RMI Plastics Extrusion and Molding Greenhouse Gas Emissions Reporting Guidance

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Background

Plastics have essential applications in modern society. Key packaging applications support the medical and food storage services needed for populous urbanized life. Beyond packaging, plastics are used in buildings, water system infrastructure, transportation, machinery, clothing, electronics, and other consumer goods. They are also fundamental to the construction capital equipment needed for a net-zero energy transition, such as solar panels and electrical wiring.

The plastics sector is a major component of the broader petrochemical sector and source of greenhouse gas (GHG) emissions. The petrochemical industry accounted for 14% of the total primary demand for oil in 2019 by volume. Converting oil and gas feedstocks to plastics directly emits 1.4–1.6 Gt CO_2e/y and managing petrochemical waste emits another 0.2 Gt CO_2e/y.[1] Most primary production methods rely on fossil fuels for both material feedstocks and conversion energy. Producing fossil fuel feedstocks for plastics adds another 0.2–0.8 Gt CO_2e/y to the atmosphere.[2]

The plastics extrusion and molding sub-sector is a vital segment of the plastics supply chain but is often overlooked in emissions reporting. Converting oil and gas to bulk plastic resin pellets accounts for over half of life-cycle plastic emissions, yet plastic molders and extruders are the sole direct users of these pellets. The electricity used by molding and extruding facilities accounts for an estimated 17%–30% of cradle-to-grave plastic emissions.[3] Additionally, these facilities are often where additives and other product design elements that can influence the recyclability of the final product are incorporated, impacting the remaining 9% of emissions at end of life. Fortunately, they also have powerful tools to reduce emissions if the right demand incentives are aligned to the right data.

This guidance document applies general Horizon Zero carbon accounting principles for consistency with non-plastic critical commodities.[4] The overarching principle is the need for companies to report emissions at the product level from a specific asset (see *Supply Chain Asset and Geographic Basis* for definition of an "asset"). This is required because purchasing decisions for a material are made at the product level. This guidance seeks to inform such purchasing decisions by providing carbon accounting principles designed to drive industry decarbonization actions. To enable useful product-level GHG emissions disclosures, three key principles are applied:

1. Primary data: As much as possible, emissions calculations should be based on first-hand information from various supply chain partners.[i]
2. Consistent boundary for comparison: Companies shall report emissions against a fixed boundary (i.e., a consistent set of processes) to enable comparability and consistency between disclosures.
3. Measurement made for market: Calculation and reporting decisions should enable the development of a market for low-carbon products, resulting in low-carbon production for the plastics sector as a whole.

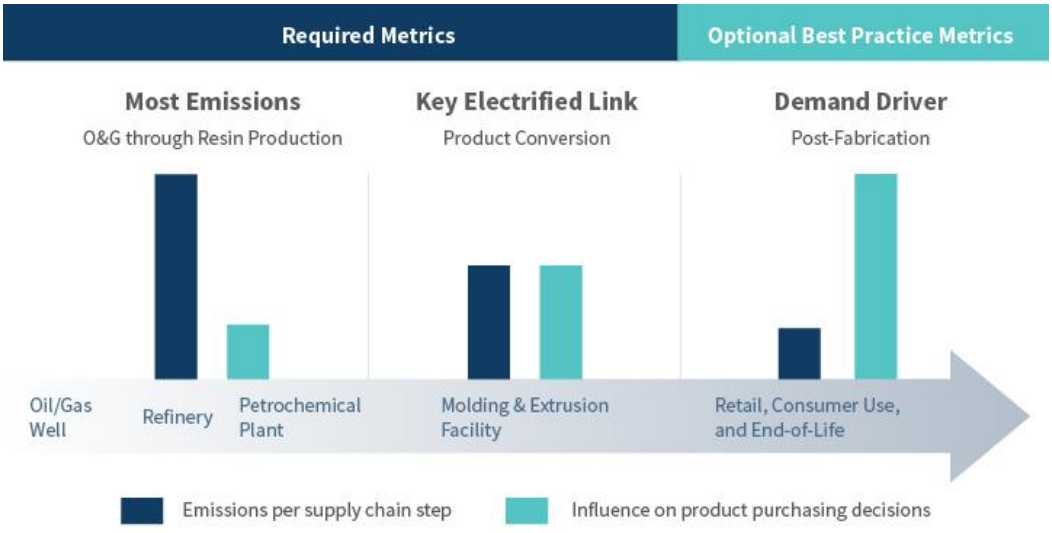
[i] Reference TfS PCF Guidelines Section 5.2.5 for data source definitions.

