COUNTING CARBON

A LIFECYCLE ASSESSMENT GUIDE FOR PLASTIC FUELS

CO_2

CO_2

CO_2

CO_2

BELLONA

ZERO WASTE EUROPE

RETHINK PLASTIC

SUMMARY

- Converting fossil plastics to fuels is sometimes marketed as a part of the solution to the environmental and waste problems the plastic industry is currently facing. These fuels are produced by converting plastics back to their original form, fossil fuels (plastic refining). They are ultimately burnt and the fossil carbon is released to the atmosphere, exacerbating climate change.

- Some proponents have claimed that plastic fuels could be labelled as low-carbon, effectively using plastic production as a stepping stone to greenwash CO2 coming from fossil oil and gas. Proponents of plastic fuels have tried to achieve this by labelling the input as waste, therefore simply ignoring that fossil carbon in their greenhouse gas (GHG) calculations.

- Favourable accounting, using selective life cycle assessment (LCA) (with narrow boundaries such as cradle-to-gate or gate-to-gate), allows for the CO2 emissions from the burning of plastics to be lost, giving the false impression that almost no GHGs will be emitted to the atmosphere.

- By promoting plastic fuels through various channels, the oil, gas and petrochemical industries can continue extracting and releasing fossil carbon into the atmosphere without any economic or political consequences. Partial LCAs and mislabelling of inputs for plastic fuels play into such narratives since they omit over 90% of the GHG emissions they cause (see figure 1).

- To prevent gaming and selective accounting, robust guidelines for a full LCA are needed. **The fossil carbon embedded within plastics needs to be traced from the extraction of the fossil carbon to its emission into the atmosphere. In LCA terms, this translates to a cradle-to-grave LCA which takes into account both the fossil origin of the plastic and the emissions caused by the final combustion of the fuel.**

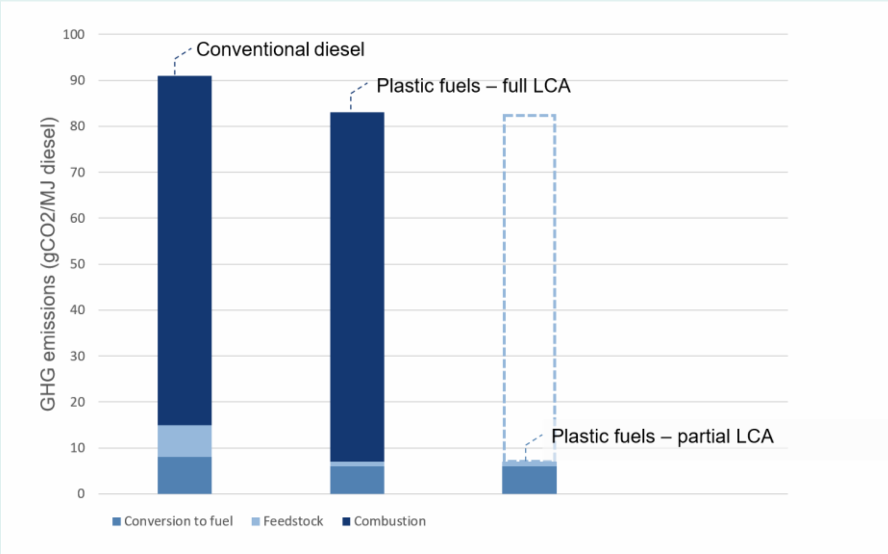

Figure 1: Not accounting for the combustion of plastic fuels leaves approximately 90% of the emissions related to the fuel unaccounted for. Adapted from Benavides et al. 2017 (Benavides, Sun, Han, Dunn, & Wang, 2017).

1 INTRODUCTION

Over the past 50 years, plastic has become an integral part of our society. It has transformed our lives and ecosystems, both for better and for worse.

Since the 1950s when we first started producing plastic resins, we've produced approximately 9.2 billion tons of it. More than 70% of it has been discarded in landfills or the environment (Geyer, Jambeck, & Law, 2017).

Plastic has also been one of the major demand drivers for petrochemical feedstock coming from the oil and gas industry (IEA, The Future of Petrochemicals, 2018). Nearly every piece of plastic is manufactured from fossil fuels, kept in circulation for a brief period of time and then landfilled, incinerated or disposed of (Geyer, Jambeck, & Law, 2017). The entire plastic value chain, including its production, use and disposal will add more than 850 million metric tons of greenhouse gases to the atmosphere in 2019. That is equivalent to 189 five-hundred-megawatt coal power plants (CIEL, 2019), comparable to the total emissions of Germany (UBA, 2018).

As one of the fastest growing culprits behind climate change and environmental pollution (IEA, The Future of Petrochemicals, 2018), plastics production, consumption and disposal methods are increasingly under scrutiny. In an effort to continue their profitable business and prevent a change in production and consumption patterns, some plastic and fuel manufacturers have been promoting fuels made out of plastic. They have argued that liquid and gaseous fuels produced by the gasification and/or pyrolysis of plastic can reduce greenhouse gas (GHG) emissions when compared to the production of conventional fuels (The Explorer, 2019).

The purpose of this briefing is to assess the greenhouse gas accounting methods used to measure the climate impacts of such fuels. Since there has been no example of a comprehensive and impartial life-cycle assessment to date, this briefing compares two scenarios of accounting and shows how partial assessments will not accurately estimate the total increase of CO2 in the atmosphere.

To put the analysis into context, some key information on plastics, thermal depolymerisation and LCAs is given. Following these sections, the briefing delves deeper into the LCA requirements for plastic fuels and compares two scenarios: the full LCA that accounts for all GHG emissions to the atmosphere and the partial LCA which leaves 90% of emissions unaccounted for. Finally, the briefing concludes with policy recommendations on how to set up the necessary environmental safeguards for the LCA that will be used to analyse the impact of plastic fuels.

Despite a lack of preliminary assessments, these fuels are included in fuel targets under the revised Renewable Energy Directive of the European Union (REDII) as ''liquid and gaseous fuels that are produced from liquid or solid waste streams of non-renewable origin'' (also referred to as 'recycled carbon fuels'). The climate performance of these fuels, along with other environmental impacts, will be evaluated under a delegated act by 2021 (Zero Waste Europe & Bellona, 2019). Given this political context, the aim of this briefing is to inform policymakers and help them establish a blueprint for an impartial assessment of the greenhouse gas footprint of such fuels.

