METHODOLOGY

METHODOLOGY FOR COLLECTION OF SARGASSUM AND OTHER MACROALGAE TO AVOID EMISSIONS FROM DECOMPOSITION AND TO USE FOR BENEFICIAL PRODUCTS

SDG 13

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SUMMARY

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1| Definition

1.1.1 | For the purpose of this methodology, the following definitions apply

- Sargassum or other macroalgae: Sargassum is a genus of brown macroalgae in the order Fucales. Numerous species are distributed throughout the temperate and tropical oceans of the world, where they generally inhabit shallow water and coral reefs. Some species are free-floating and not connected to the sea floor, and thus float into shallow and beach areas, creating environmental and social problems along coastal areas. Macroalgae is a general term for thousands of species of seaweed and kelp. For the purposes of this methodology, collection of macroalgae is only eligible if, in the baseline scenario, the macroalgae would have been collected and treated as other solid waste and sent to a Solid Waste Disposal Site.
- Useful product: A product made from Sargassum or other waste macroalgae that has quantifiable value and can be sold into the commercial market. Examples can include but not be limited to fertilizer, bioplastics, emulsifiers and other cosmetic products.
- Processing facilities: The Sargassum or other macroalgae will be taken to a facility where it can be processed into useful products or converted to a material that would be transferred to another facility and used as a feedstock in the manufacturing of a useful product.
- Solid Waste Disposal Site (or Landfill): Designated areas intended as the final storage place for solid waste, including material diverted as a result of the project activity. Stockpiles are considered a SWDS if: (a) their volume to surface area ratio is 1.5 or larger; and if (b) a visual inspection by a validation/verification body confirms that the material is exposed to anaerobic conditions (i.e. it has a low porosity and is moist).

2| Scope, Applicability, and entry into force

2.1 | Scope

2.1.1 | This methodology is globally applicable to project activities that collect Sargassum or other waste macroalgae species that would otherwise be disposed in a landfill and processes this macroalgae into useful products. As a result, less waste is put into landfills and fewer methane emissions will take place from the baseline scenario. In addition, the products made from the waste macroalgae may also displace more carbon-intensive products, further reducing GHG emissions.

2.2 | Applicability

2.2.1 | This methodology is applicable under the following conditions:

2.2.1.1 | Sargassum or other macroalgae are present at such a level in the environment that they cause other problems, for example crowding out other native species, that the macroalgae's removal from near or on-shore areas is

the baseline practice. As a result, in the absence of the project activity, the macroalgae would be landfilled or stockpiled where the waste would decompose anaerobically and emit methane.

2.2.1.2 | The waste macroalgae is converted to a useful product.

2.2.1.3 | The methodology is applicable globally and can use any kind of macroalgae species, that meets the definition of waste macroalgae in Section 1.1.1 and that would, in the baseline scenario, be disposed in a Solid Waste Disposal Site. As such, simply harvesting any type of seaweed – or growing seaweed for the purpose of producing useful products – would not be eligible under this methodology and for the generation of carbon credits.

2.2.1.4 | The destination(s) of the waste macroalgae in the baseline scenario is/are known, and the data needed to determine the baseline methane emissions can be collected.

2.2.1.5 | The Sargassum or macroalgae processing facility shall demonstrate compliance with all applicable regional and national regulations.

2.2.1.6 | The Sargassum or macroalgae is collected on-shore or near-shore and not collected in the open ocean, defined as being outside the territorial waters of a specific country (12 nautical miles) under the UN Convention on the Law of the Sea.

2.2.1.7 | The processing facility shall store the sargassum in a manner and for a period of time that reduces or eliminates any potential for methane emissions to occur through anaerobic decomposition.

2.3 | Safeguards

2.3.1 | Safeguarding principles: Projects using this methodology shall adhere to most recent edition of the Safeguarding Principles and Requirements[1]. In particular, Principle 9 – Environment, ecology and land use – requires the project developer to ensure a precautionary approach to natural resource conservation and avoid negative environmental impacts. This includes:

- Sub-principle 9.1 – Landscape modification and soil. Projects that involve the production, harvesting, and/or management of living natural resources by small-scale landholders and/or local communities shall adopt the appropriate and culturally sensitive sustainable resource management practices.
- Sub-principle 9.5 – Hazardous and non-hazardous waste. Particular attention should be paid to avoiding or minimizing pollution and discharge of hazardous waste from the sargassum processing facility

[1] https://globalgoals.goldstandard.org/standards/103_V1.2_PAR_Safeguarding-Principles-Requirements.pdf

itself. For example, sargassum and other species of seaweed can accumulate toxins, such as arsenic. Project developers shall have a plan to avoid any such discharges to the environment and must demonstrate an ability to dispose of any hazardous waste in a safe and sustainable manner.

- Sub-principle 9.10 – High conservation value areas and critical habitats. While removal of a species that has become so dominant that it crowds out other species (thus having only positive effects), the project developer will need to consider any *negative* effects of removing Sargassum or other macroalgae from the ecosystem, including impacts on marine wildlife and biodiversity. The mitigation of negative impacts shall be done as per the local laws and regulations, and if no such regulations are yet in place then international standards shall be followed.

2.4 | Entry into force

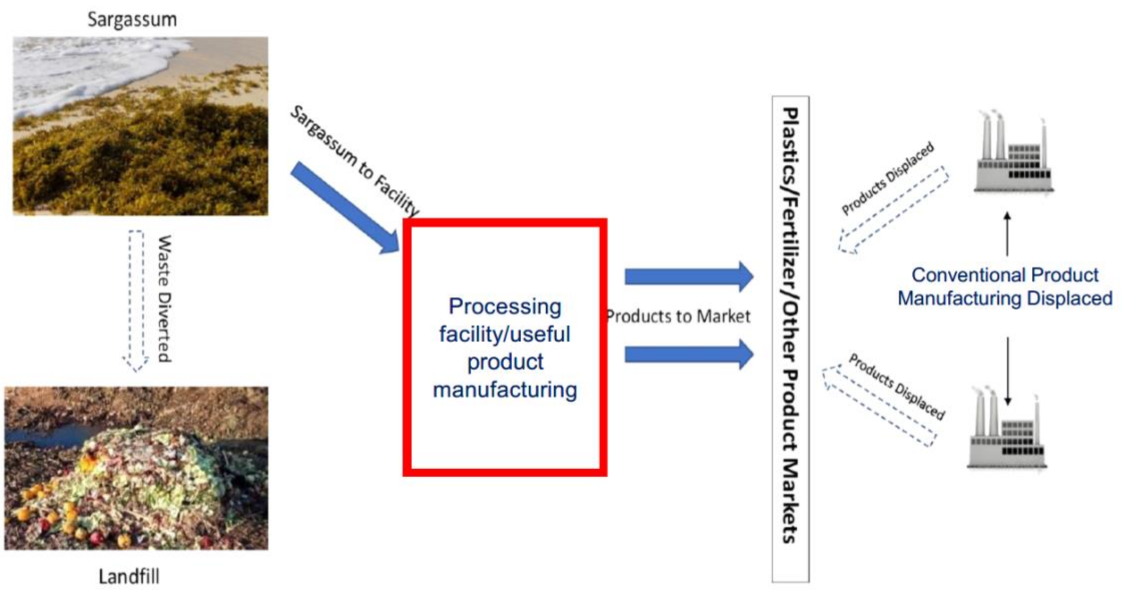
2.4.1 | The date of entry into force of this methodology is dd/mm/2023.