This guidance provides details specific to the plastics sector to implement these broad accounting principles.

The decarbonization levers incentivized through this guidance include:

1. Maximize the percentage of mechanically recycled plastic
2. Maximize the percentage of energy input from renewable electricity
3. Minimize carbon combustion and methane leaks
4. Deploy low-emission virgin plastic production technologies (e.g., renewable electric crackers)
5. Apply low-emission chemical recycling systems when GHG effects are sensible (e.g., recycling medical hazardous waste that must otherwise be incinerated, displacing coal-based plastics[5])

Exhibit 1: Reporting metrics for the supply chain steps from oil and gas well extraction and processing through molding is required for this guidance. Post-fabrications steps (retail, consumer use, and end-of-life) are optional. Although upstream steps are the most emission-intense, downstream steps have the most influence on consumer purchasing decisions, and product conversion has the most potential for electrification.



Reporting Metrics and Basis

Product Footprint Basis

For consistent emissions-intensity reporting, this guidance uses the following units: kilograms of carbon dioxide equivalent per kilogram of fabricated product (e.g., bottle or tub) or semi-fabricated product (e.g., film roll stock) — kg CO_2e/kg — on a 100-year global warming potential (GWP) basis. The product would include base resin, masterbatch resin, and any direct additives. Note that emissions intensity is calculated prior to any labeling, printing, or other types of decoration. All non-core components are also excluded from the calculation unless they exceed a 5% mass cutoff. This streamlines product carbon footprint (PCF) calculations by allowing simple addition with upstream resin producers following Together for Sustainability's "Product Carbon Footprint Guideline for the Chemical Industry" (PCF Guidance).[6]

Mechanical recycling is a key lever to reduce emissions that can be limited by waste stream contamination and inclusion of additives that inhibit recyclability or recyclate quality. Key additives with significant embodied emissions are included regardless of concentration (e.g., titanium dioxide, carbon black) to provide reasonable representation of the true PCF and to incentivize production activities that support recycling. Resin input codes can be aggregated to one broad resin type listed in the Appendix or equivalents to streamline reporting if aggregated cradle-to-pellet resin PCFs are documented to be within 10% of their aggregated average. Molded or extruded products can also be aggregated into major product types (e.g., bottles, films, fibers, sheets) if their mass per unit is documented within 10% of their aggregated average.

Exhibit 2: Examples of product aggregation allowances within 10% variance. Disaggregation is always allowed and preferred.

Allowed to be averaged as a resin input to the same product batch	Resins must be treated separately for highest/lowest plastic type data and product batch identification	Allowed to be combined into a single product batch	Products must be treated as separate batches for emissions attributes
Resin Code U-26731 Intensity = 1.8 $kgCO_2e/kg$	Resin Code U-26734 Intensity = 1.7 $kgCO_2e/kg$	HDPE Film of 1.0 kg/m^2	HDPE Film of 1.0 kg/m^2
Resin Code U-26732 Intensity = 2.0 $kgCO_2e/kg$	Resin Code U-26735 Intensity = 2.0 $kgCO_2e/kg$	HDPE Film of 1.1 kg/m^2	HDPE Film of 1.2 kg/m^2
Resin Code U-26733 Intensity = 2.2 $kgCO_2e/kg$	Resin Code U-26735 Intensity = 2.3 $kgCO_2e/kg$	HDPE Film of 0.9 kg/m^2	HDPE Sheet of 1.0 kg/m^2
			HDPE Sheet of 1.2 kg/m^2

Temporal Basis

The most recent full reporting or calendar year shall be applied as the time boundary for PCF calculations, if representative of an average year of production. For production years that are not continuous or irregular, production data may be averaged for a longer time to reduce variability due

to unplanned outages, turnaround, or other atypical production conditions. When applying average production data in a PCF calculation, no more than the last three years of production (reporting or calendar) shall be averaged and used in a PCF calculation. Primary data used in the calculation of PCFs shall be as recent as practicable and not older than five years. Secondary data (e.g., LCI data from databases) shall be as recent as practicable but not older than 10 years. Unless otherwise stated above, temporal decisions should be consistent with 2022 Together for Sustainability's PCF Guidance."[7]

Supply Chain Asset and Geographic Basis

Companies should report PCFs based on the smallest asset size practical, ideally at the production line level with minimal aggregation by broad resin type and product type. This allows geographical representation of power grid emissions through a grid factor ($kgCO_2e/kWh$). A reported PCF shall only aggregate assets processing one aggregated broad resin type per the rules in *Product Footprint Basis* where the power grid factor is within 5% of the aggregated average.

