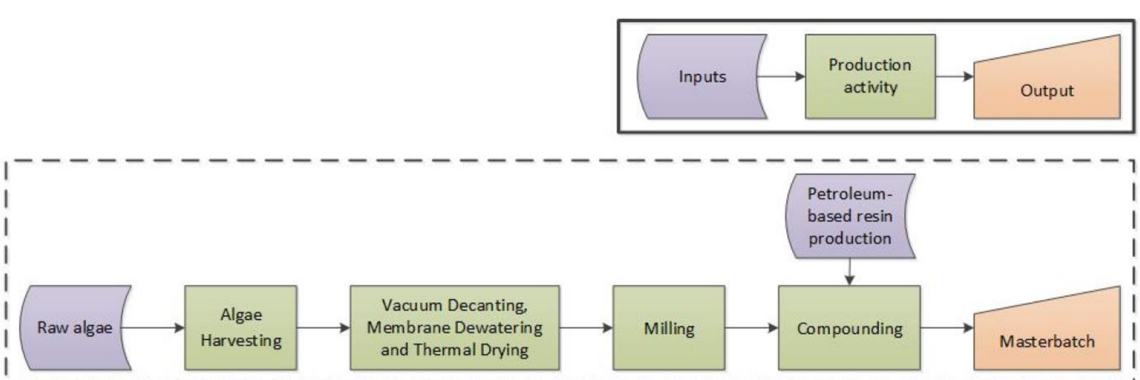
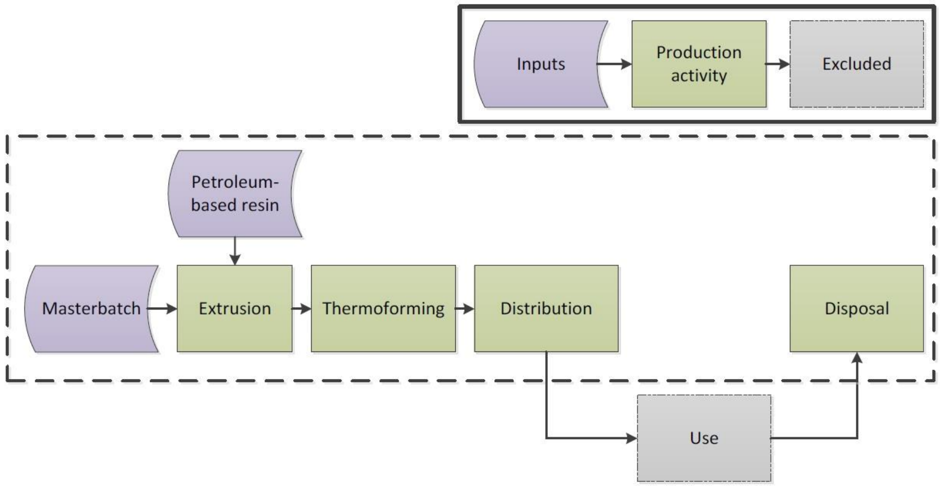


Figure 2: Cradle to Grave:




**Solaplast 1700 Series resin versus Polystyrene**

The comparative analysis in Figure 3 illustrates the impacts of algae blended masterbatch with PS vs. PS, cradle-to-gate. The data for the plastic has been contributed by most major U.S. resin manufacturers through the US LCI database and represents the average commodity sold in the U.S. The data are generic in nature and do not represent a particular manufacturer's plastic. In all categories, except water, the algae blended masterbatch with PS has fewer impacts, pound per pound, than PS. Water scarcity is generally low in Alabama when compared to other drought prone areas of the United States. The water consumption is tied to electrical power generation and usage. The production of algae biomass absorbs pollutants from water, such as nitrogen and phosphorus. Although using electricity to create algae blended plastics consumes electricity, there is the benefit of having clean water from the algae production itself. Figure 4 shows the tabulated quantified impacts for each of the LCA categories.

Figure 3: Solaplast 1700 Series resin compared to virgin polystyrene.