3| Baseline Methodology

3.1 | Project Boundary

3.1.1 | The project boundary includes:

- The physical area where Sargassum or macroalgae is collected, such as beach or near-shore area;
- Transport of sargassum from the collection point to the processing facility
- The facility that processes the Sargassum or macroalgae into a useful product or a feedstock for a useful product;
- The facility that uses the processed macroalgae as a feedstock to make a useful product.
- The location where the disposal of sargassum takes place in the absence of the project activity (eg: landfill).



3.2 | Emissions sources included in the project boundary

Table 1. Emissions sources included in or excluded from the project boundary

Source		Gas	Included?	Justification/Explanation
Baseline	Organic waste diversion	CO_2	No	Excluded due to emissions being neutral and part of the natural carbon cycle.
		CH_4	Yes	CH_4 is the main GHG emitted when sargassum and other macroalgae goes to landfill
		N_2O	No	Excluded for simplicity
		Other	No	N/A
	GHGs from traditional plastics and other product manufacturing	CO_2	Yes	The use and combustion of fossil fuels is the primary source of emissions from the traditional process of manufacturing more carbon intensive materials, including the refining of raw materials and process energy. Note: Transportation of useful products or (in the baseline) of more carbon-intensive materials is not considered in either the baseline or project case because it is assumed that under either scenario, conventional products or products would require similar means of transport.
		CH_4	No	Excluded for simplicity
		N_2O	No	Excluded for simplicity

Source		Gas	Included?	Justification/Explanation
		Other	No	N/A
Project	GHGs from the project facility and transportation from collection point to processing location (if relevant)	CO_2	Yes	Use of electricity and combusted fuels are the primary energy sources that would be used to power a facility processing the sargassum, as well as transportation of macroalgae from collection point to the processing facility (Section 3.7.6).
		CH_4	No	CH_4 emissions are assumed to be very small. The sargassum would be sent to a processing facility where it would be utilized in a short time frame. Thus, it can be assumed the sargassum will not be stored where there could be no oxygen and thus anaerobic decomposition.
		N_2O	No	N_2O emissions are assumed to be very small.
		Other	No	No other GHGs will be emitted
	GHGs from the release/disposal useful products at end of life	CO_2	No	Excluded due to emissions being neutral and part of the natural carbon cycle
		CH_4	No	CH_4 emissions are assumed to be very small
		N_2O	No	N_2O emissions are assumed to be very small.
		Other	No	No other GHGs will be emitted

3.3 | Demonstration of additionality

3.3.1 | As noted in Section 3.3.2, one of the standard additionality assessment tools can be used. When examining the barriers to implementing the activity, the project developer shall demonstrate that the project could not or would not take place without carbon finance. Possible reasons for the need for carbon finance may be that the initial investment or the on-going marketing, distribution, quality control, manufacturing and maintenance costs are unaffordable for the target population. Additional context can include but not be limited to:

- The entire area of Blue Carbon is very new, with very little seaweed (and Sargassum in particular) being harvested and virtually no production of products from seaweed-based feedstocks taking place. These alternative products tend to be more expensive, are produced at smaller scale and thus face many market barriers that the carbon finance can help overcome.
- Finance/Investment Barriers: The cost of seaweed-based products may be much greater than their conventional counterparts. There is also substantial capital expense required to establish the

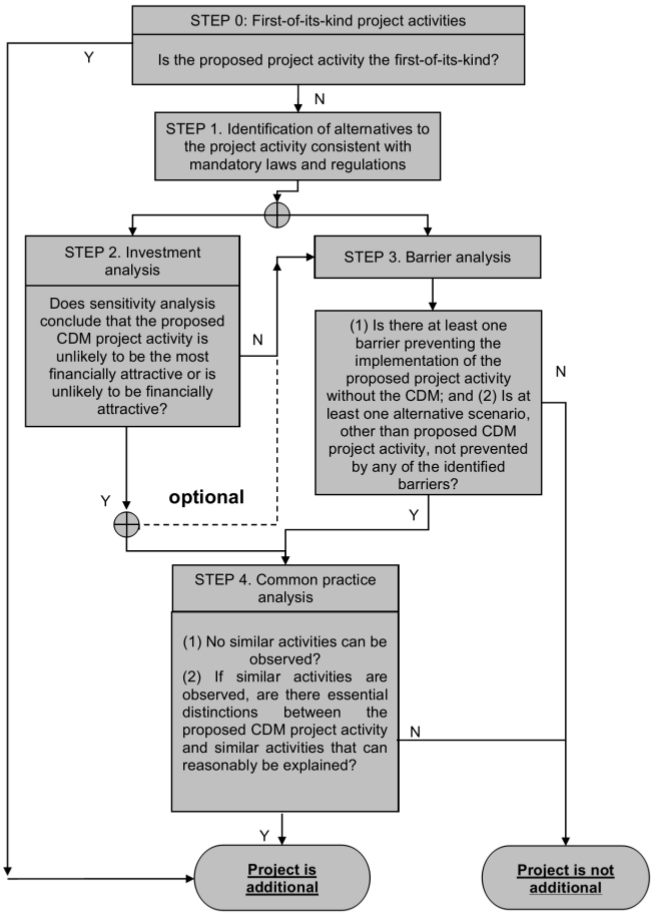
Sargassum/seaweed collection networks and the facilities required to process the macroalgae. Such up-front investment barriers can be alleviated though the additional revenue streams provided by carbon offsets.

- Common Practice: For the purposes of this methodology, the common practice test will be met by applying a benchmark of 20%. More specifically, project developers shall demonstrate through the indications of common practice cited below, that more than 80% of Sargassum or the target macroalgae in the region are disposed off in landfills or left to decompose in stockpiles. Project developers shall provide to the validation and verification body such evidence. At the time of the writing of this methodology, the level of project activity (the use of Sargassum for useful products) is essentially zero. Indications of common practice can include but not be limited to:
    - Records or attestations from waste haulers (or facilities impacted by Sargassum inundation, such as beachfront properties) confirming the prevalence of sending waste macroalgae to landfills;
    - Independent studies or research indicating both the lack of commercial use for waste macroalgae within the region or country as well as analysis of the scale of macroalgae disposal in landfills;
    - Independent market analysis on the lack of use of the particular species of macroalgae being collected in the production of useful products by the project developer.