Required Metrics

The required reporting metrics listed below create the basis for transparent decarbonization demand signals from consumers to suppliers. These metrics extend industry best practices from the full upstream supply chain to allow consumers to value real emissions reduction efforts and make informed procurement decisions. Resin input types and percentages within each product shall be displayed if above a minimum threshold of 2% by mass of the semi-fabricated product. Cradle-to-fabrication gate emissions intensity should add the resin product carbon footprint from upstream suppliers to their operational emissions from additive embodied emissions, electricity, and other heat consumption. This would include life-cycle emissions of energy used, such as the methane leaks from natural gas supplied to the building or to the power grid linked to the facility. See *Methodology* section for additional details.

Resin product footprint intensities and primary data share, the percentage of emissions measured from real assets, shall be calculated according to Together for Sustainability's PCF guidance in most cases. Guidance for special inputs like mechanical recycling and bio non-plastic polymers is provided in the *Methodology* section. Methane intensity of gas used should move toward consistent reporting, as the industry converges toward best practices in the coming years. Requesting methane-specific data from suppliers alongside more primary data in fossil-based inputs' carbon footprint estimates will improve the overall accuracy of accounting measures and align with increasingly stringent global best practice. Where primary data is not available, using more accurate, measurement-informed, asset-specific intensity estimates for fossil-based inputs should be prioritized. For example, using OCI+ basin level intensity estimates or MiQ zone averages should be used to fill supplier primary data gaps.[8]

Exhibit 3: Required reporting metrics

Resin types within product (Select all claimed in product): ☐ Virgin Plastic – mass %* ☐ Mechanical Post-Consumer Resin (PCR) – mass % ☐ Chemical PCR – mass % ☐ Bio-based Plastic** – mass % ☐ Bio-based alternatives to plastic** – mass % ☐ CCU-based Plastic – mass %	Total Product	Highest Emissions Plastic Type Input (e.g., Chemical PCR)	Lowest Emissions Plastic Type Input (e.g., Mechanical PCR)
Cradle-to-Fabrication Gate Emissions Intensity ($kgCO_2e/kg$ fab product resin) Fabrication power emissions basis used for PCF: ☐ Location-based averages ☐ Location-based market residuals ☐ Market-based	Input (e.g., 2.5 $kgCO_2e/kg$)	Input (e.g., 3.2 $kgCO_2e/kg$ Chemical PCR)	Input (e.g., 0.9 $kgCO_2e/kg$ Mechanical PCR)
Primary Data Share of full PCF (CO_2e) %	Input (e.g., 60%)	Input (e.g., 80% Mechanical-PCR)	Input (e.g., 30% Bio-Based Plastic)
Methane Leak Intensity (gCH_4/kg fab product resin)	Input (e.g., 1.2 $kgCH_4/kg$)	Input (e.g., 2.2 $kgCH_4/kg$ Virgin Plastic)	Input (e.g., 0.4 $kgCH_4/kg$ Mechanical PCR)
Primary Data Share of Methane Leak Intensity (CH_4) %	Input (e.g., 20%)	Input (e.g., 90% Mechanical-PCR)	Input (e.g., 10% Bio-Based Plastic)

*Virgin plastic includes purchased scrap/regrind/additive masterbatches.
**See *Bio-Based Plastics and Molded/Extruded Alternatives* section for additional description.

Best Practice Optional Metrics

Cradle-to-resin gate emissions intensities are necessary but may not be sufficient to drive the correct decarbonization behavior through product differentiation. Increased transparency to other downstream metrics can support corporate goals toward increased renewable energy use and low-emission circularity. End-of-life reporting is optional due to low data quality, but extended producer responsibility regulations are making this increasingly important to declare. The renewable energy emissions score can provide context to value renewable purchases that reduce emissions most. The recyclability score has wide adoption in European markets and can support industry circularity needs for high-quality mechanical PCR. Use intensity, the service life per mass of product, can provide a final differentiating factor for customer and product design decisions. Appendix B provides a more detailed explanation of each metric along with calculation methods where applicable.

