EUROPEAN COMMISSION
Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
Joint Research Centre

Head of Unit

Call for existing data and information relevant to "Comparative Life-Cycle Assessment of alternative feedstock for plastics production"

Introduction

In January 2018, the European Commission adopted the European Strategy for Plastics in a Circular Economy[1], proposing a vision where alternative materials and feedstocks are developed and used where evidence clearly shows that they are more sustainable compared to the non-renewable alternatives. The set of measures identified in the Annex to implement the Strategy includes specific actions aimed at better understanding the life-cycle impacts of alternative feedstock for plastic production, as well as identifying the conditions under which the use of biodegradable and compostable plastics is beneficial[2]. In this context, the Joint Research Centre (JRC) was entrusted by the Directorate-General for Internal market, Industry, Entrepreneurship and SMEs (DG GROW) with the project "*Environmental sustainability assessment comparing through the means of lifecycle assessment the potential environmental impacts of the use of alternative feedstocks (biomass, recycled plastics, CO_2) for plastic articles in comparison to using current feedstocks (oil and gas)*".

The main purpose of this project is to elaborate a consistent and appropriate Life Cycle Assessment (LCA) based methodology and to apply it to a number of case studies to evaluate potential environmental impacts of the use of alternative feedstocks[3] for plastic articles[4] production in comparison to using current fossil-based feedstocks. Also the end of life treatment of different types of plastic articles (e.g. bio-degradable- and non-bio-degradable) will be looked at, considering their behaviour under different conditions (e.g. in home composting, in industrial composting, in anaerobic digestion, mechanical recycling, or when littered on land or in the marine environment). Not all bio-based plastics are biodegradable and not all biodegradable plastics are necessarily bio-based. We are interested in receiving comprehensive data and information on all options, i.e. bio-based (whether biodegradable or not) and biodegradable (whether bio-based or not).

---

[1] COM(2018) 28 final
[2] Annex 1 to COM(2018) 28 final, providing a list of future EU measures to implement the European Strategy for Plastics in a Circular Economy.
[3] Including *crop, food and other organic waste or residues, plastic waste* and *carbon dioxide* (CO_2) .
[4] The following definition of **article** is adopted: an object that during production is given a special shape, surface or design which determines its function to a greater degree than does its chemical composition. For instance, an article could be an extruded PET bottle.

EUROPEAN COMMISSION
Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
Joint Research Centre

Head of Unit

Purpose of the "call for data and information"

After a first screening of the existing literature, to avoid we are missing relevant information, with this call we are providing relevant stakeholders with the opportunity to send to us existing data and technical information that is relevant for this project, with a focus on the aspects further elaborated below (Annex I).

The request refers to existing Life Cycle Inventory (LCI) data, Life Cycle Impact Assessment (LCIA) data and complete Life Cycle Assessment (LCA) studies, as well as to data and technical information that can help to build those. No new data and studies are required to be developed for the purpose of this call, which rather aims at contributing to the mapping of the existing knowledge base, focusing on relevant and up-to-date data and studies. Studies comparing bio-based plastics, recycled plastics, CO_2-based plastics with fossil-based plastics are especially of interest, as well as studies evaluating several end of life scenarios for plastics including littering (on land or marine), recycling and/or other end of life options for biodegradable plastics[5] (e.g. composting and anaerobic digestion). Data and studies that reflect a broad range of impact categories and that have gone through a well-defined quality assurance process (e.g. peer review according to ISO 14040/44) are especially welcome.
In the project, we will reflect as far as possible the European average situation, rather than being limited to product or company specific supply chains. However, studies on both are welcome.

To avoid double work on all sides, existing studies and references that have been already identified by JRC as potentially relevant are listed in Annex II.