3.3.2 | As noted above, the project developer shall demonstrate additionality by conforming to additionality requirements of one of the options below,

a. Applicable GS4GG Activity Requirements;

b. CDM Tool 01 - Tool for the Demonstration and Assessment of Additionality; the flowchart below offers a decision-tree when following this tool:



c. [CDM Tool 19- Demonstration of additionality of microscale project activities]; (not applicable to Gold Standard microscale projects)

d. [CDM Tool 21 – Demonstration of additionality of small-scale project activities]; (applicable to small-scale projects only)

e. An approved Gold Standard VER additionality tool

3.4 | Baseline scenario determination

3.4.1 | In the baseline scenario, it is assumed that the macroalgae would have been disposed off into a landfill. Project proponents will use the analysis in Section 3.5.1 to confirm this conclusion.

3.4.2 | Project developers will also need to either (a) ONLY collect sargassum that is known to be going to the landfill or (b) estimate what percentage of sargassum in a given area is left on the shore, buried or otherwise may go to a destination where the seaweed does not decompose under anaerobic conditions. In other words, project proponents will claim credits for the quantity of macroalgae that is known to be going to the landfill and decomposed under anaerobic conditions in the baseline scenario. For example, if 90% of sargassum in a given project boundary goes to landfill and 10% rots on the beach in low-lying piles (or goes to other uses), then a discount factor of 10% will be applied to the baseline emissions. The project developer may use surveys, independent assessments, attestations from waste haulers, government data or industry

analyses to determine the levels of Sargassum going to solid waste disposal sites.[2]

3.4.3 | Project developers may therefore be incentivized to ensure all sargassum collected would have definitively gone to a solid waste disposal site. A survey may be used for assessing both the overall destinations for 100% of the sargassum within the project boundary, as well as determining which sargassum would have definitely gone to the landfill. This could include, for example, collecting sargassum only from resorts or other beach areas that have contracts with waste haulers to take the macroalgae to landfill or even collecting sargassum near the entrance to the landfill. Project developers will have flexibility in how to make this determination (including providing documents or attestations from beach owners and waste haulers during verification as long as those entities have no commercial interest in the carbon offset project).

3.4.4 | The last consideration in the baseline scenario is the fact that fresh Sargassum and other macroalgae may have a higher methane generating potential than rotting Sargassum. If this is the case, project developers may elect to consider rotting and fresh Sargassum as separate waste types *j* in Section 3.6. When calculating baseline emissions, project proponents can consider different types of waste (j), which pertains, in this case, to different species of macroalgae. However, for the purposes of this methodology, a different waste type can be assigned to rotting and fresh macroalgae which would, for example, require different analyses of methane generating potential (eg: parameter BMP_j).

3.4.5 | In determining the baseline scenario, project proponents shall take into account any polices and measures that contribute to the host country's Nationally Determined Contributions (NDCs), as well as any specific legislation or policy regarding participation in the Paris Agreement's Article 6.2/6.4 mechanisms. For example, if the diversion of sargassum from landfills is part of the host country's national efforts to reduce emissions as part of its NDC, the project activity itself could be considered the baseline.

3.5 | Selection and justification of the baseline scenario

3.5.1 | Prior to any project using this methodology, the project proponents shall use CDM modality 48(a) – *the existing actual or historical emissions, as applicable*. When developing a new project using this methodology, project developers shall outline potential other baseline scenarios, including but not limited to:

[2] Note that sargassum may be replaced with other macroalgae throughout a crediting period because the methodology is not limited to sargassum. However, the project would have to meet all other requirements of the methodology.

- Undertaking the proposed project without the benefit of carbon finance;
- Having the Sargassum or other macroalgae simply rot or decompose in place but in piles small enough not to decompose anaerobically;
- An alternative commercial use for the macroalgae that would cause the waste to be diverted from a solid waste disposal site without the benefit of carbon finance.

3.5.2 | Project proponents shall assess these scenarios and provide analysis, as well as appropriate evidences, to show that the baseline scenario – disposal in a solid waste disposal site in an anaerobic condition – is the most likely of these scenarios when considering cost, technology development, local laws and other factors.

3.6 | Baseline Emissions

3.6.1 | Baseline emissions are divided into two components: (1) the avoided methane emissions from the diversion of Sargassum or other waste macroalgae that would have been sent to a solid waste disposal site (SWDS) in the absence of this project activity; and (2) the displacement of more carbon-intensive products by the (same) useful products brought to market by the project.

3.6.2 | Baseline emissions from Component 1 is based on the CDM TOOL 4, *Emissions from Solid Waste Disposal Sites*, which calculates avoided methane based on the first order decay (FOD) model. The model differentiates between the different types of waste j with respective constant decay rates (k_j) and fractions of degradable organic carbon (DOC_j). The model calculates the methane generation occurring in year y on the waste streams of waste types j ($W_{j,x}$) disposed in the SWDS over a specified time period (years).

3.6.3 | In cases where at the SWDS methane is captured (e.g. due to safety regulations) and flared, combusted or used in another manner that prevents emissions of methane to the atmosphere, the emissions are adjusted for the fraction of methane captured (fy).

3.6.4 | Baseline Emissions in year y (BE_y) are calculated as follows

$$BE_y = BE_{AM,y} + BE_{PD,y}$$

Where *Eq. 1*

$BE_{AM,y}$	=	Baseline emissions from Component 1, avoided methane, in year y (tCO2eq)
$BE_{PD,y}$	=	Baseline emissions from Component 2, product displacement, in year y (tCO2eq)

3.6.5 | Baseline emissions for Component 1 are calculated as follows[3]:

$BE_{AM,y}$ =

$$\varphi_y \times (1 - f_y) \times GWP_{CH4} \times (1 - OX) \times \frac{16}{12} \times F \times DOC_{f,y}$$

$$\times MCF_y \times \sum_{x=1}^{y} \sum_{j} \left(W_{j,x} \times DOC_j \times e^{-k_j \times (y-x)} \times \left(1 - e^{-k_j}\right) \right)$$

Eq. 2

Where:

X	=	Years in the time period in which waste is disposed at the SWDS, extending from the first year in the time period (*x* = 1) to year *y* (*x* = *y*)
Y	=	Year of the crediting period for which methane emissions are calculated
$DOC_{f,y}$	=	Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year *y* (weight fraction)
$W_{j,x}$	=	Amount of Sargassum or waste macroalgae type *j* prevented from disposal in the SWDS in the year *x* (t)
φ_y	=	Model correction factor to account for model uncertainties for year *y*
f_y	=	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year *y*
GWP_{CH4}	=	Global Warming Potential of methane
OX		Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
F		Fraction of methane in the SWDS gas (volume fraction)
MCF_y		Methane correction factor for year *y*
DOC_j		Fraction of degradable organic carbon in the Sargassum or waste macroalgae type *j* (weight fraction)
k		Decay rate for the waste type *j* (1 / yr)
j		Type of Sargassum or waste macroalgae