Exhibit 4: Best practice optional reporting metrics

Best Practice Optional Reporting Metrics	Total Product
Molding Renewable Energy Share and Procurement Rating	Input (e.g., 50% of molding energy renewable, of which 50% is Tier 1 and 50% is Tier 2)
Recyclability Rating (RecyClass, APR Recyclablity Category, or How2Recycle)	Input (e.g., RecyClass A, APR Preferred, or How2Recycle Widely Recyclable)
End-of-Life Emissions Intensity ($kgCO_2e/kg$)	Input (e.g., 0.5 $kgCO_2e/kg$)
End-of-Life Primary Data Share %	Input (e.g., 5%)
Use intensity (service life in X.Y years/kg of plastic product)	Input (e.g., 0.1 years/kg)
Credits and other notes (i.e., nature-based offsets that must be reported separately per GHG Protocol & Together for Sustainability guidance)	Input (e.g., Consider -0.3 $kgCO_2e/kg$ material and energy substitution credits for chemical recycling, or consider -3.0 $kgCO_2e/kg$ in removal credits for bio-based plastic from algae)

Methodology

Site and Process Level Emissions Calculation

The calculation for both site and process level is adapted from the ISO 14404 series, which is the standard used the by the plastic industry, specifically:

$$E_{CO2} = \sum_{t=1}^{N} EF_{s,d,CO2} \times Q_{s,d,CO2} + \sum_{t=1}^{N} EF_{s,i,CO2} \times Q_{s,i,CO2}$$

Where s (from 1 to N) refers to each emission source (i.e., fuel, energy, or other input), EF refers to emissions factors, Q refers to site quantity, d and i refer to direct and indirect emissions respectively, and E refers to emissions.

Direct emissions, known as Scope 1, refer to carbon emissions from fuel sources and on-site electricity generation. The emissions factor is defined based on the carbon intensity of that fuel source/electricity generation (e.g., on-site diesel generators).

Indirect emissions, known as Scope 2, refer to emissions that occur outside of the direct molding/extruding process. This includes generation emissions for electricity used in the fabrication process. More details on calculating electricity-related emissions are provided in *Electricity Grid Factor Determination* and Appendix A provides a table with estimated energy consumption for different molding techniques.

Calculated emissions for the fabrication process determined using the above formula should be added to the upstream cradle-to-gate emissions for the resin received from suppliers. The following formula provides the total product carbon footprint on a kg bulk resin fraction of semi-fabricated product basis:

$$PCF_{Total} = PCF_{Upstream} + PCF_{Fabrication}$$

In line with *Required Metrics*, separate emissions determinations should be made for each type of plastic present (e.g., bio-based, chemically recycled, mechanically recycled) in the semi-fabricated product, in addition to the total product.

Additives

Per *Product Footprint Basis*, additives' emissions should be included in the product carbon footprint calculation if they contribute a significant environmental impact or are more than 2% by weight of the semi-fabricated product. A significant environmental impact refers to additives whose production results in environmental or emissions impacts significantly greater than the resin production either from resource extraction or processing. The table below provides a list of common additives that should be included even if they are below the materiality threshold. Some additives are combined with a base resin to create a concentrate/masterbatch which is then added to the product during fabrication. For concentrates/masterbatches the polymer portion should be assumed to have the same emissions as the base resin if no supplier-specific emissions number is provided.

Exhibit 5: Additives included in PCF and primary data calculations

Additives included in PCF and counted in primary data % (e.g., asset-level data strongly preferred)	Additives included in PCF but not counted in primary data % (e.g., asset-level data encouraged but lower priority)
Carbon Black	All others below 2% PCF materiality threshold
Zinc Oxide	
Titanium Oxide	
Glass beads and fibers	
Calcium Carbonate	
All others above 2% PCF materiality threshold	

Electricity Grid Factor Determination

For this guidance, electricity grid factors are determined using both market and location-based methods in accordance with the GHG Protocol.[9] Priority should be to incentivize siting facilities in areas with a strong renewable grid and/or to invest in renewable power additions in a dirtier grid for the greatest emissions reductions. Fabricators should obtain the relevant emissions factor from the facility's electricity supplier for the most representative value and use grid factors representative of the local, regional, or national level. Preferentially, the narrowest level grid factor that applies to a facility should be utilized for greatest accuracy.