KEY FACTS ABOUT PLASTIC

Virtually all synthetic polymers produced today come from a fossil source. They are produced by refining naphtha into monomers such as ethylene and propylene, which are then used for the production of polymers (Polyplastics, 2019; Plastics Europe, 2019). In other words, crude oil is refined into a product which is then either discarded or incinerated at the end of its lifecycle (UNEP, 2018). Regardless of the duration of their use, most polymers produced so far have found their way into the environment or landfills (Geyer, Jambeck, & Law, 2017).

For instance, 98% of plastic packaging is produced from a virgin feedstock, mostly crude oil and gas. Recycled (or downcycled) plastics and bio-based plastics contribute in trace amounts; measuring only about 2-2.5% of overall production. Then, at the end of the lifecycle of the packaging, most of the 78 million tons of plastic packaging produced annually is thrown to landfills, into marine and terrestrial ecosystems, or burned in waste incineration plants (World Economic Forum, Ellen MacArthur Foundation, & McKinsey & Company, 2016). The small portion of packaging which goes to recycling is effectively downcycled, since the physical properties of the material change due to its degradation through the mechanical recycling process (Scalenghe, 2018).

Such unsustainable waste management has initiated increasing scrutiny as mountains of plastic continue to grow, which in turn has elicited some responses from the chemical industry.
Hydrocarbon liquid and gaseous fuels made out of plastic materials (also referred to in this briefing as plastic fuels) are sometimes marketed as a part of the solution to the problems the plastic industry is currently facing.

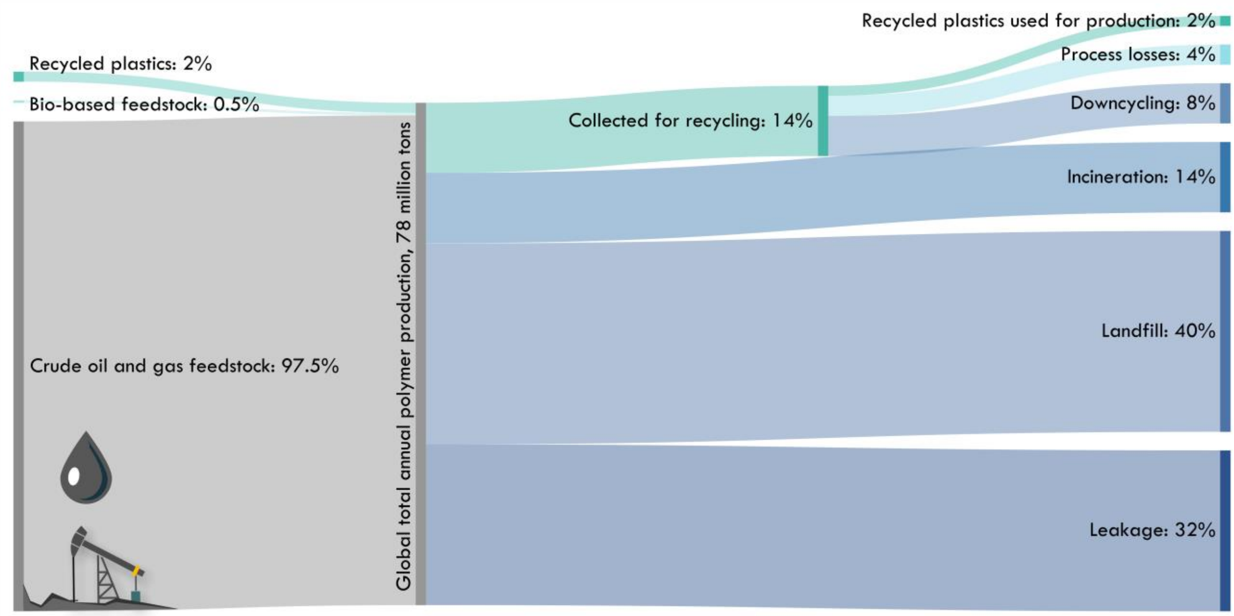

Figure 2: A Sankey diagram showing material flows of the production, use and disposal of plastic packaging (in 2013) (World Economic Forum, Ellen MacArthur Foundation, & McKinsey & Company, 2016; European Commission, 2018).

2 THERMAL DEPOLYMERISATION: BURNING OF FOSSIL CARBON RENAMED

The production of these fuels entails the conversion of plastics back to their original form; fossil fuels. All of these processes fall under the category of thermal depolymerisation: the breaking of polymer bonds with heat and pressure. Such thermal reactions, unlike mechanical recycling, consume a considerable amount of energy and consequently chip away at any potential GHG emission reductions from recycling (Zero Waste Europe, 2019; GAIA, 2017; Rollinson & Oladejo, 2019).[1]

KEY FACTS ABOUT THERMAL DEPOLYMERISATION

The thermal depolymerisation processes can be divided into three different categories[2] (pyrolysis, gasification and hydrogenation). The process results in gaseous and solid hydrocarbon fractions. Some of these outputs can be further refined to produce a fuel suitable for combustion.[3] However, most of the products resulting from these processes need to be purified to remove impurities (e.g. ash).

Process	Definition
Pyrolysis	Decomposition of materials containing carbon in high temperatures in the absence of oxygen – resulting in char, tar oil and uncondensed gases.
Gasification	Partial oxidation of materials containing carbon - resulting in a mixture of carbon monoxide and hydrogen (synthetic gas, also known as syngas).
Hydrogenation	Treatment of materials containing carbon with hydrogen in the presence of a catalyst – resulting in saturated liquid and gaseous hydrocarbons.

Table 1: Three energy intensive processes eligible to convert plastic into gaseous and liquid feedstock for fuels (ETC, 2018).