Many of the variables listed in Equation 1 can use defaults as described below. There are two – the methane correction factor (MCF) and degradable organic

[3] Note that project developers may use CDM TOOL4 to accommodate future changes in the Tool without needing any adjustment in this methodology.

content (DOC_f) which have additional calculation procedures if project developers do not wish to use a default. These are outlined below:

$$DOC_{f,y} = DOC_{f,m} = 0.7 \times \frac{12}{16} \times \frac{BMP_j}{F \times DOC_j}$$

Eq. 3

Where:

$DOC_{f,y}$ = Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year *y* (weight fraction)

$DOC_{f,m}$ = Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for month *m* (weight fraction)

BMP_j = Biochemical methane potential for the residual waste type *j* disposed or prevented from disposal (t CH4/t waste)

F = Fraction of methane in the SWDS gas (volume fraction)

DOC_j = Fraction of degradable organic carbon in the waste type *j* (weight fraction)

j = Residual waste type applied to the tool

For methane correction factor, in cases where the water table is above the bottom of the SWDS (for example, due to using waste to fill inland water bodies, such as ponds, rivers or wetlands), the MCF should be determined as follows:

$$MCF_y = MAX\left\{\left(1 - \frac{2}{d_y}\right), \frac{h_{w,y}}{d_y}\right\}$$

Eq. 4

Where:

MCF_y	= Methane correction factor for year y
$h_{w,y}$	= Height of water table from the base of the SWDS (m)
d_y	= Depth of SWDS (m)

3.6.6 | Baseline emissions for Component 2 are calculated according to the formula below. Note that in Version 1 of this methodology, the primary displaced product is conventional plastic materials (see Appendix I). The Sargassum or other macroalgae used as a feedstock in this example are used for products

that displace petroleum-based plastics, including packaging, boxes and other end-uses.[4]

It should also be noted that project developers will need to track to which countries the sustainably-produced products are going. In other words, if the Sargassum is collected in one country, the products made from the Sargassum may be exported to another, and the displacement of emissions takes place in the second country. Thus, the displacement emissions factor for each type of plastic should reflect the emissions associated with that plastic type in the destination country. If the products go to multiple countries, the parameter below representing the emissions factor of the displaced product ($EF_{DP,i}$) must be calculated for each country according to the percentage of product exported to each country (eg: 30% to Country A, 50% to Country B, 20% to Country C). Alternatively, the project developer may use an $EF_{DP,i}$ factor from one country, but evidence shall be provided to the validator/verifier that the one factor is the lowest and thus most conservative.

$$BE_{PD,y} = \sum_i (Q_{DP,i,y} * EF_{DP,i})$$

Eq. 5

Where

$Q_{DP,i,y}$	= Quantity of useful product *i* produced that displace other products in year y (metric tons)
$EF_{DP,i}$	= Emissions factor of the displaced product (DP) *i* in year y (tCO2eq/metric ton of displaced products manufactured)

3.7 | Project emissions

3.7.1 | Project Emissions occur primarily from the emissions generated by the facilities that either treat and process the Sargassum or macroalgae or use the processed material as a feedstock for a final useful product. This last point is only relevant if these two steps in the process – macroalgae processing and final product manufacturing – are separated. These emissions are caused by the use of electricity and fossil fuels at these processing facilities.

3.7.2 | Project emissions in year y (PE_y) can be calculated as follows:

$$PE_y = PE_{elec,y} + PE_{ffc,y} + PE_{DG,y} + PE_{Trans,y}$$

[4] While Version 1 includes only plastics, project proponents can propose other products to be displaced with macroalgae-based products through an amendment to Gold Standard. Such amendment proposals shall have very clear and detailed data – relevant to the country where the project is located – on the emissions associated with producing that product (see example in Appendix of plastic materials).

Eq. 6

Where:

$PE_{elec,y}$	=	Project emissions from the use of electricity at the processing facilities in year y (tCO2eq)
$PE_{ffc,y}$	=	Project emissions from fossil fuel combustion at the processing facilities in year y (tCO2eq)
$PE_{DG,y}$	=	Project emissions from the gradual degradation of the final products (tCO2eq). End of life degradation would only be a concern for products that might decompose anaerobically, thus re-releasing methane. If a product would be used only in aerobic environments (eg: biostimulants) or would definitely non-biodegradable (which can be demonstrated to a verifier), end-of-life considerations would not be a factor. For products that could conceivably end up in a landfill, 100% bio-based plastic replacement products for example, it can be considered unlikely that methane would be re-emitted in any significant quantities, when one considers municipal waste streams include composting, incineration, etc. This can generally be assumed to be the case for other products like biofuels, non-degradable plastics and agriculture or food products. In these cases, this parameter does not have to be calculated, but sufficient evidence should be provided to the validation/verification body. In other cases, project developers should present to the validator the range of products that would be produced by the project activity and if a substantial amount of biodegradable materials could conceivably end up in a landfill, then appropriate discounts should be applied. For example, if a project is producing 100,000 tons of clearly biodegradable products and 5% of those products could conceivably end up in a landfill, then the project developer should take a 5% discount off the baseline emissions.
$PE_{Trans,y}$	=	Project Emissions from the transport of the sargassum from the collection point to the processing facility (tCO2eq)

3.7.3 | Project emissions from electricity use at the processing facility(ies) are calculated as follows[5]:

[5] Project proponents may also use the CDM tools: *Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation* or *Tool to calculate the emission factor for an electricity system*

$$PE_{elec,y} = Q_{elec,y} \times EF_{elec} \times (1 + TDL_{elec})$$

Eq. 7

$Q_{elec,y}$	=	Quantity of electricity used at the processing facility or facilities in year y (MWh)
EF_{elec}	=	Emissions factor of the electricity (tCO_2/MWh)
TDL_{elec}	=	Transmission and distribution losses associated with the electricity use if coming from the grid (%)

3.7.4 | Project emissions from the use of fossil fuels at the processing facility(ies) are calculated as follows[6]:

$$PE_{ffc,y} = \sum_f Q_{f,y} \times NCV_f \times EF_f$$

Eq. 8

$Q_{f,y}$	=	Quantity of fossil fuel *f* combusted at the facility or facilities in year y
NCV_f	=	Net calorific value of fossil fuel *f* (TJ/fuel units)
EF_f	=	Emission factor of fossil fuel *f* (tCO_2/TJ)

3.7.5 | Project emissions from the gradual degradation of the final products

$$PE_{DG,y} = \sum_i Q_{DP,i,y} \times R_{CO_2 released,i}$$

Eq. 9

$Q_{DP,i,y}$	=	Quantity of useful product *i* produced that displace other products in year y (metric tons) and which are expected to decompose over time (metric tons). Note this may not be 100% of all production of product *i.*
$R_{CO_2 released,i}$	=	Ratio of CO_2 released relative to mass of product *i* (tCO_2 emitted per ton of final product). To be determined based on the chemical composition of product *i*, provided to the validation/verification body.