Existing facilities can lower their grid factor by using contractual mechanisms (market-based methods) to source renewable energy. This would include self-generation owned by the company, purchase from on-site installations owned by a supplier and directly delivered to the fabricator, direct sourcing from an off-site generator with no grid transfers, and direct procurement from off-site grid-connected generators (e.g., power purchase agreements). For transparency, fabricators should use the emissions factors for the contractual amount of energy from the specific generation

facility and the associated energy mix. If renewable energy is used to meet electricity needs then sufficient documentation must be presented as proof (Energy Attribute Certificates, guarantees of origin, power supply contracts, etc.). If market-based grid factors are used for only some products within a grid region, residual grid mixes should be used for remaining products made within the grid region to avoid double counting risks. Note that the method of renewable energy procurement should be provided as part of the optional reporting metric listed in *Best Practice Optional Reporting Metrics* and described in Appendix B.

Transportation

Transportation emissions for resin from chemical plant gate to product conversion facility and for semi-fabricated product from product conversion facility to consumer should be calculated using the Global Logistics Emissions Council (GLEC) framework.[10] Transportation emissions are often a small percentage of the overall PCF but should be evaluated in an iterative process to ensure that assumption holds true. If the associated emissions impact for these transportation steps is less than 5% of the total PCF, then the emissions can be omitted.

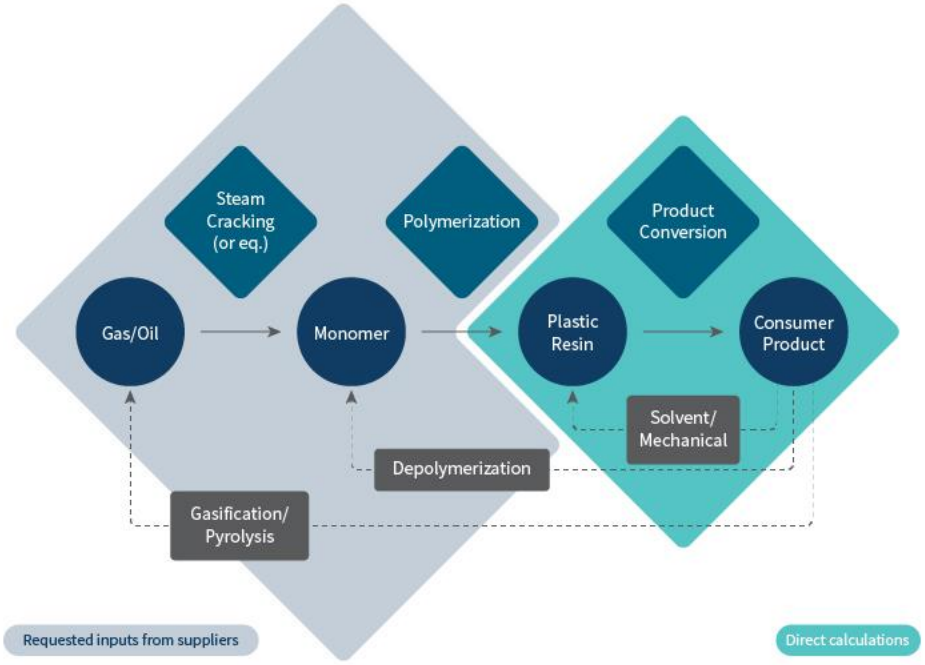
Bio-Based Plastics and Molded/Extruded Alternatives

Bio-based plastic resin's PCF should be provided by the supplier and include land use change impacts in accordance with GHGP's Land Sector and Removals Guidance.[11] Credits for avoided emissions associated with bio-based inputs will not be included in the PCF calculation but can be reported separately (see *Best Practice Optional Metrics).* For bio-based resins that are processed identically to fossil-based resins there is no difference in calculation methodology for the product conversion step. Innovative bio-derived alternatives to traditional plastics are being developed and the production steps may include more direct and indirect emissions than traditional fossil-based plastics. All steps involved in the creation of the semi-fabricated product should be accounted for in the PCF calculation.