Pyrolysis, gasification and hydrogenation were developed decades ago (Garcia-Nunez, et al., 2017; GAIA, 2017; GIZ, 2017). Despite their long history, they are not economically viable and do not operate on a significant commercial scale (ETC, 2018; Rollinson & Oladejo, 2019).[4] According to GIZ, companies specialising in pyrolysis and gasification failed to scale up because they were not profitable (GIZ, 2017).

Ultimately these processes and their outputs (plastic fuel) result in the release of fossil carbon to the atmosphere, therefore increasing the overall amount of CO2 in the atmosphere and contributing to further climate change. The production and use of plastic fuels via thermal depolymerisation is just another term for burning fossil carbon. Redefining such a process as low-carbon is greenwashing. **However, some manufacturers have claimed that these fuels could be labelled as low-carbon, effectively using plastic fuels to greenwash CO2 coming from fossil oil and gas.**

To arrive at a favourable GHG footprint, some stakeholders have suggested the analysis of the impact of the fuel through an LCA. However, the outcome of the LCA varies drastically depending on the goal and scope of the analysis. In other words, as long as the goal and the boundaries remain arbitrary, the results can be manipulated to anyone's advantage.

1 The questionable climate impact of chemical recycling is not within the scope of this briefing, but should be analysed further in order to assess whether the technology is compatible with EU's climate goals.
2 Another method of thermal depolymerisation is plasma pyrolysis.
3 These hydrocarbons can also be used to produce polymers. This process is often referred to as chemical recycling (for more information on chemical recycling: https://zerowasteeurope.eu/wp-content/uploads/edd/2019/08/2019_08_29_zwe_study_chemical_recycling.pdf)
4 Since the feedstock used by these processes is often heterogeneous waste, their operation generally results in high energy consumption, high maintenance and cleaning costs & low yields

3 HOW AN LCA WORKS: THE USE AND ABUSE OF GREENHOUSE GAS ACCOUNTING METHODS

An LCA is a tool that evaluates the potential environmental impacts associated with a product (Ecochain, 2019; EEA, 1997). By collecting data about the impact of a certain product, it quantifies its effect on the environment (EC, 2019). An LCA is normally done in several stages, starting off with a definition of the goal and the scope, collection of data needed for the analysis, inventory analysis and finally the interpretation of the data collected.

In the context of the REDII, the most relevant environmental impact category of the LCA is the global warming potential (GWP), which describes the greenhouse gas effect caused by the production, distribution and use of the product.[5] This briefing focuses specifically on this category of environmental impacts.

Normally the assessment includes all of the stages of the product; including the extraction of raw materials, production process, distribution, use and disposal (EEA, 1997). A full LCA considers all emissions at all stages across the life cycle of a product. Indirect and direct emissions are included to ensure the product has a beneficial climate change impact across its entire production chain. This is commonly referred to as a cradle-to-grave or a well-to-wheel assessment.

LCAs can also focus on a specific part of the lifecycle of a product. However, this means that the scope of the analysis is more narrow and might leave out some emissions related to the product. In other words, the smaller the scope of the analysis, the better the products GHG footprint will look. Since there is no obligation to include all of the emissions related to a product (cradle-to-grave), LCA boundaries are often arbitrary and depending on their goal can lead to very different results.

3.1 GOAL OF THE LCA

Particularly in the context of public policies, LCAs are tailored to a specific purpose. The first step of an LCA is to define a goal for the analysis. One of the problematic aspects of an LCA, particularly relevant for policy making, is that it may be considered cradle-to-grave for one purpose/context while only covering part of the lifecycle in another context.

In the case of the delegated acts of the REDII mentioned earlier, the LCAs are meant to inform EU policies that aim to reach certain climate targets. More precisely, the purpose of these specific LCAs is to estimate “the potential for

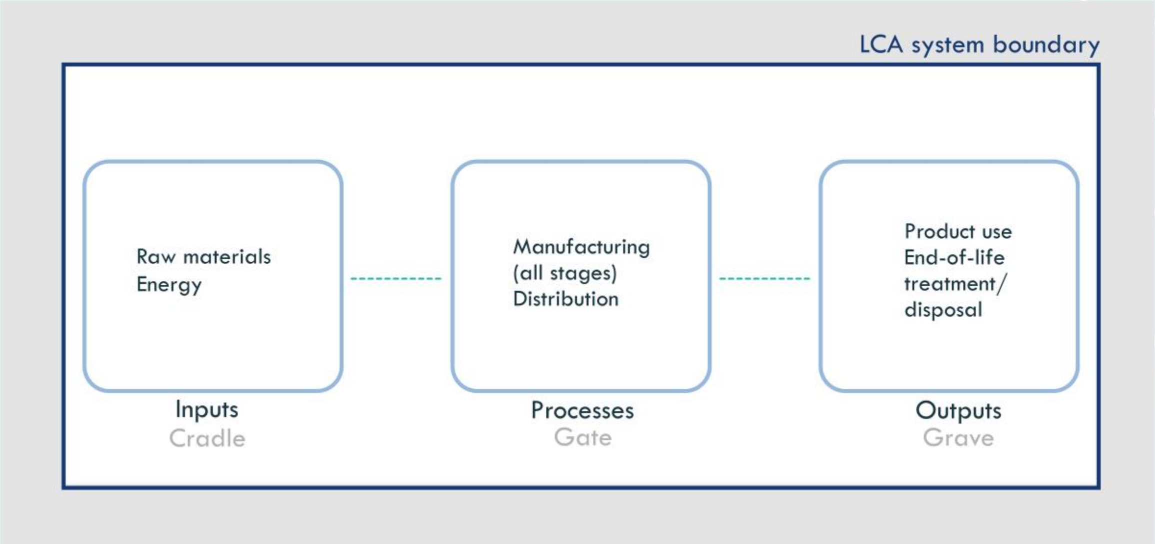

Figure 3: A full lifecycle analysis includes all inputs, processes and outputs associated to a product (EEA, 1997).

5 More precisely, it is a measure which describes how much energy 1 ton of a greenhouse gas (e.g. CO_2) emitted into the atmosphere will absorb over a given period of time (EPA, 2017).

delivering substantial greenhouse gas emissions savings compared to fossil fuels based on a lifecycle assessment of emissions.'' A partial LCA that excludes key parts of the lifecycle of a product which are relevant to the assessment of emissions is therefore not in line with this goal.