[5] In this context, biodegradable plastics include: (a) plastic materials and products that biodegrade under specific controlled conditions (e.g. industrial composting, home composting, anaerobic digestion) according to relevant European, national or international standards (e.g. EN 13432, EN 14995, ISO 18606, AS 5810, NF T 51-800); (b) plastic materials and products which biodegrade on –agricultural- soil according to specific European, national or international standards (e.g. EN 17033); as well (c) plastic materials that (bio)degrade into the land, marine or riverine environment according to specific and well-defined testing procedures (to be explicitly specified). Whenever data and information is provided about any of these kind of biodegradable plastic materials and/or products, the biodegradability claim should be substantiated by relevant supporting documents (e.g. third-party verified certifications according to relevant European, national or international standards). When no standards are applicable (e.g. for bio-degradation into the marine environment), a clear specification of the testing procedure should be provided.

How will the collected data and information be used?

Once the data and information collection exercise is completed, all input will be analysed and taken into account as appropriate in the development of the methodology and of the LCA case studies. It is the intention that later this year a draft version of the methodology and the preliminary results of five screening case studies will undergo a technical stakeholder consultation (with a consultation period of four weeks).

The results of the LCA work will be made public. In the interest of transparency to all stakeholders, the data used for the calculations and the related sources shall also be made publicly available. Therefore, the JRC cannot use for its calculations confidential information or data that cannot be disclosed.

By submitting the data and information to the European Commission, the provider of the data and information confirms that he/she is in possession of all necessary Intellectual Property Rights to disclose this data and information to the European Commission and he/she gives the right to the European Commission to use the data and information, including the right to disclose the data sources and the data itself to the public. The provider of the data and information agrees that no compensation related to any Intellectual Property Rights will be granted and that no such request will be made.

How can data and information be provided?

Please feel free to forward this call to organisations or individuals, who you think are in a position to provide relevant input to this call.

Data and information relevant to the present call can be provided to JRC through the e-mail address JRC-LCA4PLASTICS@ec.europa.eu.

Deadline

We welcome any input until July 31, 2018.

Further questions?

For any question regarding the call for data and information, or the project in general, stakeholders may address the EC-JRC project team at the e-mail address JRC-LCA4PLASTICS@ec.europa.eu.

EUROPEAN COMMISSION
Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
Joint Research Centre

Head of Unit

The European Commission and the whole project team would like to thank in advance all stakeholders for their contribution to a successful data and information collection exercise.

Luisa MARELLI

Acting Head of Unit

JRC, *Bioeconomy Unit (D.1)*

Johanna BERNSEL

Acting Head of Unit

DG GROW Chemicals Unit (D.2)

EUROPEAN COMMISSION
Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
Joint Research Centre

Head of Unit

ANNEX I: REQUESTED DATA AND INFORMATION

DATA AND INFORMATION RELATED TO CONVENTIONAL FOSSIL-BASED POLYMERS AND ARTICLES

- Any detailed Life Cycle Inventory (LCI) or LCA report/study other than those available on the PlasticsEurope website that cover the supply chain of the relevant fossil-based polymers (HDPE, LDPE, PP, PET, EPS, PS, PVC).
- Disaggregated LCI or life cycle impact assessment (LCIA) data for relevant unit-processes involved in fossil-based polymer (HDPE, LDPE, PP, PET, EPS, PS, PVC) production, and especially for polymerisation and monomer production. Data should cover all relevant input and output flows of the processes (energy, materials, chemicals, land use, water use, emissions into air, water and soil, waste etc.). Data is requested to be representative of the average industry production at the EU level, and of the potential variability around this average (e.g. through the 20^{th} and 80^{th} percentiles of the LCI data sample for Europe). Transparent information about any performed allocation should be provided.
- Type and quantity of the most relevant additives used in the production of specific fossil-based polymers (HDPE, LDPE, PP, PET, EPS, PS, PVC) and/or plastic articles (e.g. bottles, bags, cups, mulching film, -food- packaging film, etc.).
- LCI data or LCA studies on the production of the most relevant additives used for specific fossil-based polymers and/or plastic articles.
- Data on the fate, exposure and potential (toxicological) effects over the life cycle of additives used for the relevant fossil-based polymers and/or plastic articles.
- Contribution of specific fossil-based plastic articles to littering and microplastics formation: e.g. estimated quantity of article littered per year at the global/European scale; estimated share (%) of the total yearly production/sales that is littered rather than going to proper disposal/treatment (e.g. which is a reasonable estimate of the share of crisp bags sold/produced in one year that is littered? 1%; 2%; ....?).
- Data on the fate, exposure and potential (toxicological) effects of specific fossil-based plastic articles littered into the land/marine environment (e.g. microplastic formation, ingestion of larger plastic particles and their effects).
- Data or information about potential recycling incompatibilities due to bio-based or biodegradable polymers and plastic articles in current mechanical recycling plants for