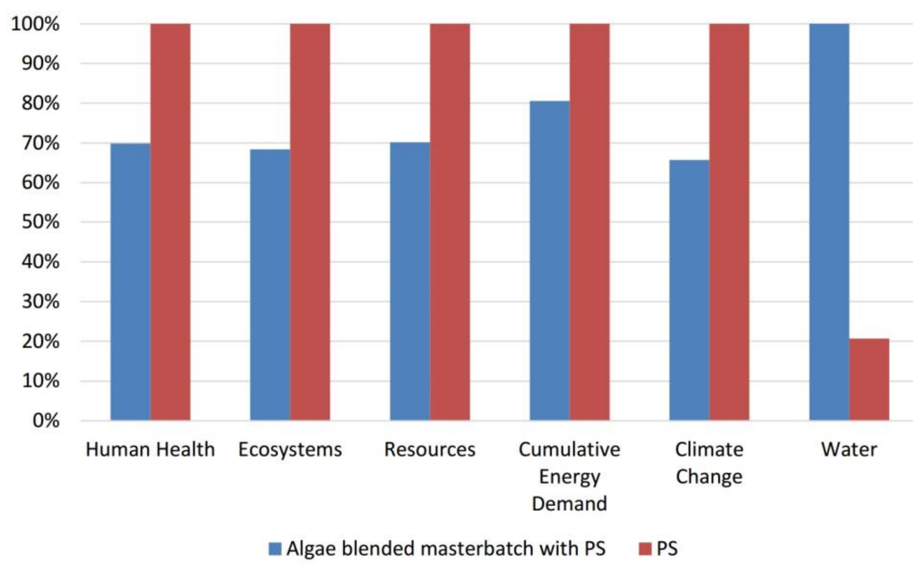


Figure 4: Comparison of quantified impacts for each impact category.

| Impact category | Unit | Algae/ PS | PS |
|---|---|---|---|
| Human Health | DALY | 2.90E-06 | 4.15E-06 |
| Ecosystems | species.yr | 1.41E-08 | 2.06E-08 |
| Resources | Econ Units | 1.11E-01 | 1.58E-01 |
| Cumulative Energy Demand | MJ | 3.57E+01 | 4.43E+01 |
| Climate Change | kg $CO_2$ eq. | 1.78E+00 | 2.71E+00 |
| Water | m3 | 6.55E-03 | 1.36E-03 |

**<u>Solaplast 1600 Series resin versus High Density Polyethylene</u>**

The LCA study also evaluated high density polyethylene (HDPE). The results of the uncertainty analysis indicate with a high level of certainty that the algae blended masterbatch with HDPE has fewer impacts than HDPE in human health, ecosystems, resources and climate change, as illustrated in figure 5. The results are uncertain in cumulative energy demand, therefore the comparative results for cumulative energy demand are not shown. The results indicate with a high level of certainty that the algae blended masterbatch with HDPE has more impacts than HDPE in water for the same reasons listed for the Polystyrene comparison.

Figure 5: Solaplast 1600 series resin compared to High Density Polyethylene.

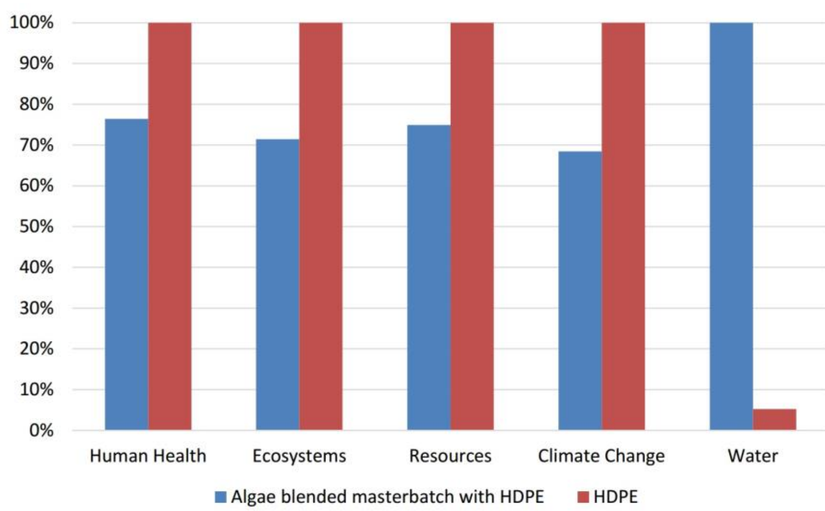



Figure 6: Comparison of quantified impacts for each impact category.

| Impact category | Unit | Algae/ HDPE | HDPE |
|---|---|---|---|
| Human Health | DALY | 2.39E-06 | 3.12E-06 |
| Ecosystems | species.yr | 1.26E-08 | 1.77E-08 |
| Resources | Econ Units | 9.60E-02 | 1.28E-01 |
| Climate Change | kg $CO_2$ eq. | 1.58E+00 | 2.31E+00 |
| Water | m3 | 6.35E-03 | 9.65E-04 |

**<u>Solaplast 2000 Series resin versus Poly Lactic Acid</u>**

The results shown in Figure 7 indicate with a high level of certainty that the algae blended masterbatch with PLA has fewer impacts than PLA in human health, ecosystems, climate change and water. The results are uncertain in resources and cumulative energy demand, therefore the comparative results for these categories are not provided. In the PLA comparison, the Solaplast 2000 resin used less water than the virgin resin despite similar electrical consumptions compared to other formulations. This is due to the large quantities of water used in the growth of corn production process for PLA. Figure 8 shows the quantified impacts of Solaplast 2000 series compared to pure PLA.