Ultimately, looking at what comes out of the ground and goes up into the atmosphere is the only way to determine the additional GHG emissions to the atmosphere. **Plastic with embedded fossil carbon needs to be traced from the extraction of the fossil carbon all the way to its emission into the atmosphere. In LCA terms, this translates to a cradle-to-grave LCA which takes into account both the fossil origin of the plastic and the emissions caused by the final combustion of the fuel.**

3.2 SCOPE AND INVENTORY ANALYSIS

As illustrated in Figure 3: a full lifecycle analysis includes all inputs, processes and outputs associated to a product (EEA, 1997), therefore, evaluating a product based on a full LCA raises questions about (i) the inputs which are needed (e.g. the embedded fossil carbon within the plastic and electricity and energy inputs), (ii) the emissions during the manufacturing of the product and (iii) the emissions generated during the product end-of-life processing and use (grave).

For instance, an LCA boundary designed to show a beneficial climate performance of a fuel can exclude emissions released by the combustion of that fuel. The following section focuses on how the boundaries of an LCA can be drawn up to make a product seem like a better alternative to its fossil equivalent.

3.3 THE ISSUE OF ALLOCATION TO MULTIPLE PRODUCTS

In addition to a narrow scope for an LCA, allocation of emissions to different products is another factor that plays an important role in the final outcome.

For instance, if plastic is labelled as 'waste', some argue that it doesn't have to be counted as a source of (fossil) carbon and therefore can be renamed as carbon neutral. This argument is based on the premise that the material would otherwise be unused. This means that any product derived from this fossil material would be counted as carbon neutral or low carbon.

Some private certification mechanisms have already started using this misleading argument. For instance, one certification system counts the fossil emissions of end-of-life products such as plastics as zero: **'[F]ossil end-of-life products and production residues shall be considered to have zero-life-cycle emissions up to the collection of those materials.** The calculation of greenhouse gas emissions shall therefore start with the collection of the material at the point of origin.'' (RSB, 2018).

Since the boundaries of their LCA exclude the final emissions of the fuel on the basis that the input is zero carbon, the result of such an analysis gives a false result that doesn't correspond to real-world emissions.

In their work on the quantification of GHG emission savings, also focusing on the Recycled Carbon Fuels in REDII, the Joint Research Centre (JRC) has illustrated a similar example of fuels made out of steel blast furnace gas: **"'if you say blast furnace gas is a "waste or residue" its emissions are zero in RED (II): a game of semantics.''** (JRC ISPRA, 2019).

The examples in this report illustrate how such narrow system boundaries and mislabelling can lead to an inaccurate LCA of plastic fuels and ultimately, a detrimental impact on EU climate goals.

As stated earlier, the main aim of any fuels included in the REDII is to achieve emission reductions. The LCA should therefore be designed to make sure that the product indeed has a beneficial climate impact across its entire production and use. In other words, **the mitigation potential needs to be assessed along the entire lifecycle of the product** (EC, 2019). In case of policy-related environmental assessments the big picture needs to be taken into account; including upstream and downstream trade-offs (EC, 2019).

4 FULL LCA ACCURATELY ACCOUNTS FOR EMISSIONS TO THE ATMOSPHERE

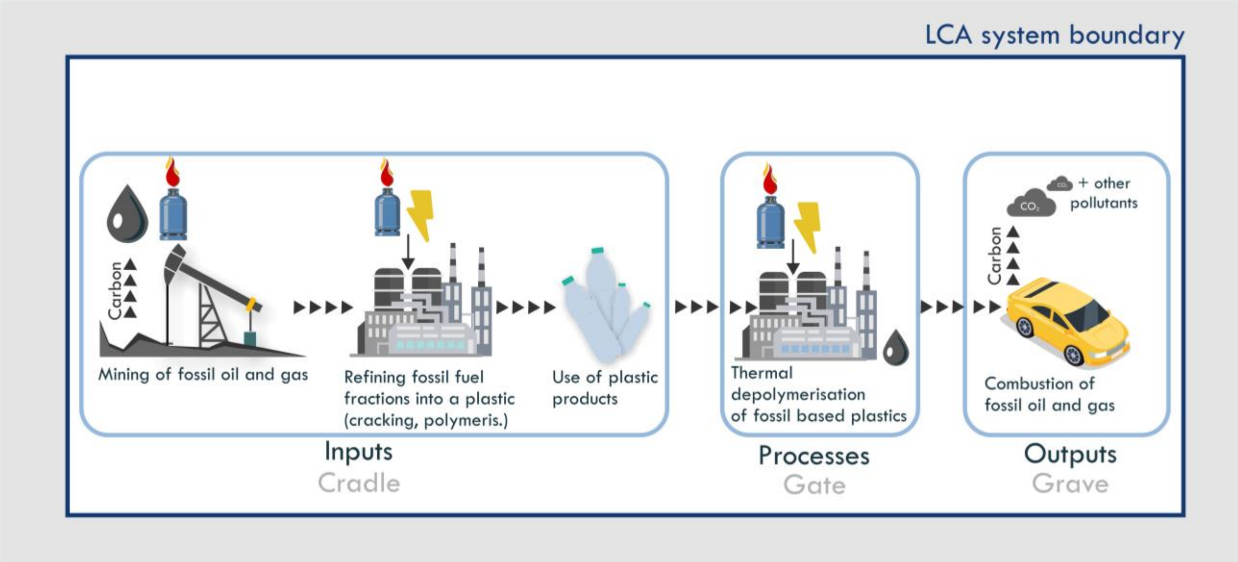

Figure 4: The fossil inputs to plastic fuel production, including the fossil carbon embedded in plastic, is a crucial element of the full lifecycle analysis.

In the case of plastic fuels, this assessment would have to start from the part of the lifecycle that contributes the most to its climate impact (Benavides, Sun, Han, Dunn, & Wang, 2017); the embedded carbon in plastic products. **Approximately 91% of the emissions from plastic fuel can be attributed to the fossil carbon embedded in the plastic input** (see Figure 5) (Benavides, Sun, Han, Dunn, & Wang, 2017).