conventional fossil-based plastics. What are realistic thresholds for the presence of biodegradable or bio-based "contaminants" in the mechanical recycling process of HDPE, LDPE, PP, PET, EPS, PS, PVC across Europe (e.g. as % of contaminants in the incoming waste stream and/or in the recycled material)? Figures should be based on the currently available infrastructure and should be representative of the average recycling industry at the EU level and of the potential variability around this average (e.g. through the 20^{th} and 80^{th} percentiles of the reference data sample, if available).

- Data about the current presence of bio-based and biodegradable plastic articles in the plastic waste stream sent to mechanical recycling processes. Data should be representative of the average recycling industry at the EU level and of the potential variability around this average (e.g. through the 20^{th} and 80^{th} percentiles of the reference data sample, if available).

EUROPEAN COMMISSION
Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
Joint Research Centre

Head of Unit

DATA AND INFORMATION RELATED TO BIO-BASED AND BIODEGRADABLE POLYMERS AND ARTICLES

- Identification of the main bio-based (biodegradable and non-biodegradable) and biodegradable (bio-based and non-bio-based) plastic articles to be suggested for the comparative LCA study. Data (or data sources) on the following elements are specifically welcome:
    - the market potential of bio-based and biodegradable plastic articles (e.g. bags, bottles, cups, -food- packaging film, mulching film, construction articles, automotive articles, etc.) in the EU, including production amounts (in tonnes per year) and indicative sale prices (approximate range in EUR/t), current market shares (in %), trends (share in % or production in t/year), forecasts (expected growth in % or t/year), job creation (number of full time employees);
    - the potential for deployment of bio-based and biodegradable plastic articles at the EU level, including information on:
        - feedstock availability for polymer producers, in terms of amounts required in comparison to the available stock (in t/year), or response of feedstock supply to the demand (in years);
        - technology restrictions for polymer converters (e.g. technically possible with available technology and processes, technically possible providing process changes occur, technically possible providing equipment investment, only at R&D stage);
        - development status of technology (e.g. in operation at industrial scale, tested at plant scale, tested at pilot scale, tested at laboratory scale – R&D);
        - economic restrictions (in payback time – i.e. in years).
- Life cycle inventory (LCI) or life cycle assessment (LCA) studies on bio-based and biodegradable polymers, monomers, or specific plastic articles (especially welcome, if also a background report/information is available and if reviewed). Transparent information about any performed allocation should be provided.
- Disaggregated LCI or life cycle impact assessment (LCIA) data for relevant unit-processes involved in the production of: (a) drop-in bio-based polymers (PET, HDPE, LDPE, EPS, PS, PVC) and monomers (ethylene, ethylene glycol, terephthalic acid, etc.);

as well as (b) alternative bio-based and biodegradable (bio-based or non bio-based) polymers (PEF, PLA, PBS, PBAT, PHA, starch-based polymers, etc) and respective monomers (furandicarboxylic acid, lactic acid, succinic acid, 1,4-butanediol, adipic acid, dimethyl terephthalate, etc.). Data should cover all relevant input and output flows of the processes (energy, materials, chemicals, land use, water use, emissions into air, water and soil, waste etc.). Moreover, data should be representative of the average industry production at the EU level and/or in the relevant country(-ies), and of the potential variability around this average (e.g. through the 20^{th} and 80^{th} percentiles of the LCI data sample). Transparent information about any performed allocation should be provided.