3.7.6 | Project emissions from the transportation of sargassum from the collection point to the processing facility

In the vast majority of cases, the sargassum processing facility would be close to the source of the sargassum, and below certain limits, the emissions associated with transporting the sargassum can be considered *de minimis*. If the total amount of sargassum collected in a year is transported no more than

[6] Project proponents may also be able to use the CDM's *Tool to calculate project or leakage CO2 emissions from fossil fuel combustion*

200 km, transportation emissions would not have to be considered. In cases where large amounts of sargassum is shipped somewhere else, project developers can use a tonne-mile accounting system. Project proponents shall provide an ex-ante analysis in the PDD of whether this parameter will need to be monitored based on where the macroalgae is being collected and where it will be processed.

A tonne-mile is the unit that describes one tonne of a product being shipped one mile (or kilometer). Thus, if 500 tonnes of sargassum is shipped 300 miles, that would be 150,000 tonne miles. The number could be multiplied by default emission factors, which are published by the US EPA Climate Leaders program based on the specific mode of transport as indicated in the table below. Note that the original EPA data was in tonne-miles, but this project will use tonne-kilometers, with the conversion provided.

Transport Mode	Emissions in mtC02/tonne-mile	Emissions in mtC02/tonne-km
Rail	0.0000231	0.0000143
Waterborne	0.000044	0.000027
Truck	0.00023	0.00014
Air	0.00139	0.00086

Source: EPA Climate Leaders

$$PE_{Trans,y} = W_{j,x} \times D_{,y} \times EF_{Trans}$$

Eq. 10

$D_{,y}$	=	Distance the sargassum or microalgae travels in year y to get from the collection point to the processing facility (km)
EF_{Trans}	=	Default emissions factor as indicated in the table above (mtC02/tonne-mile or converted to km).

3.8 | Leakage emissions

3.8.1 | No material source of leakage emissions have been identified from this project activity.

3.9 | Emission reductions

3.9.1 | The emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \quad \text{Eq. 11}$$

Where:

ER_y	=	Emission reductions in year y (t CO_2e/yr)
BE_y	=	Baseline emissions in year y (t CO_2e/yr)
PE_y	=	Project emissions in year y (t CO_2e/yr)
LE_y	=	Leakage emissions in year y (t CO_2e/yr)

3.10 | Changes required for methodology implementation in 2nd and 3rd crediting periods

3.10.1 | When the project developers apply for crediting period renewal, the baseline situation with regards to sargassum disposal and emission factor for production of useful products (e.g. plastics) shall be reassessed, in addition to other relevant methodological parameters as per the latest version of the methodology available at the time submission of renewal of crediting period.

3.11 | General requirements for data and information sources

3.11.1 | In the following tables of data and parameters monitored and not monitored, there are cases where a variety of source documents or studies may be applied to determine a parameter, or to cross-check a parameter.

3.11.2 | When multiple sources are available and fulfill the requirements for defining or cross-checking a parameter, the most relevant source should be chosen. Criteria for relevance include geographical (e.g. more specific to the project boundary location), temporal (e.g. more recent) and others. The VVB shall assess the relevance of the source applied compared to the other sources available. While conservativeness is a guiding principle for selecting data, the source applied to define or cross-check the parameter may not be the most conservative, if it can be shown to be the most relevant.

3.12 | Data and parameters not monitored

3.12.1 |

Parameter ID	**MAU 1**
Data/Parameter:	F
Data unit:	-
Description:	Fraction of methane in the SWDS gas (volume fraction)
Source of data:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories and to the extent there are any relevant parameters, the IPCC 2019 refinements should be used as appropriate.
Any comment:	Value to be applied: 0.5. Upon biodegradation, organic material is converted to a mixture of methane and carbon dioxide

Parameter ID	MAU 2
Data/Parameter:	OX
Data unit:	-
Description:	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Source of data:	Based on an extensive review of published literature on this subject, including the IPCC 2006 Guidelines for National Greenhouse Gas Inventories/2019 IPCC Refinements
Any comment:	Value to be applied: 0.1

Parameter ID	MAU 3
Data/Parameter:	φ_y
Data unit:	-
Description:	Default value for the model correction factor to account for model uncertainties
Source of data:	CDM TOOL 4
Any comment:	For Humid or Wet Conditions: 0.85; for Dry Conditions: 0.80

Parameter ID	MAU 4
Data/Parameter:	$MCF_{Default}$
Data unit:	-
Description:	Methane Correction Factor
Source of data:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Any comment:	In case that the SWDS does not have a water table above the bottom of the SWDS then select the applicable value from the following: (a) 1.0 for anaerobic managed solid waste disposal sites. These must have controlled placement of waste (i.e. waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) levelling of the waste; (b) 0.5 for semi-aerobic managed solid waste disposal sites. These must have controlled placement of waste and will include all of the following structures for introducing air to the waste layers: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating pondage; and (iv) gas ventilation system;

	(c) 0.8 for unmanaged solid waste disposal sites – deep. This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of greater than or equal to 5 meters; (d) 0.4 for unmanaged-shallow solid waste disposal sites or stockpiles that are considered SWDS. This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of less than five meters. This includes stockpiles of solid waste that are considered SWDS (according to the definition given for a SWDS). MCF accounts for the fact that unmanaged SWDS produce less methane from a given amount of waste than managed SWDS, because a larger fraction of waste decomposes aerobically in the top layers of unmanaged SWDS. In case of a water table above the bottom of the SWDS, a larger proportion of the SWDS is anaerobic and MCF shall be calculated using data on the height of the water table.

Parameter ID	**MAU 5**
Data/Parameter:	$DOC_{f,default}$
Data unit:	-
Description:	Default value for the fraction of degradable organic carbon (DOC) in MSW that decomposes in the SWDS
Source of data:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories/2019 IPCC Refinements
Any comment:	Value to be applied: 0.5. This factor reflects the fact that some degradable organic carbon does not degrade, or degrades very slowly, in the SWDS. Project developers can also estimate DOC on a yearly basis

Parameter ID	**XXX 6**
Data/Parameter:	DOC_j
Data unit:	-
Description:	Fraction of degradable organic carbon in the waste type *j* (weight fraction)
Source of data:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)

Any comment:	Project developers can equate the Sargassum or other macroalgae to the defaults provided below, with justification provided to the verifier.