As illustrated in Figure 4, a full LCA should track the fossil carbon from its initial extraction to its final emission. In order to measure the real net increase of emissions to the atmosphere, the embedded carbon in plastic materials should be counted as a fossil input to the fuel production.

When the final combustion emissions are included into the equation, the total CO2 increase in the atmosphere is correctly accounted for. Using these system boundaries and counting all the carbon coming in and out of the system, the reduction of emissions is only between 1-14% compared to conventional diesel[6] (Benavides, Sun, Han, Dunn, & Wang, 2017).

As Figure 5 shows, most of the emissions produced by combusting plastic fuels come from the fossil plastic input: ''it is the use of the non-recycled plastics-derived [...] fuel that emits the fossil carbon contained in the non-recycled plastics feedstock.'' (Benavides, Sun, Han, Dunn, & Wang, 2017).

A full LCA, including combustion, shows that the atmospheric emissions caused by the combustion of plastic fuels are very similar to those of conventional diesel. In other words, when measured correctly, plastic fuels ultimately result in a substantial increase of emissions to the atmosphere.

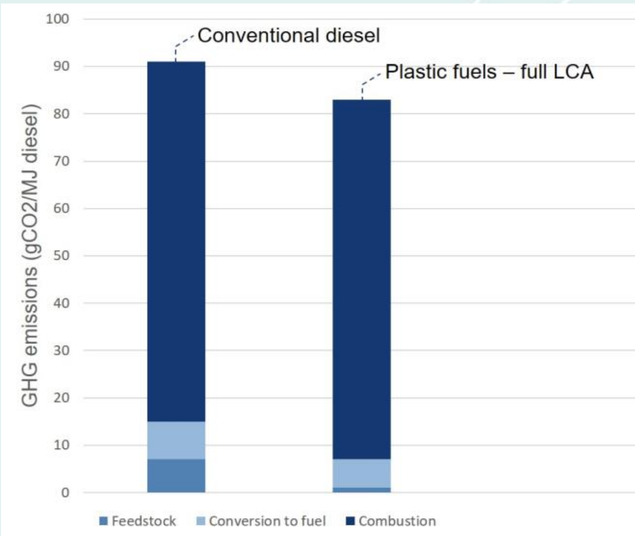

Figure 5: Comparison of full life-cycle GHG emissions of plastic fuels with fossil diesel, adapted from Benavides et al. 2017 (Benavides, Sun, Han, Dunn, & Wang, 2017)

6 The study compared the difference in GHG emissions between the petroleum ultra-low sulphur diesel and the ultra-low sulphur diesel produced via pyrolysis of non-recycled plastics. The analysis uses a well-to-wheel (cradle-to-grave) system boundary.

5 PARTIAL LCA DOES NOT ACCOUNT FOR 91% OF EMISSIONS TO THE ATMOSPHERE

Some proponents of plastic fuels advocate for a different approach to accounting. They claim that a partial lifecycle assessment can be justified with the premise that the input for the product would otherwise be unused.

Yet, the previous section of this briefing showed that the inputs that are the largest culprit behind the emissions of plastic fuels. In other words, the emissions caused by the burning of plastic fuels are the most significant contributor to the carbon footprint of the fuel while emissions from feedstock preparation and their conversion to fuel make up a smaller share of the final GHG footprint (1.2% and 7.23% respectively).

Notably, some assessments have taken this fossil carbon out of the equation to create the impression that plastic fuels have emissions significantly lower than fossil fuels. With the fossil input labelled as waste and the final fuel product consequently labelled carbon neutral, the only emissions associated with the fuel then come from processing (effectively a gate-to-gate LCA). By calling the input a waste/carbon neutral, the majority of the emissions associated with the product are not counted at all.

These partial LCAs do not reflect the fossil origin of the plastic going into the process and do not reflect the amount of CO2 emitted in reality.

Ignoring these embedded emissions in the plastics, means that approximately 91% of the CO2 released into the atmosphere is not accounted for.

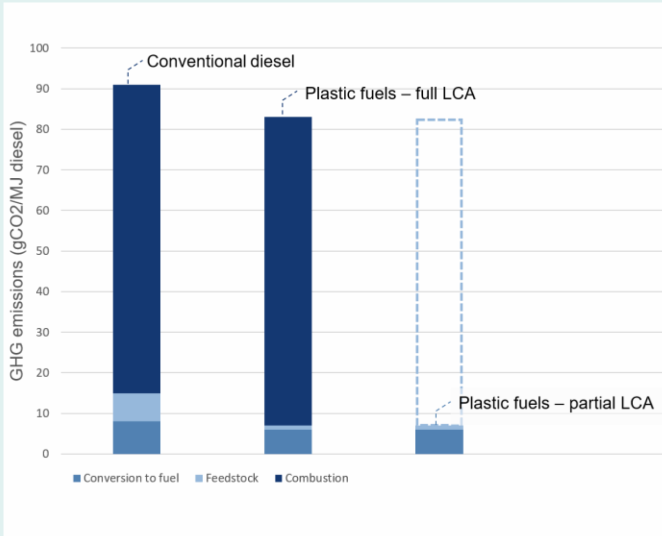

Figure 6: Not accounting for the combustion of plastic fuels leaves approximately 90% of the emissions related to the fuel unaccounted for. Adapted from Benavides et al. 2017 (Benavides, Sun, Han, Dunn, & Wang, 2017).