- Data/information on the average composition of bio-based feedstocks (including their country of origin) used for the production of specific bio-polymers/bio-monomers supplied to the EU market (e.g. bio-PE, bio-MEG, PLA, PHA, PBAT, starch, etc.).
- Type and quantity of the most relevant additives used in the production of specific bio-polymers (e.g. bio-PE, bio-PET, PLA, PHA, PBAT, starch, starch blends etc.) and/or bio-based and biodegradable plastic articles (e.g. bottles, bags, cups, mulching film, -food-packaging film, etc.).
- LCI data on the production of the most relevant additives used for bio-based and biodegradable polymers and/or plastic articles.
- Data on the fate/release, potential exposure and possible (toxicological) effects over the life cycle of the most relevant additives used for specific bio-polymers and/or bio-plastic articles (e.g. migration from food packaging, human uptake via diet and subsequent effects on human health).
- Certification of (bio)degradability of specific bio-plastic articles (e.g. bags, bottles, cups, mulching film, packaging film, etc.), under specific controlled (e.g. composting) or uncontrolled (e.g. agricultural soil) conditions, according to specific relevant European, national or international standards (e.g. EN 13432, EN 14995, ISO 18606, AS 5810, NF T 51-800, EN 17033).
- Information about the (bio)degradability of specific bio-plastic articles (e.g. bags, bottles, cups, mulching film, packaging film, etc.) under conditions for which no standards are yet available (e.g. for the marine and riverine environment). In this case, supporting information about the procedure and methods used to determine bio(degradability) shall be provided.

- Data about degradation rates (during composting/digestion or in the land/marine environment) of specific bio-polymers and/or bio-plastic articles (e.g. bags, bottles, cups, mulching film, etc.).
- Data about bio-methane potential of biodegradable polymers and/or plastic articles (e.g. bio-methane tests, batch or continuous reactor).
- Contribution of specific bio-plastic articles to littering and/or microplastic formation: estimated quantity of article littered per year at the global/European scale; share (%) of the total yearly production/sales that is littered rather than going to proper disposal/treatment (e.g. which is a reasonable estimate of the share of crisp bags sold/produced in one year that is littered? 1%; 2%; ....?).
- Data on the fate, exposure and potential (toxicological) effects of specific bio-plastic articles littered into the land/marine environment (e.g. microplastic formation, ingestion of larger plastic particles and their effects).
- Data or information about potential recycling incompatibilities due to bio-based and biodegradable polymers and plastic articles in current mechanical recycling plants for conventional fossil-based plastics. What are realistic thresholds for the presence of biodegradable or bio-based "contaminants" in the mechanical recycling process of HDPE, LDPE, PP, PET, EPS, PS, PVC across Europe (e.g. as % of contaminants in the incoming waste stream and/or in the recycled material)? Figures should be based on the currently available recycling infrastructure and should be representative of the average recycling industry at the EU level and of the potential variability around this average (e.g. through the 20^{th} and 80^{th} percentiles of the reference data sample, if available).
- Data about the current presence of bio-based and biodegradable plastic articles into the plastic waste stream sent to mechanical recycling processes. Data should be representative of the average recycling industry at the EU level and of the potential variability around this average (e.g. through the 20^{th} and 80^{th} percentiles of the reference data sample, if available).

EUROPEAN COMMISSION
Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
Joint Research Centre

Head of Unit

DATA AND INFORMATION RELATED TO RECYCLED PLASTIC WASTE-BASED POLYMERS AND ARTICLES

- Identification of the main recycled plastics articles to be suggested for the comparative LCA study. Data (or data sources) on the following elements are specifically welcome:
    - the market potential of recycled plastic articles (e.g. packaging and food containers articles, construction articles, automotive articles, etc.) in the EU, including production amounts (in tonnes per year) and indicative sale prices (approximate range in EUR/t), current market shares (in %), trends (share in % or production in t/year), forecasts (expected growth in % or t/year), job creation (number of full time employees);
    - the potential for deployment of recycled plastic articles at the EU level, including information on:
        - feedstock availability for polymer producers, in terms of amounts required in comparison to the available stock (in t/year), or response of feedstock supply to the demand (in years);
        - technology restrictions for polymer converters (e.g. technically possible with available technology and processes, technically possible providing process changes occur, technically possible providing equipment investment, only at R&D stage);
        - development status of technology (e.g. in operation at industrial scale, tested at plant scale, tested at pilot scale, tested at laboratory scale – R&D);
        - economic restrictions (in payback time – i.e. in years).
- Life cycle inventory (LCI) or life cycle assessment (LCA) studies on recycled polymers, or specific recycled plastic articles (especially welcome, if also a background report/information is available and if reviewed). Transparent information about any performed allocation should be provided.
- Disaggregated LCI or life cycle impact assessment (LCIA) data for relevant unit-processes involved in recycled polymer production, and especially for polymerisation and monomer production from feedstocks. Data should cover all relevant input and output flows of the processes (energy, materials, chemicals, land use, water use, emissions into air, water and soil, waste etc.). Data is requested to be representative of the average