Default values for DOC_j

Waste type *j*	***DOC_j* (% wet waste)**
Wood and wood products	43
Pulp, paper and cardboard (other than sludge)	40
Food, food waste, beverages and tobacco (other than sludge)	15
Textiles	24
Garden, yard and park waste	20

If the waste type cannot clearly be described as a combination of waste types in the table above or if a default value is not available or if the project participants wish to measure *DOCj,* then project participants should measure *DOCj* in an ignition loss test according to the procedure in EN 15169 or similar national or international standards. This measurement is only required once at the start of each crediting period, for each waste type *j* and the value determined for *DOCj* remains valid during the crediting period.

Parameter ID	**MAU 7**
Data/Parameter:	k_j
Data unit:	1/yr
Description:	Decay rate for the waste type *j*
Source of data:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)
Any comment:	Project developers shall equate the Sargassum or other macroalgae to the defaults provided below, with justification provided to the verifier. Note that Sargassum generally starts to decay very rapidly once it’s out of the water (or suffocated near land). Decay study have demonstrated significant sugar conversion within 12 hours of beaching. The project developer would decide on the appropriate classification and provide justification to the validation/verification body. If such a classification cannot be made with certainty, then the project developer will follow the guidance provided at the end of this table.

Default values for the decay rate (k_j)

Waste type *j*		Boreal and Temperate (MAT≤20°C)		Tropical (MAT>20°C)	
		Dry (MAP/PET <1)	Wet (MAP/PET >1)	Dry (MAP< 1000mm)	Wet (MAP > 1000 mm)
Slowly degrading	Pulp, paper, cardboard (other than sludge), textiles	0.04	0.06	0.045	0.07
	Wood, wood products and straw	0.02	0.03	0.025	0.035
Moderately degrading	Other (non-food) organic putrescible garden and park waste	0.05	0.10	0.065	0.17
Rapidly degrading	Food, food waste, sewage sludge, beverages and tobacco	0.06	0.185	0.085	0.40

Note: MAT – mean annual temperature, MAP – Mean annual precipitation, PET – potential evapotranspiration. MAP/PET is the ratio between the mean annual precipitation and the potential evapotranspiration.

If a waste type disposed in a SWDS cannot clearly be attributed to one of the waste types in the table above, project participants should choose, among the waste types that have similar characteristics, the waste type where the values of *DOCj* and *kj* result in a conservative estimate (lowest emissions), or request a revision of/deviation from this methodology.

Parameter ID	**MAU 8**
Data/Parameter:	BMP_j
Data unit:	t CH4/t waste
Description:	Biochemical methane potential (BMP) of waste type *j* disposed or prevented from disposal

Source of data:	Samples
Any comment:	Conduct a fermentation test on a sample of the MSW or the residual waste that is at least 500 g in weight. The test should be undertaken according to a national or international standard, which may need to be adapted to conduct the test on a sample that is 500 g or more in weight. The duration of the fermentation test should be until no further methane is generated (indicating the complete conversion of BMP to methane). Take the average of at least three test results. Once calculated, the value determined is valid during the crediting period The BMP is the basis of estimating *DOCf,y* and *DOCf,m* which describes the fraction of DOC that degrades under the specific conditions occurring in the SWDS (for example the moisture, temperature and salt content of the SWDS.

Parameter ID	**MAU 9**
Data/Parameter:	EF_y
Data unit:	tCO2/TJ
Description:	Emission factor of fossil fuel *f*
Source of data:	Any of the following sources may be applied: - IPCC defaults - Fuel-specific value from invoice / fuel supplier - National defaults
Any comment:	To determine the emission intensity of any fossil fuels used at the Sargassum/macroalgae processing or final product processing facilities

Parameter ID	**MAU 20**
Data/Parameter:	EF_{elec}
Data unit:	tCO2/kWh
Description:	Emission factor associated with the electricity use
Source of data:	Determined by applying CDM Tool 05, “Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation” or CDM Tool 07 “Tool to calculate the emission factor for an electricity system”
Any comment:	

Parameter ID	**MAU 31**
Data/Parameter:	TDL_{elec}
Data unit:	%
Description:	Transmission and distribution losses associated with the electricity use
Source of data:	To be based on data as obtained from national, regional or local authorities, not more than 3 years old
Any comment:	

Parameter ID	**MAU 42**
Data/Parameter:	$R_{CO2released}$
Data unit:	Ratio
Description:	Ratio of CO2 released relative to the quantity of final product (tCO2 emitted per ton of final product).
Source of data:	Provided by the project proponent; to be determined based on the chemical composition of the product, provided to the verifier.
Any comment:	Project developers shall apply specific standardized tests that determine the degradability of the product and the CO2 that would be released. For example, the ISO has published standard tests for biodegradability and carbon mass balance that apply to: • Natural and/or synthetic polymers and copolymers, and mixtures of these; • Plastic materials that contain additives such as plasticizers and colorants; • Water-soluble polymers; • Materials that, under test conditions, do not inhibit the activities of microorganisms present in the inoculum. All consumer products should be tested by independent laboratories for aerobic biodegradability using the methods described in ISO 14851:2019 for natural aqueous biodegradability and ISO 14852:2021 for ultimate biodegradability in an aqueous environment. In both methods project developers can use the optional carbon balance annex (E and C respectively). This test reports shall be provided to the validation/verification body upon request and for each useful product generated by the project activity. In a theoretical example, if a product is 50% carbon by weight or 500kg/ton, biodegrability and carbon balance could assess that releases of 500 kg of CO2/ton would take place with the remainder as microbial mass. That would mean the losses were 500/2.66 or 187kg of carbon from the original mass or 37% of carbon in the material.

Parameter ID	MAU 53
Data/Parameter:	$EF_{DP,i}$
Data unit:	tCO2eq/ton of displaced product produced
Description:	Emissions factor of the displaced product (DP) *i* in year y
Source of data:	Project proponent and third-party data – see Appendix 1 for the example of petroleum-based plastics. When the displacement of plastic is taking place outside the US, project developers must use third-party, independent data (similar to EPA and its Waste Reduction Model) to determine the EF for each type of displaced plastic. Alternatively, project proponents can use the process for eligible plastic types listed in AMS III.A.J to determine the emissions associated with displacement of conventional plastic production.
Any comment:	While Version 1 of this methodology includes only plastics, project proponents can propose other products to be displaced with macroalgae-based products through an amendment to Gold Standard. Such amendment proposals should have very clear and detailed data – relevant to the country where the project is located – on the emissions associated with producing that product.