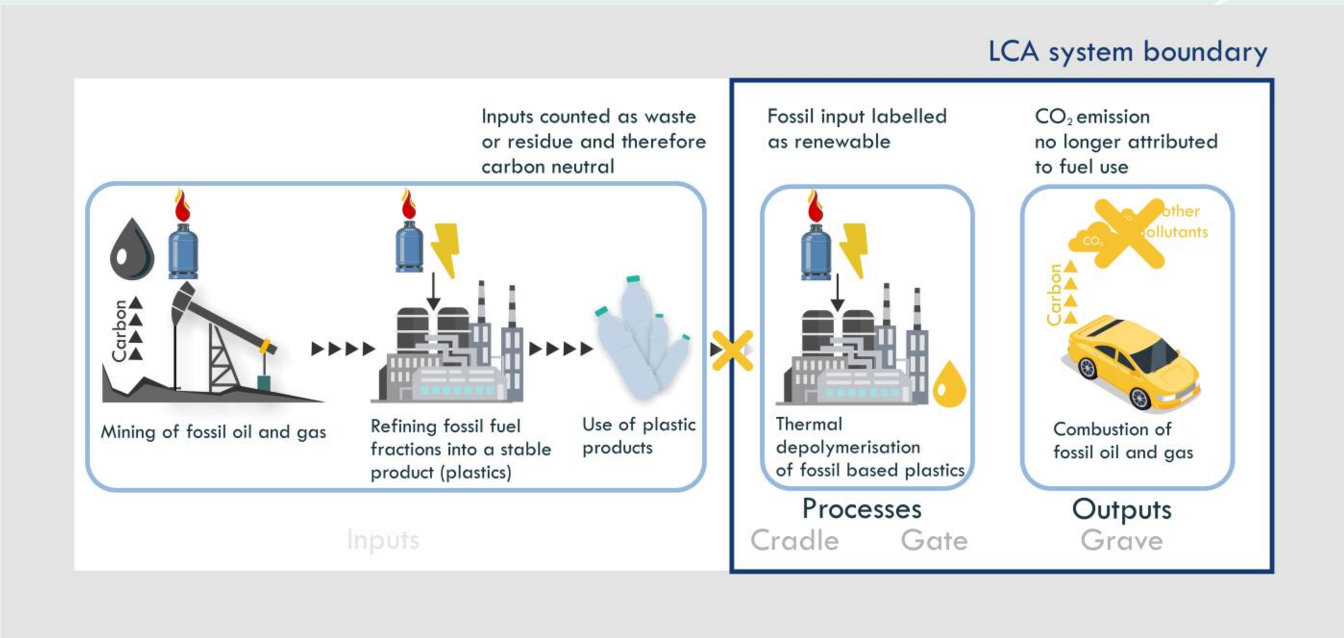

Figure 7: An example of a narrow LCA for plastic fuels: by labelling the input as waste, the carbon embedded in fossil plastic is labelled as carbon neutral.

5.1 PARTIAL LCA WOULD NOT REFLECT REAL-WORLD EMISSIONS: EXAMPLES

Some industries have claimed that their products provide a significant reduction in emissions when compared to conventional fossil fuels.

One plastic fuel producer claims a reduction of 75% GHG compared to traditional fossil fuels (Renew, 2019). Another plastic fuel manufacturer estimated a reduction in greenhouse gas emissions of 90% compared to conventional fossil fuel production (The Explorer, 2019). However, just as it was illustrated above in Figure 7, their LCA dismisses the emissions related or embedded into the input by declaring it waste. Their calculation is based on a certification mechanism which leaves out the inputs and labels them as carbon neutral (RSB, 2018). As a result, their assessment of the GHG impact of their fuels is misleading.

In the case of fossil plastic fuels, such reductions are not possible to achieve without either a restricted, narrow LCA boundary or allocation of emissions to some other product within the value chain.

In their research, Benavides et al. (2017) show that these fuels, when produced with fossil plastic waste, would result in an emission reduction in the range of 1-14% when compared to fossil fuels. To put this into perspective, other low-carbon fuels have to meet a threshold of 70% emission reductions compared to fossil fuels by 2021 (EC, 2018).

In LCA terms, a cradle-to-gate or gate-to-gate analysis will not account for the burning of fossil-based plastic fuels. This gives the false impression that the fuels are low carbon, when in fact they are produced from a fossil fuel feedstock and their production and use leads to significant additional emissions to the atmosphere.

5.2 OTHER REASONS TO STEER CLEAR FROM PLASTIC FUELS

Proponents of plastic fuels sometimes argue that these fuels will displace an equivalent amount of conventional fossil fuels from the system. This argument also comes up in discussions about accounting exercises, such as LCAs.

However, there is no scientific basis for the assumption that the equivalent amount of fossil fuels (as plastic fuels produced) will remain unused. The use of other alternative fuels and energy sources on a larger scale has shown that they do not necessarily displace oil imports or prevent the use of fossil fuels (Malça & Freire, 2011; York, 2012).

In other words, there has been no proof of correlation between the substantial displacement of fossil fuels and the production of 'alternative' drop-in fuels. On the contrary, their production sometimes causes adverse effects. For instance, biofuels have caused an increase in the supply of petroleum products, causing a decline in the fuel price by 1.07-1.1% and thus a 1.5-1.6.% increase in total global fuel consumption (Hochman, Rajagopal, & Zilberman, 2010).

Apart from causing adverse effects on the fuel market, plastic fuels would have a negative impact on the EU's circular economy targets. These targets aim to substantially reduce the non-recyclable feedstock that these fuels rely on (Council of the EU, 2019). **Supporting the conversion of fossil plastic to fuels would go against these goals and instead incentivise additional consumption of virgin plastics.**

The EU has established increasingly ambitious targets that tackle the issue of non-recyclable plastic waste at its source (Council of the EU, 2019). The current European Strategy for Plastics in a Circular Economy focuses on reuse and improved product design and penalises non-recyclable plastic products (EC, 2018).

CO_2

Consequently, plastic fuel plants will face an increasing scarcity of post-consumer non-recyclable plastic, making them even less profitable. The investments in plastic fuels productions sites would also cause a continuous demand for plastic, since the plants will have to operate in order to justify and pay off the initial expense.

For all these reasons, supporting plastic fuels would go against EU's current commitments outlined in the EU Action Plan for a circular economy and European Green Deal.

While it is out of the scope of the LCAs to account for such indirect effects of plastic fuels, there is a clear need for a full system perspective when it comes to their assessment.

6 WHY DO MANUFACTURERS WANT TO PRODUCE PLASTIC FUELS?

Plastic fuels might be labelled as a waste disposal solution, but in reality they are designed to support some of the most lucrative markets in the world; the petrochemical, oil and gas industries.

If fuels are produced from fossil plastic, these industries will continue to profit from 1) production and extraction of fossil crude oil and gas, 2) production of fossil-based polymers and 3) production of 'low-carbon' fuels.