industry production at the EU level, and of the potential variability around this average (e.g. through the impacts corresponding to the 20th and 80th percentiles of the LCI data sample for Europe). Transparent information about any performed allocation should be provided.

- Data or information about potential recycling incompatibilities due to bio-based and biodegradable polymers and plastic articles in current mechanical recycling plants for conventional fossil-based plastics. What are realistic thresholds for the presence of biodegradable or bio-based "contaminants" in the mechanical recycling process of HDPE, LDPE, PP, PET, EPS, PS, PVC across Europe (e.g. as % of contaminants in the incoming waste stream and/or in the recycled material)? Figures should be based on the currently available recycling infrastructure and should be representative of the average recycling industry at the EU level and of the potential variability around this average (e.g. through the 20th and 80th percentiles of the reference data sample, if available).

- Data about the current presence of bio-based and biodegradable plastic articles in the plastic waste stream sent to mechanical recycling processes. Data should be representative of the average recycling industry at the EU level and of the potential variability around this average (e.g. through the 20th and 80th percentiles of the reference data sample, if available).

- Type and quantity of the most relevant additives used in the production of specific recycled polymers (e.g. HDPE, LDPE, PET, PP, EPS, PS, PVC) and/or recycled plastic articles (e.g. bottles, bags, cups, mulching film, -food- packaging film, etc.).

- LCI data or LCA studies on the production of the most relevant additives used for specific recycled polymers and/or plastic articles.

- Data on the fate/release, potential exposure and possible (toxicological) effects over the life cycle of the most relevant additives used for specific recycled polymers and/or recycled plastic articles.

EUROPEAN COMMISSION
Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
Joint Research Centre

Head of Unit

DATA AND INFORMATION RELATED TO CO_2-BASED POLYMERS AND ARTICLES

- Information about currently viable applications/technologies (industrial or pilot scale) and/or about applications/technologies that are more promising for deployment in the short-medium term (e.g. 2030). Information complemented by quantitative data on the market and or current/forecasted production capacity (tonnes per year) is especially welcome.

- Existing life cycle inventory (LCI) or life cycle assessment (LCA) study on CO_2-based polymers, monomers, key intermediates, production technologies or articles (especially welcome, if also a background report/information is available and if reviewed). Transparent information about any performed allocation should be provided.

- Disaggregated LCI or life cycle impact assessment (LCIA) data for relevant unit-processes involved in the production of CO_2-based polymers (e.g. polyurethane) and monomers (e.g. polyols). Data should cover all relevant input and output flows of the processes (energy, materials, chemicals, land use, water use, emissions into air, water and soil, waste etc.). Moreover, data should be representative of the average industry production at the EU level and/or in the relevant country(-ies), and of the potential variability around this average (e.g. through the 20^{th} and 80^{th} percentiles of the LCI data sample). Transparent information about any performed allocation should be provided.

- Any recommended CO_2-based polymers or articles to be considered in a (full) LCA case study and rationale.

ANNEX II: list of identified existing relevant studies

Alvarenga, R. A., Dewulf, J., De Meester, S., Wathelet, A., Villers, J., Thommeret, R., & Hruska, Z. (2013). Life cycle assessment of bioethanol-based PVC: Part 1: Attributional approach. Biofuels, Bioproducts and Biorefining, 7(4), 386–395.

Alvarenga, R. A., Dewulf, J., De Meester, S., Wathelet, A., Villers, J., Thommeret, R., & Hruska, Z. (2013). Life cycle assessment of bioethanol-based PVC: Part 2: Consequential approach. Biofuels, Bioproducts and Biorefining, 7(4), 396–405.