Recycling Methods

Mechanical recycling and chemical recycling methods that produce a pellet such as solvent recycling are included in this guidance's scope. The emissions associated with these post-consumer recycled resins are to be developed by the supplier of these materials. The cut-off method is to be applied to recycled resin. Under this method, the recovered flake or bailed recyclate from a material recovery facility is assigned zero embodied emissions because the production emission burden is assigned to the first end-use of the recyclate. The emissions associated with subsequent steps upon leaving the recovery facility (e.g., grinding, pelletizing, packaging, transportation for mechanical recycling and dissolution, de-inking, grinding, pelletizing, transportation for solvent chemical recycling), are accumulated and associated with the recovered resin.

Exhibit 6: Conversion of plastic resin to a consumer product and solvent/mechanical recycling are in scope for this guidance. Depolymerization and pyrolysis recycling methods are not included.

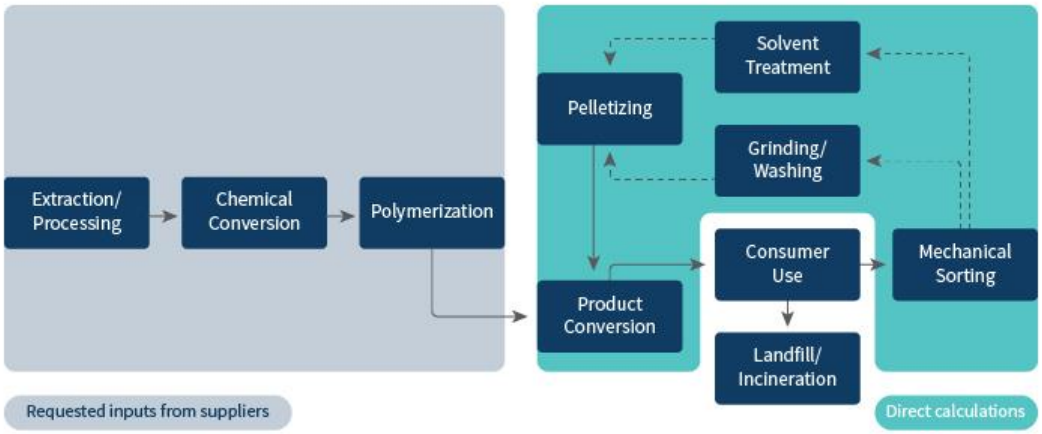


Note: The GHG Protocol cut-off approach is used for plastic from solvent and mechanical recycling. The impacts of sorting, transportation, and other preparatory steps in the recycling process are attributed to the secondary product, and any burdens or credits from previous life cycles are not included.

Recycling methods that do not produce a pellet or flake are not included in the guidance scope. This would exclude gasification and pyrolysis processes which take post-consumer mixed plastic waste and use heat to break the materials down into a pyrolysis oil or gas. This oil or gas is then fed back into the plastic production supply chain upstream of the molding/extrusion step to be further converted into a pellet. Similarly, chemical or thermal depolymerization processes that break plastic waste down to monomers that are then further processed into polymer pellets would be excluded. The emissions associated with the chemically recycled inputs should be included in the upstream suppliers' PCF and would not be calculated in the product conversion step. The percentage of a purchased resin that is produced using these processes can and should be reported separately toward recycled content targets. Additionally, the assumed avoided end-of-life emissions for the recyclate would be reported separately as part of the optional best practice metrics.

Any scrap produced at a molding/extruding facility (e.g., edge trim, sprues, runners) and recycled back into the forming process is not counted as recyclate. Similarly, purchased pre-consumer or post-industrial scrap should be categorized according to its primary production route which is typically virgin plastic. Secondary data from Appendix A should be used in absence of any primary data from the original producer. An exception for post-industrial scrap will be accepted if robust accounting documentation can prove all cradle-to-gate emissions were allocated to other products from the true source production line. This may count as zero burden (0 $kgCO_2e/kg$ product resin) up to a limit of 15% total product resin.

Exhibit 7: The boundaries for this guidance include product conversion and any processes included in mechanical recycling (mechanical sorting, grinding, washing, and pelletizing).