Due to their limited scale and the competitive nature of the global oil market, these fuels will only supplement an already established fossil fuel system (Malça & Freire, 2011; Hochman, Rajagopal, & Zilberman, 2010). This will allow the oil and gas sector to continue business as usual and keep the global fossil fuel markets afloat.

The downstream segment of the oil and gas industry also benefits from the production of plastic fuels. The processing and refining industry, also referred to as the petrochemical industry, produces the main feedstock for the production of plastics. According to the IEA, plastics are a key demand driver for products of the petrochemical industry (IEA, 2018). A spike in demand for plastic waste would incentivise plastic production, thereby creating additional revenue streams for petrochemical refineries. Companies such as Shell and Saudi Aramco are already ''funnelling billions of dollars into petrochemical complexes as they bank on growing demand for the materials used to make items such as plastic packaging, washing detergent and home insulation'' (Financial Times, 2018). Ultimately, the fuel produced would be a drop-in fuel and would hence perpetuate a system of internal combustion engines and fossil fuel blending.

In a nutshell, fossil plastic fuels would not only perpetuate the use of fossil fuels and their derivatives, but they would stimulate their further uptake in the market.

Large oil and gas companies have already started looking into plastic fuels and are developing pilot projects (Shell, 2019). The industry has also invested substantial resources to influence EU policy making (CEO, Food & Water Europe, FoE Europe, & Greenpeace, 2019). By promoting plastic fuels through various channels, the oil, gas and petrochemical industries can continue extracting and releasing fossil carbon into the atmosphere without any economic or political consequences.

A partial LCA assessment of plastic fuels plays into such narratives since it omits major culprits of the GWP of plastic fuels. It is precisely due to this context that robust guidelines for a full LCA are needed.

7 RECOMMENDATIONS

A FULL LCA WOULD AVOID GREENWASHING OF PLASTIC FUELS

Developing a robust accounting system for the GWP of recycled carbon fuels will be a crucial part of the REDII and its implementation. With no time to spare and a looming climate crisis, establishing robust accounting rules is crucial to incentivising truly low-carbon alternatives.

RECOMMENDATIONS

- **In order to account for all emissions coming from plastic fuels, the LCA guidelines for the REDII delegated acts should account for all direct and indirect emissions from cradle-to-grave. This includes the fossil carbon embedded in the inputs for the fuels.**

- The embedded fossil carbon in plastic is the largest contributor to the final GWP of plastic fuels. Accordingly, **the 'cradle' stage of the LCA should include the extraction, refining and cracking process to include this fossil origin.**

- If plastic is treated as waste, there is a risk that both the plastic material and the transport fuel produced from it will be labelled as carbon neutral. **Measures should be taken to prevent such double counting of 'emission reductions' in the plastic and the transport sector.**

- Public policy LCAs must be put into the wider context of EU policy making and **adverse effects on other climate policies must be mitigated** (e.g. circular economy and waste prevention targets).

For more information on plastic fuels and the environmental impacts of plastic waste visit the following links:

1. On environmental criteria for recycled carbon fuels (the REDII fuel category including plastic fuels): https://zerowasteeurope.eu/wp-content/uploads/2019/04/NGO-joint-briefing-RCF.pdf
2. On chemical recycling: https://zerowasteeurope.eu/wp-content/uploads/edd/2019/08/2019_08_29_zwe_study_chemical_recycling.pdf
3. On the impact of plastics on the climate: https://www.ciel.org/wp-content/uploads/2019/05/Plastic-and-Climate-FINAL-2019.pdf

REFERENCES

- Benavides, P. T., Sun, P., Han, J., Dunn, J. B., & Wang, M. (2017, April 27). Life-cycle analysis of fuels from post-use non-recycled plastics. Fuel, pp. 11-22.
- Break Free From Plastic, & Heinrich Böll Stiftung. (2019). Plastic Atlas.
- CEO, Food&Water Europe, FoE Europe, & Greenpeace. (2019, October 24). Retrieved from Big Oil and gas buying influence in Brussels: With money and meetings, subsidies and sponsorships, the oil and gas lobby is fuelling the climate disaster: https://corporateeurope.org/sites/default/files/2019-10/FFP%20Briefing%20-%20Big%20Oil%20and%20Gas%20buying%20influence%20in%20Brussels%20-%20Oct%202019.pdf
- CIEL. (2019). Plastic & Climate: The Hidden Costs of a Plastic Planet.
- Council of the EU. (2019). Retrieved from Council adopts ban on single-use plastics: https://www.consilium.europa.eu/en/press/press-releases/2019/05/21/council-adopts-ban-on-single-use-plastics/
- EC. (2018, January 16). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS: A European Strategy for Plastics in a Circular Economy. Retrieved from https://eur-lex.europa.eu/resource.html?uri=cellar:2df5d1d2-fac7-11e7-b8f5-01aa75ed71a1.0001.02/DOC_1&format=PDF
- EC. (2018, December 11). DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the promotion of the use of energy from renewable sources. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=EN
- EC. (2019). Environment: Integrated Product Policy . Retrieved from European Platform on Life Cycle Assessment (LCA): https://ec.europa.eu/environment/ipp/lca.htm
- EC. (2019). European Platform on Life Cycle Assessment (LCA). Retrieved from Environment: https://ec.europa.eu/environment/ipp/lca.htm
- Ecochain. (2019). Life Cycle Assessment (LCA) – Complete Beginner's Guide. Retrieved from https://ecochain.com/knowledge/life-cycle-assessment-lca-guide/
- EEA. (1997). Life Cycle Assessment: A guide to approaches, experiences and information sources. Copenhagen: European Environment Agency.
- EPA. (2017, February 14). Greenhouse Gas Emissions. Retrieved from Understanding Global Warming Potentials: https://www.epa.gov/ghgemissions/understanding-global-warming-potentials
- ETC. (2018). Mission Possible: Sectoral Focus - Plastics. The Energy Transitions Commission.
- European Commission. (2018). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS: A European Strategy for Plastics in a Circular Economy.
- Financial Times. (2018, June 10). Retrieved from Oil groups stand by bets on out-of-favour plastics: https://www.ft.com/content/f986fa62-6c94-11e8-92d3-6c13e5c92914
- GAIA. (2017). WasteGasification & Pyrolysis: High Risk,Low Yield Processes for Waste Management.
- Garcia-Nunez, J., Pelaez-Semaniego, M., Garcia-Perez, M., Fonts, I., Abrego, J., Westerhof, R., & Garcia-Perez, M. (2017). Historical Developments of Pyrolysis Reactors: A Review. Energy&Fuels, 5751−5775.
- Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. Science Advances.
- GIZ. (2017). Waste-to-Energy Options in Municipal Solid Waste Management . Bonn: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.
- Heyne, S., Bokinge, P., & Nyström, I. (2019). Global production of bio-methane and synthetic fuels -. CIT Industriell Energi AB.
- Hochman, G., Rajagopal, D., & Zilberman, D. (2010). The Effect of Biofuels on Crude Oil Markets. AgBioForum, 112-118.
- IEA. (2018). Retrieved from The Future of Petrochemicals: https://www.iea.org/reports/the-future-of-petrochemicals
- IEA. (2018). The Future of Petrochemicals. OECD/IEA.