Arnold, J. C., & Alston, S. M. (2012). Life cycle assessment of the production and use of polypropylene tree shelters. Journal of Environmental Management.

Basf (2017). Introduction to Life Cycle Assessment of Fruit &Vegetable Bags in France

Belboom, S., & Léonard, A. (2016). Does biobased polymer achieve better environmental impacts than fossil polymer? Comparison of fossil HDPE and biobased HDPE produced from sugar beet and wheat. Biomass and Bioenergy, 85, 159–167.

Bisinella V., Albizzati P. F., Astrup T. F., Damgaard A. (2018). Life Cycle Assessment of grocery carrier bags.

Broeren, M. L. M., Kuling, L., Worrell, E., & Shen, L. (2017). Environmental impact assessment of six starch plastics focusing on wastewater-derived starch and additives. Resources, Conservation and Recycling, 127(September), 246–255.

CEN (2015) EN 16760 Bio-based products - Life Cycle Assessment

CEN (2016) CEN/TR 16957 Bio-based products - Guidelines for Life Cycle Inventory (LCI) for the End-of-life phase

Chen, L., Pelton, R. E. O., & Smith, T. M. (2016). Comparative life cycle assessment of fossil and bio-based polyethylene terephthalate (PET) bottles. Journal of Cleaner Production.

de Léis, C. M., Nogueira, A. R., Kulay, L., & Tadini, C. C. (2017). Environmental and energy analysis of biopolymer film based on cassava starch in Brazil. Journal of Cleaner Production.

Deng, Y., Achten, W. M. J., Van Acker, K., & Duflou, J. R. (2013). Life cycle assessment of wheat gluten powder and derived packaging film. Biofuels, Bioproducts and Biorefining.

Detzel, A., & Krüger, M. (2006). Life Cycle Assessment of POLYLACTIDE (PLA) -A comparison of food packaging made from NatureWorks® PLA and alternative materials.

Fernández-Dacosta, C., Van Der Spek, M., Hung, C. R., Oregionni, G. D., Skagestad, R., Parihar, P., Ramirez, A. (2017). Prospective techno-economic and environmental assessment of carbon capture at a refinery and CO2 utilisation in polyol synthesis. Journal of CO2 Utilization.

Gérand, Y., & Roux, P. (2014). Novinpak(ii) system Life Cycle Assessment – Comparative Life Cycle Assessment of the Novinpak® PET/RPET bottle and traditional glass bottle including vine growing and winemaking. Irstea Montpellier; UMR ITAP - ELSA group.

Groot, W. J., & Borén, T. (2010). Life cycle assessment of the manufacture of lactide and PLA biopolymers from sugarcane in Thailand. International Journal of Life Cycle Assessment, 15(9), 970–984.

Guo, M., Stuckey, D. C., & Murphy, R. J. (2013). End-of-life of starch-polyvinyl alcohol biopolymers. Bioresource Technology.

Hansen, A. P., da Silva, G. A., & Kulay, L. (2015). Evaluation of the environmental performance of alternatives for polystyrene production in Brazil. Science of the Total Environment, 532, 655–668.

Hermann, B. G., Blok, K., & Patel, M. K. (2010). Twisting biomaterials around your little finger: Environmental impacts of bio-based wrappings. International Journal of Life Cycle Assessment.

Hermann, B. G., Debeer, L., De Wilde, B., Blok, K., & Patel, M. K. (2011). To compost or not to compost: Carbon and energy footprints of biodegradable materials' waste treatment. Polymer Degradation and Stability.

Hoppe, W., Thonemann, N., & Bringezu, S. (2017). Life Cycle Assessment of Carbon Dioxide–Based Production of Methane and Methanol and Derived Polymers.

Hottle, T. A., Bilec, M. M., & Landis, A. E. (2017). Biopolymer production and end of life comparisons using life cycle assessment. Resources, Conservation and Recycling, 122, 295–306.

Kendall, A. (2012). A life cycle assessment of biopolymer production from material recovery facility residuals. Resources, Conservation and Recycling, 61, 69–74.