4| Monitoring methodology

4.1 | Data and parameters monitored

Parameter ID	MAU 14
Data/Parameter:	W_x
Data unit:	Metric tons
Description:	Total amount of sargassum or waste macroalgae collected and thus diverted from an SWDS
Source of data:	Project participants. To the extent appropriate, the project participant may get data from waste haulers as well as obtain any data that would need to be discount the quantity of saragassum that would have gone to landfill, as outlined in Section 3.4.2. For example, if not 100% of sargassum is being collected, discount factors may have to be applied, and the sources for that data may be surveys, independent assessments, attestations from waste haulers, government data or industry analyses.
Monitoring frequency:	Continuous, must be weighed on a wet basis

QA/QC procedures:	Measurement devices – scales – must be calibrated in accordance with manufacturers specifications with the calibration reports provided to the verifier.
Any comment:	Project developer should provide analysis for what percentage of Sargassum collected would have otherwise gone to a landfill, as outlined in Section 3.4.2

Parameter ID	**MAU 15**
Data/Parameter:	f_y
Data unit:	%
Description:	Fraction of methane captured at the SWDS and flared, combusted or used in another manner that prevents the emissions of methane to the atmosphere in year *y*
Source of data:	Landfill: Select the maximum value from the following: (a) contract or regulation requirements specifying the amount of methane that must be destroyed/used (if available) and (b) historic data on the amount captured. For (b), three years of data should be obtained but one year can be sufficient if three years of data is not available. Project developer shall justify to the validator the non-availability of 3 years and suitability of one year of data in this case.
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Parameter ID	**MAU 16**
Data/Parameter:	d_y
Data unit:	M
Description:	Depth of the SWDS
Source of data:	Project participants and SWDS operator
Monitoring frequency:	Monitoring well that is also used to measure the height of the water table
QA/QC procedures:	
Any comment:	This parameter needs to be monitored to identify whether the SWDS has a water table above the bottom of the SWDS, such as due to using waste to fill inland water bodies, such as ponds, rivers or wetlands. If the SWDS does have a water table above the bottom of the SWDS, then this parameter is used to determine the MCF

Parameter ID	MAU 17
Data/Parameter:	$h_{w,y}$
Data unit:	m
Description:	Height of the water table in the SWDS
Source of data:	Project participants and SWDS operator
Monitoring frequency:	Annual
QA/QC procedures:	Monitoring well
Any comment:	This parameter needs to be monitored to identify whether the SWDS has a water table above the bottom of the SWDS, such as due to using waste to fill inland water bodies, such as ponds, rivers or wetlands. If the SWDS does have a water table above the bottom of the SWDS, then this parameter is used to determine the MCF.

Parameter ID	MAU 18
Data/Parameter:	$Q_{f,y}$
Data unit:	mass or volume units (e.g. kg, Litres, standard m^3)
Description:	Quantity of fossil fuel *f* combusted at the facility or facilities in year y
Source of data:	Project Proponents, using: - Direct measurement with meter, scales - Taken from fuel invoice or purchase receipt
Monitoring frequency:	Continuous
QA/QC procedures:	Use calibrated flow or gas meters. Or use gas utility bills and/or supply records and receipts from other fuel suppliers (eg: diesel). Calibration must be conducted according to the equipment manufacturer's specifications. All bills/records to be archived in central database and made available to the verifier.
Any comment:	

Parameter ID	MAU 19
Data/Parameter:	$Q_{elec,y}$
Data unit:	MWH
Description:	Quantity of electricity used at the processing facility or facilities in year y
Source of data:	Project proponents, backed up by data from the electric utility
Monitoring frequency:	Continuous or based on monthly utility bills
QA/QC procedures:	Use calibrated electricity meters or utility bills. Calibration must be conducted according to the equipment manufacturer's specifications. Alternatively, utility billing data can be used.

Any comment:	All bills/records to be archived in central database and made available to the verifier.

Parameter ID	MAU 60
Data/Parameter:	$Q_{DP,i,y}$
Data unit:	metric tons
Description:	Quantity of useful product *i* produced that displace other products in year y
Source of data:	Project proponents based on weights from scales
Monitoring frequency:	Continuous
QA/QC procedures:	All measurement devices will be calibrated in accordance with the manufacturers specifications and calibration reports provided to the verifier.
Any comment:	A key variable is exactly what type of plastic is being displaced by the product. The project developer will need, for each batch of product produced indicate the type of plastic it is substituting for (PET, HDPE, etc.). This analysis should be presented to the verifier using transparent data. If no justification can be provided, then the project developer may use the lowest (most conservative) factor of 1.41 (HDPE) in the case of US-based displacement. In addition, the project proponent should, for the purposes of calculating project emissions from useful products that will degrade over time, track and monitor the percentage of products that are not expected to biodegrade and present that information to the verifier. If that information is not available, then 100% of the useful product should be considered biodegradable and thus emit CO_2 as a project emission.

Parameter ID	MAU 71
Data/Parameter:	Quantity of arsenic and any other hazardous waste collected from macroalgae.
Data unit:	metric tons
Description:	Quantity of arsenic or other hazardous waste removed from collected sargassum or other macroalgae and sent to a hazardous waste facility for disposal
Source of data:	Project proponents
Monitoring frequency:	Reported at each verification
QA/QC procedures:	Project proponents must demonstrate to a verifier that the waste has been disposed of in a manner that meets all relevant local and national regulations dealing with hazardous waste disposal.
Any comment:	

Parameter ID	MAU 82
Data/Parameter:	$D_{,y}$
Data unit:	km
Description:	Distance the sargassum is transported from the collection point to the processing facility, to be broken down by different transport modes if more than one mode is used
Source of data:	Project proponents
Monitoring frequency:	Reported at each verification
QA/QC procedures:	Project proponents must indicate to a verifier the total distance traveled by each transport mode with records from the shipping or trucking company.
Any comment:	

4.2 | General requirements for sampling

4.2.1 | Not applicable

ANNEX 1: DISPLACEMENT EMISSION FACTORS FOR PETROLEUM BASED PLASTICS

Introduction and Background *(Based on VM0040* **--** *Methodology for Greenhouse Gas Capture and Utilization in Plastic Materials)*

This methodology relies on emission factors for each type of plastic produced by the project activity in order to calculate baseline emissions associated with the displacement of virgin plastic production ($EF_{DP,i}$). This appendix provides additional information about how $EF_{DP,i}$ is determined, including default factors for projects located in the United States and the process that must be used by projects located outside of the United States to calculate $E_{DP,i}$.

Emissions associated with the manufacture of plastic materials through conventional processes include the extraction and processing of raw materials, which are primarily petroleum products, emissions associated with the manufacturing process itself, and emissions associated with the transportation of plastic materials. These emissions vary depending on the type of plastic material – the production of polypropylene, for example, generates almost 40% fewer emissions than the production of polystyrene.

Calculation of Default Factors for Projects in the United States

Projects located in the United States may use a default value for $EF_{DP,i}$, based on the United States Environmental Protection Agency (U.S. EPA) Waste Reduction Model (WARM), which was created to calculate the GHG emissions of waste management practices in the United States, including from the recycling and landfilling of plastic materials.