The emissions associated with virgin and recycled post-consumer inputs would be provided by the supplier. Physically, the virgin and recycled inputs may be inseparable from the final semi-fabricated plastic product; however, the total emissions associated with processing the different inputs should be determined using data on the mass share of each kind of recyclate in the final product. Using this mass allocation method will facilitate reporting of the percentage of recycled input by type as outlined above in *Required Metrics*. This will incentivize investments in low-emissions processing technologies and increase accuracy in recycled content reporting.

Appendix A: Molding & Extruding Secondary Emissions Data

Manufacturers should detail the molding technique used to produce their consumer product; several common techniques are described here. Injection molding is a process where plastic resin is heated beyond its melting point, injected into a mold, and cooled before part removal. The blow molding process begins with a hollow tube of plastic, which is then inserted into a mold. Compressed air is then used to expand the plastic until it fills the mold, forming a final hollow product. An alternative technique, thermoforming, heats a sheet of plastic until it is pliable, which is then stretched across a mold. The sheet is either pushed (with another part of the mold) or pulled with a vacuum onto the mold and cooled. Both film and fiber extrusion are continuous processes that include melting the plastic resin and pushing it through a die or spinneret with many small diameter holes.

Molders and extruders should use primary product and asset-level data whenever possible. If not available, the following secondary data tables should be used according to the equation below:

$$PCF_{Fab,x} = EI_{Fab,x} \times GIF$$

Where

$PCF_{Fab,x}$ =
$Product\ carbon\ footprint\ of\ the\ fabrication\ (molding\ or\ extruding)\ step\ for\ plastic\ resin\ x\ (\frac{kgCO2e}{kg\ product})$

$$EI_{Fab,x} = Energy\ Intensity\ of\ fabrication\ step\ forplastic\ resin\ x\ (\frac{kWh}{kg})$$

$$GIF = Grid\ Intensity\ Factor\ (\frac{kgCO2e}{kWh})$$

Resin Type	Process Type	Energy Intensity (kWh/kg) [12]
LDPE	Injection Molding	2.6
	Blow Molding	1.9
	Film Extrusion	1.5
	Other Extrusion	3.8
	Others	3.4
LLDPE	Injection Molding	2.6
	Rotational Molding	5.9
	Film Extrusion	1.3
	Others	3.6
HDPE	Injection Molding	2.8
	Blow Molding	2.2
	Film Extrusion	1.1
	Other Extrusion	3.8
	Others	3.4

PP	Injection Molding	2.6
	Blow Molding	1.9
	Extrusion	1.5
	Fiber	1.8
	Others	2.3
PET	Film Extrusion	1.5
	Solid State (injection, blow molding, and extruding)	2.2
	Fiber	1.7
PVC	Films and Sheets	1.6
	Pipes and Fittings	2.4
	Profiles and Tubes	2.6
	Others	2.1
PS	GPPS	2.3
	HIPS	1.8
	EPS and XPS	1.9
	ABS	1.3
SAN and ABS	Others	1.8
PUR	Rigid Foam	1.8
	Flexible Foam	1.3
	Flexible Foam Slabstuck	1.3
	Molded Foam	2.0
	Elastomer	2.2
	Others	1.7

The grid intensity factor most specific to the asset producing the product should be applied. As a last resort, the national or economic union grid factor should be used, preferably from IEA sources. The table below provides an example of the grid intensity factor from the IEA's 2021 electricity market report.[13]

Region	Grid Intensity ($kgCO_2e/kWh$)
China	0.580
EU	0.216
India	0.707
US	0.353

Below is a list of typical literature cradle-to-pellet virgin and mechanically recycled resin carbon intensities. This data can provide a good benchmark to compare supplier-provided data. Note any non-typical high-carbon intensity processes such as methanol to olefin or coal supply chains are not represented in these values. If a plastic molder or extruder has reason to believe sources come from high-intensity processes or regions, higher emissions factors should be expected and assumed unless certification proves otherwise.