Kikuchi, Y., Hirao, M., Narita, K., Sugiyama, E., Oliveira, S., Chapman, S., Cappra, C. M. (2013). Environmental performance of biomass-derived chemical production: A case study on sugarcane-derived polyethylene. Journal of Chemical Engineering of Japan, 46(4), 319–325.

Kim, S., & Dale, B. E. (2008). Energy and greenhouse gas profiles of polyhydroxybutyrates derived from corn grain: A life cycle perspective. Environmental Science and Technology, 42(20), 7690–7695.

Liptow, C., & Tillman, A.-M. (2012). A Comparative Life Cycle Assessment Study of Polyethylene Based on Sugarcane and Crude Oil. Journal of Industrial Ecology, 16(3), 420–435.

Mattila, T., Kujanpää, M., Dahlbo, H., Soukka, R., & Myllymaa, T. (2011). Uncertainty and Sensitivity in the Carbon Footprint of Shopping Bags. Journal of Industrial Ecology, 15(2), 217–227.

McDevitt, J. E., & Grigsby, W. J. (2014). Life Cycle Assessment of Bio- and Petro-Chemical Adhesives Used in Fiberboard Production. Journal of Polymers and the Environment.

Meyer, D. E., & Katz, J. P. (2016). Analyzing the environmental impacts of laptop enclosures using screening-level life cycle assessment to support sustainable consumer electronics. Journal of Cleaner Production.

Muller B. (2012). Eco-Efficiency Analysis Comparative study of bags Eco-Efficiency Analysis of bags made of different materials for transportation of staple goods, reuse and disposal of organic waste.

Nuss, P., & Gardner, K. H. (2013). Attributional life cycle assessment (ALCA) of polyitaconic acid production from northeast US softwood biomass. International Journal of Life Cycle Assessment, 18(3), 603–612.

Papong, S., Malakul, P., Trungkavashirakun, R., Wenunun, P., Chom-In, T., Nithitanakul, M., & Sarobol, E. (2014). Comparative assessment of the environmental profile of PLA and PET drinking water bottles from a life cycle perspective. Journal of Cleaner Production.

Parker, G., & Edwards, C. (2012). A Life Cycle Assessment of Oxo-biodegradable, Compostable and Conventional Bags Executive Summary.

Piemonte, V., & Gironi, F. (2012). Bioplastics and GHGs saving: The land use change (LUC) emissions issue. Energy Sources, Part A: Recovery, Utilization and Environmental Effects.

Piemonte, V., & Gironi, F. (2011). Land-use change emissions: How green are the bioplastics? Environmental Progress and Sustainable Energy, 30(4), 685–691.

Pro.Mo/Unionplast (2015). Comparative Life Cycle Assessment (LCA) study of tableware for alimentary use Disposable dishes in PP, PS, PLA, cellulose pulp and reusable ceramic dishes Disposable glasses in PP, PS, PLA, PE coated cups and reusable glass cups.

Razza, F., Innocenti, F. D., Dobon, A., Aliaga, C., Sanchez, C., & Hortal, M. (2015). Environmental profile of a bio-based and biodegradable foamed packaging prototype in comparison with the current benchmark. Journal of Cleaner Production.

Rossi, V., Cleeve-Edwards, N., Lundquist, L., Schenker, U., Dubois, C., Humbert, S., & Jolliet, O. (2015). Life cycle assessment of end-of-life options for two biodegradable packaging materials: Sound application of the European waste hierarchy. Journal of Cleaner Production.

Tsiropoulos, I., Faaij, A. P. C., Lundquist, L., Schenker, U., Briois, J. F., & Patel, M. K. (2015). Life cycle impact assessment of bio-based plastics from sugarcane ethanol. Journal of Cleaner Production, 90, 114–127.

Van der Harst, E., Potting, J., & Kroeze, C. (2014). Multiple data sets and modelling choices in a comparative LCA of disposable beverage cups. Science of the Total Environment.

von der Assen, N., & Bardow, A. (2014). Life cycle assessment of polyols for polyurethane production using CO2 as feedstock: insights from an industrial case study. Green Chem.