The WARM model disaggregates the different sources of emissions associated with plastic production and includes process energy from the petroleum refining process, process non-energy emissions, and transportation emissions, as shown in Table 3a below[7]. For the purposes of this methodology, only process and process non-energy emissions are included because emissions from the transportation of plastic materials are not expected to be different in the baseline and project scenarios (e.g., because traditional plastic or GHG-containing plastic both must be transported to their final destination).

Note – The tCO_2e in Table 3a and Table 3b, below, are expressed in short tons. For the purposes of calculating baseline emissions in Equation 2, the default values included in Table 4, below, have been converted into metric tCO_2e.

Table 3a: Source Reduction Emission Factors for Plastic

[7] https://www.epa.gov/sites/production/files/2016-03/documents/warm_v14_containers_packaging_non durable_goods_materials.pdf

Material (a)	Process Energy (b)	Transportation Energy (c)	Process Non-Energy (d)	Net emissions (e) [e=b+c+d]
HDPE	1.18	0.15	0.20	1.53
LDPE	1.40	0.15	0.21	1.76
PET	1.74	0.07	0.39	2.20
LLDPE	1.14	0.15	0.25	1.54
PP	1.17	0.13	0.21	1.51
PS	1.86	0.15	0.45	2.46
PVC	1.68	0.08	0.14	1.90

The WARM model takes into account that some plastic is created from recycled materials, and therefore not all plastic materials on the market are from 100% raw materials, in its calculation of net emissions from plastic production. Table 3b, below, includes the emissions from "raw material acquisition" for the current mix of recycled vs. virgin plastic in the market (column "b"), as opposed to column "c" which calculates the emission factor for 100% virgin inputs. Note that the values in Table 3b are negative because this section of the WARM model is referencing reductions in emissions for every ton of plastic where its use is avoided.

Note that the figures in column "e" in Table 3a do not match column "b" in Table 3b below. This is because the transportation energy in the WARM model does not include retail transportation, which is 0.04 tCO_2/t of plastic for all plastic types[8]. The values in column "e" of Table 3a are equal to: [net emissions from 100% virgin inputs, Table 3b] – [0.04].

[8] See Table 5-4 on page 5-5: https://www.epa.gov/sites/production/files/2016-03/documents/warm_v14_containers_packaging_non-durable_goods_materials.pdf.

Table 3b: Raw Material Acquisition and Manufacturing Emission Factor for Virgin Production of Plastics (tCO_2e/Short Ton)

Material (a)	Raw Material Acquisition and Manufacturing for Current Mix of Inputs (b)	Raw Material Acquisition and Manufacturing for 100% Virgin Inputs (c)	Net Emissions for Current Mix of Inputs (d)	Net Emissions for 100% Virgin Inputs (e)
HDPE	-1.47	-1.57	-1.47	-1.57
LDPE	-1.80	-1.80	-1.80	-1.80
PET	-2.20	-2.24	-2.20	-2.24
LLDPE	-1.58	-1.58	-1.58	-1.58
PP	-1.55	-1.55	-1.55	-1.55
PS	-2.50	-2.50	-2.50	-2.50
PVC	-1.95	-1.95	-1.95	-1.95
Mixed Plastics	-1.92	-1.98	-1.92	-1.98

The net emission factor (EF_i) for each type of plastic is calculated as:

[(net emissions for current mix of inputs (Table 3b)) – (transportation energy (Table 3a)) – (retail transportation)] x (conversion factor from short tons to metric tonnes, equal to 1.102)

For example, the net emissions factor for HDPE would be equal to:

[(1.47) – (0.15) – (0.04)] x (1.102) = 1.41

There are a few types of plastic material eligible to be produced through project activities, but not included in the U.S. EPA WARM model report. These forms of plastic are:

- Thermoplastic urethane (TPU)
- Acrylonitrile butadiene styrene (ABS)
- Polycarbonate (PC)

Emission factors for these plastic materials were derived from a report prepared for the City of Winnipeg[9]. The emission factors included in this report are inclusive of

[9] https://www.winnipeg.ca/finance/findata/matmgt/documents/2012/682-2012/682-2012_Appendix_H-WSTP_South_End_Plant_Process_Selection_Report/Appendix%207.pdf

emissions associated with transportation. Therefore, to calculate emission factors for ABS, TPU and PC that are equivalent to the emission factors for other eligible plastic materials, an estimate of transportation emissions was subtracted from the total emissions. The EPA data from the WARM model specifies 0.19 metric tonnes of CO_2/per short ton of plastic (equal to 0.21 metric tonne of CO_2/per metric tonne of plastic) as the highest (and therefore most conservative) value for emissions from transportation. This value was subtracted from total emissions for the emission factors for ABS, TPU and PC included in Table 4 below. It is reasonable to infer that transporting ABS, TPU and PC would be similar in cost and energy to all other types of plastics, a point reinforced by the fact that the transport figures in the WARM model (except for PVC) are all in a very small range. The emission factors for TPU and PC were derived from the "Other Plastics" emission factor.

Table 4: *Default Emission Factors for* EF_i for projects located in the United States

Plastic Type	***Emission Factor (tCO_2e/metric tonne of plastic material produced)***
HDPE	1.41
LDPE	1.77
PET	2.30
LLDPE	1.53
PP	1.52
PS	2.55
PVC	2.02
ABS	3.25
TPU	2.49
PC	2.49

Note that project proponents must use the latest version of the WARM model (or similar sources of data in other countries) when developing a new project.

In addition, It will be incumbent upon the project developer to determine ahead of time – and present to a verifier – what type of plastic is being displaced OR use the most conservative default, which is 1.41 listed in the table above.

METHODOLOGY

DOCUMENT HISTORY

Version	Date	Description
1.0	dd/mm/yyyy	First version

List of references:

- Biological Pretreatment of Mexican Caribbean Macroalgae Consortiums Using Bm-2 Strain (Trametes hirsuta) and Its Enzymatic Broth to Improve Biomethane Potential, Raul Tapia-Tussel, et al. Energies, February, 2018. (doi:10.3390/en11030494) reports a BMP of untreated Sargassum of 81 L CH4/kg VS, and a BMP after fungal pretreatment of 104 L CH4 / kg VS. There are a large number of fungal species as part of the Sargassum microbiome.

- Enhancing biogas production from Caribbean pelagic Sargassum utilising hydrothermal pretreatment and anerobic co-digestion with food waste. Terrel Thompson, Brent Young & Saeid Baroutian. Chemosphere, 2021 (doi: 10.1016/i.chemosphere.2021.130035). BMP of untreated seaweed with 25% food waste yields 97 L/kg VS.

- Biohythane production from marine macroalgae Sargassum, coupling dark fermentation and anaerobic digestion. Jose Costa et al. Bioresource Technology 2015. Reports values of 541 L/ kg VS from Sargassum digestion