Plastic Resin Type	Cradle-to-Pellet Virgin Resin Product Carbon Footprint ($kgCO_2e/kg$ resin)[14]	Cradle-to-Pellet Mechanically Recycled Resin Product Carbon Footprint ($kgCO_2e/kg$ resin)[15]	Cradle-to-Pellet Solvent-Recycled Resin Product Carbon Footprint ($kgCO_2e/kg$ resin)[16]
LDPE	2.2	Assume a 67% reduction from virgin resin	Assume a 20% reduction from virgin resin
LLDPE	2.2		
HDPE	2.2		
PP	2.2		
PET	3.7		
PVC	2.4		
PS	3.9		
SAN and ABS	3.8		
PUR	3.9		

Appendix B: Optional Metrics

Renewable Energy Share and Procurement Rating: Ongoing revisions to the GHGP's Scope 2 Guidance could have significant implications for market-based renewable energy reporting methods. As the marketplace has evolved, greater understanding of the impact of market-based methods' effectiveness in increasing renewable energy supply has also evolved. Increasing focus on additionality, time-based load matching, certificate retirement, and location matching are the focus of many of the proposals and comments to the GHGP Scope 2 Guidance revision, highlighting the nuances involved in procuring renewable energy. Until clear guidance is issued from GHGP, a focus on transparency for renewable energy procurement methods should be the norm. For this guidance, total percentage of electrical energy usage covered by renewable energy procurement should be listed along with the method of procurement and contract term length, matched to one of the following tiers and listed as a percentage of total renewable energy procurement.

- Tier 1: 24/7 procurement hourly matching for actual load at the facility or emission matching procurement.
- Tier 2: Bundled energy certificates that include actual renewable power delivered to the facility. For example: from power purchase agreements (PPAs) or green tariffs purchased through a utility provider.
- Tier 3: Unbundled energy certificates purchased on the open market or as part of virtual power purchase agreements (VPPAs).

For example, a facility that covers 50% of required electricity usage with renewable energy certificates, half of which come from green tariffs purchased through the local utility and the rest from unbundled RECs purchased on the market, should report their renewable energy procurement rating as 50% of total electricity, 50% Tier 2, and 50% Tier 3.

Recyclability Rating: Designing products for recyclability can result in significant full life-cycle emissions reductions if a product is mechanically recycled at end of life. There are three major recyclability certifications listed in *Best Practice Optional Metrics* to indicate recyclability. RecyClass provides design for recyclability guidelines and provides certifications with an A to F rating on recyclability, a recycling rate certification based on geographic location and plastic packaging, and a letter of compatibility for semi-finished packaging. Similarly, the Association of Plastic Recyclers (APR) provides a design guide that labels components of packaging as recyclable preferred, detrimental to recycling, renders package non-recyclable, and requires testing. APR provides a "meets APR preferred guidance" recognition that certifies a product or product components as meeting all the preferred criteria for recyclability. Greenblue's How2Recycle program designates products into one of four categories: widely recyclable, sometimes recyclable, not yet recyclable, and store drop-off (recyclable at designated drop off locations at select retailers). Operators can choose to use any of these programs or other similar existing systems to provide independent certification of semi-fabricated product's recyclability.

End-of-Life Emissions Intensity/Primary Data Share %: The final disposal method for a plastic product can have significant total life-cycle emissions impacts. If information is available on a product's final end-of-life emissions (incineration, landfill, or recycled), that intensity should be provided. Plastic waste mismanagement results in significant leakage of plastic products into the environment. Increased tracking and tracing of products up to final disposal method can help

reduce this plastic leakage and provide valuable information on the true end of life for products. The end-of-life primary data share percentage will encourage increased visibility. Primary data share is determined using the following formula:

$$PDS_{PCF}(\%) = \frac{Part\ of\ PCF\ based\ on\ primary\ data\ (CO_2e)}{PCF\ (CO_2e)}$$

Use Intensity: Low-use high-waste plastic products contribute significantly to plastic pollution problems. Designing plastics for longer lifetimes can result in overall reductions in GHG emissions by reducing demand for plastics that fit in this category. This metric is intended to provide a view of the intended service life of a product to provide insight into the useful lifetime of a product and act as an indicator for the waste potential of a product. This metric should be calculated as:

$$Use\ Intensity\ (years/kg) = \frac{Service\ life\ of\ product\ (years)}{(Single\ Product\ Unit) * \frac{kg\ of\ plastic\ resin}{kg\ Single\ Product\ Unit}}$$

Credits and other notes: Purchased credits or offsets such as nature-based offsets should be reported separately from the PCF of the semi-fabricated product. This ensures transparency while allowing the benefits of such offsets to be highlighted.

Endnotes

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