- IEA. (2018, December 7). The Future of Petrochemicals. Retrieved from EU Refining Forum: https://ec.europa.eu/energy/sites/ener/files/documents/iea-the_future_of_petrochemicals.pdf
- JRC ISPRA. (2019). Some methodology principles for quantifying GHG emissions savings under the Innovation Fund.
- Malça, J., & Freire, F. (2011). Uncertainty Analysis of the Life-Cycle Greenhouse Gas Emissions and Energy Renewability of Biofuels. In M. A. Bernardes, Environmental Impact of Biofuels. IntechOpen.
- Plastics Europe. (2019). Plastics Europe. Retrieved from How plastics are made: https://www.plasticseurope.org/en/about-plastics/what-are-plastics/how-plastics-are-made
- Polyplastics. (2019). Retrieved from Plastics step-by-step: https://www.polyplastics.com/en/pavilion/beginners/01-05.html
- Renew. (2019). Retrieved from Economic & Environmental Benefits: http://renewlogy.com/renew-energy/
- Rollinson, A. N., & Oladejo, J. M. (2019). 'Patented blunderings', efficiency awareness, and self-sustainability claims in the pyrolysis energy from waste sector. Resources, Conservation & Recycling, 233-242.
- RSB. (2018, December 7). Retrieved from RSB Standard for Advanced Products: https://rsb.org/wp-content/uploads/2018/12/18-12-11_RSB-STD-02-001-v2.0-RSB-Standard-for-Advanced-Products.pdf
- Scalenghe, R. (2018). Resource or waste? A perspective of plastics degradation in soil with a focus on end-of-life options. Heliyon.
- Shell. (2019, November 21). Retrieved from SHELL USES PLASTIC WASTE TO PRODUCE CHEMICALS: https://www.shell.com/business-customers/chemicals/media-releases/2019-media-releases/shell-uses-plastic-waste-to-produce-chemicals.html
- The Explorer. (2019). Retrieved from Giving harmful plastic waste a new life: https://www.theexplorer.no/solutions/giving-harmful-plastic-waste-a-new-life/
- Transport&Environment. (2015, March). Retrieved from Study: Reasons to change the zero-rated criteria for biomass in the EU ETS: https://www.transportenvironment.org/sites/te/files/publications/2015%2001%20biomass%20ets_rating_FINAL.pdf
- UBA. (2018). Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2018. Retrieved from National Inventory Report for the German Greenhouse Gas Inventory 1990 – 2016: https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2018-05-24_climate-change_13-2018_nir_2018_en.pdf
- UNEP. (2018). THE STATE OF PLASTICS: World Environment Day Outlook .
- World Economic Forum, Ellen MacArthur Foundation, & McKinsey & Company. (2016). The New Plastics Economy — Rethinking the future of plastics.
- York, R. (2012). Do alternative energy sources displace fossil fuels? Nature Climate Change, 441–443.
- Zero Waste Europe. (2019). El Dorado of Chemical Recycling: State of play and policy challenges.
- Zero Waste Europe, & Bellona. (2019). Retrieved from Joint briefing: Recycled Carbon Fuels in the Renewable Energy Directive: https://zerowasteeurope.eu/wp-content/uploads/2019/04/NGO-joint-briefing-RCF.pdf

CO_2

Rethink Plastic, part of the Break Free From Plastic movement, is an alliance of leading European NGOs, representing thousands of active groups, supporters and citizens in every EU Member State.

Bellona Europa is the Brussels-based branch of the Norwegian Bellona Foundation, an independent non-profit organisation working on the environmental, climate and social issues of our time. We aim to identify, promote and help implement realisable solutions for the protection of nature, the environment and health. To achieve these goals, Bellona continues to work with – and against – relevant actors and stakeholders.

Zero Waste Europe is the European network of communities, local leaders, businesses, experts, and change agents working towards the same vision: phasing out waste from our society. We empower communities to redesign their relationship with resources, to adopt smarter lifestyles and sustainable consumption patterns, and to think circular.

Zero Waste Europe gratefully acknowledges financial assistance from the European Union. The sole responsibility for the content of this event materials lies with Zero Waste Europe. It does not necessarily reflect the opinion of the funder mentioned above. The funder cannot be held responsible for any use that may be made of the information contained therein.

Grateful thanks to the Children's Investment Fund Foundation for supporting Bellona's work on industrial climate action.

ACKNOWLEDGEMENTS

Author: Ana Šerdoner
Reviewer: Janek Vahk
Editor: Eilidh Robb

Design: Blush

28th January 2020

FOR ADDITIONAL GUIDANCE AND MORE DETAILED RECOMMENDATIONS, PLEASE CONTACT:

Ana Šerdoner

Policy & Project Advisor at Bellona Europa aisbl

ana@bellona.org

Janek Vahk

Climate, Energy & Air Pollution Coordinator at Zero Waste Europe

janek@zerowasteeurope.eu

CO_2

CO_2

CO_2

CO_2

BELLONA

ZERO WASTE EUROPE

RETH!NK PLASTIC