Figure 7: Solaplast 2000 series resin compared to Poly Lactic Acid

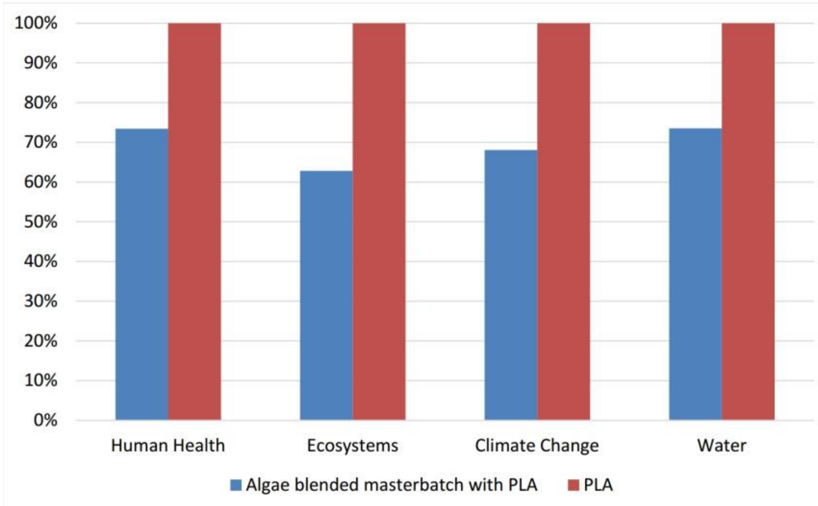



Figure 8: Comparison of quantified impacts for each impact category.

| Impact category | Unit | Algae/ PLA | PLA |
|---|---|---|---|
| Ecosystems | species.yr | 1.86E-08 | 2.96E-08 |
| Resources | Econ Units | 7.29E-02 | 8.19E-02 |
| Climate Change | kg $CO_2$ eq. | 1.60E+00 | 2.36E+00 |
| Water | m3 | 1.83E-02 | 2.50E-02 |

**Solaplast 1300 Series resin versus Ethylene Vinyl Acetate**

The results shown in Figure 9 indicate with a high level of certainty that the algae blended masterbatch with EVA has fewer impacts than EVA in resources and climate change. The results are improved but uncertain in cumulative energy demand, human health and ecosystems, therefore the comparative results for these categories are not provided. Figure 10 shows the quantified impacts of Solaplast 1300 series compared to pure EVA.

Figure 9: Solaplast 1300 series resin compared to EVA

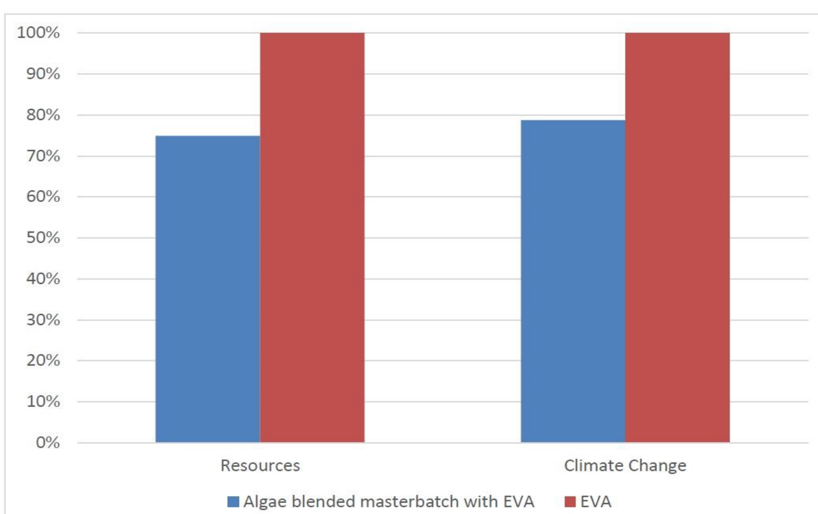


Figure 10. Comparison of quantified impacts for each impact category.

| Impact category | Unit | Algae/ EVA | EVA |
|---|---|---|---|
| Resources | Econ Units | 9.61E-02 | 1.28E-01 |
| Climate Change | kg $CO_2$ eq. | 1.17E+00 | 1.48E+00 |

**Thermoformed Polystyrene Sheet: Solaplast 1723 versus Polystyrene**

This aspect of the LCA study evaluated the conversion of Solaplast 1700 series resin into a sheet for thermoforming compared to using pure polystyrene. The results in figure 10 show with a high level of certainty that the thermoformed algae blended PS has fewer impacts than the thermoformed PS in all categories, except in water where the thermoformed algae blended PS has more impacts. Figure 12 shows the quantified impacts of Thermoformed Solaplast 1700 series compared to pure PS.

Figure 11:  Thermoformed Solaplast 1700 series resin compared to Thermoformed Polystyrene.

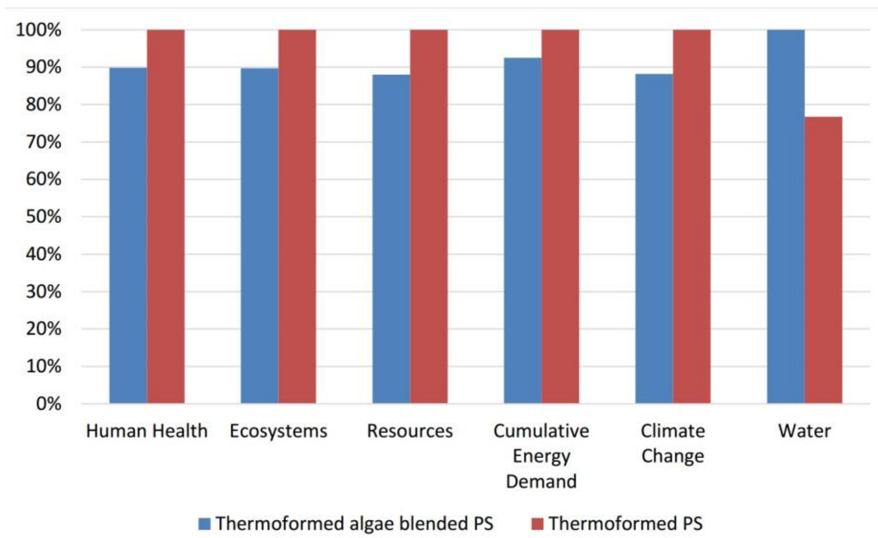



Figure 10: Comparison of quantified impacts for each impact category.

| Impact category | Unit | Thermoformed algae blended PS | Thermoformed PS |
|---|---|---|---|
| Human Health | DALY | 5.49E-06 | 6.11E-06 |
| Ecosystems | species.yr | 2.86E-08 | 3.19E-08 |
| Resources | Econ Units | 1.77E-01 | 2.01E-01 |
| Cumulative Energy Demand | MJ | 5.43E+01 | 5.87E+01 |
| Climate Change | kg $CO_2$ eq. | 3.47E+00 | 3.93E+00 |
| Water | m3 | 1.14E-02 | 8.78E-03 |

Figure 11: Overview of Impact categories used in LCA Analysis.

| Impact Category | Units | Comments |
|---|---|---|
| Human health | DALY | Accounts for years lived disabled as well as life cut short. |
| Ecosystems | Species * yr | Assessed in units of species * yr, or the number of species that may disappear due to the impact times the area over which they are affected times the duration that the species are affected. |
| Resources | Economic units | Puts a future value on resources which will be unavailable since we are using them today. |
| Climate change | kg $CO_2$ eq. | Measures global warming potential due to greenhouse gas emissions such as carbon dioxide, methane and nitrous oxides. Based on the 100 year time horizon. |
| Water | $m^3$ | Counts the amount of water consumed, in all processes, including electricity production. **Does not show impact. Used for benchmarking only.** |
| Cumulative Energy Demand | MJ | Quantifies total primary energy demand. Considers both renewable and non-renewable energy, as well as the direct and the indirect consumption of energy (through the use of materials whose extraction and processing is energy dependent). |

By analyzing the milled algae, masterbatch and thermoformed algae blended plastic, this study provides useful insight regarding the environmental impacts of Algix's operations, as well as how the algae blended plastic compares to petroleum and bio-based plastics. The LCA results also identified where the largest impacts are occurring so that Algix can make further improvements to the production system in order to continue to optimize and improve the life cycle footprint of the Solaplast product lines.

ALGIX is committed to Life Cycle Thinking and further improving our products in order to produce more with less and to ensure sustainable resource use while alleviating the stress on the environment. Various life cycle analyses support the better performance of biobased rigid packaging, in particular in the impact categories of human health, ecosystems, climate change and fossil resources.

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