CDM-MP97-A03

Draft Small-scale Methodology

AMS-III.BA.: Recovery and recycling of materials from E-waste

Version 04.0
Sectoral scope(s): 13

COVER NOTE

1. Procedural background

1. The proposed revision of small-scale methodology AMS-III.BA. was received on 16 August 2024 and deemed complete on 16 August 2024. The submission was assessed at MP 95 and MP 96, and MP agreed to request clarifications on the proposed revision to the methodology proponent.

2. Purpose

2. The purpose of the revision is to include glass as material to be recovered from e-waste and recycled, displacing the production of virgin materials.

3. Key issues and proposed solutions

3. The proposed revision is to include glass as material to be recovered from e-waste and recycled. The revision includes:

   (a) Application of a correction factor based on the share of the production in non-Annex I countries (B_i) for glass (0.67), based on the value currently available in small-scale methodology AMS-III.AJ;

   (b) Application of a specific energy consumption (SEC) for the production of raw materials displaced by the glass recycling (0.026 MWh/tglass), based on the value currently available in small-scale methodology AMS-III.AJ.

4. The MP noted that the values for the materials included in this methodology and in AMS-III.AJ. are not representative of the most recent circumstances in the recycling sector and would recommend that the Board provide a mandate to streamline both methodologies and ensure their consistency, including updating the default values.

4. Impacts

5. The revised methodology will allow the estimation of emission reductions for project activities recovering and recycling glass from e-waste, displacing the production of virgin materials.

5. Subsequent work and timelines

6. The methodology is recommended by the MP for consideration by the Board at its 125th meeting. No further work is envisaged.

6. Recommendations to the Board

7. The MP recommends the Board to approve the new methodology, to be made effective at the time of the Board’s approval.

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1. Introduction

1. The following table describes the key elements of the methodology:

Table 1. Methodology key elements

Typical project(s)	Collection and recycling activities of E-waste, comprising of end-of-life, discarded, surplus, obsolete, or damaged electrical and electronic equipment, performed in dedicated facilities with the aim of recovering materials such as ferrous metals, non-ferrous metals, plastics and glass
Type of GHG emissions mitigation action	Energy efficiency: Reduction of production of metals, ~~and~~ plastics and glass from virgin materials, thus reducing related energy consumption

2. Scope, applicability, and entry into force

2.1. Scope

2. This methodology comprises collection and recycling activities of E-waste[1] performed in dedicated facilities with the aim of recovering materials such as ferrous metals, non-ferrous metals, plastics[2] and glass. E-waste contains rare and precious metals that require specific technologies to extract and refine them. These materials are recovered and processed into secondary materials, thus displacing the production of virgin materials, thereby resulting in energy savings and greenhouse gas emission reduction.

2.2. Applicability

3. The methodology is applicable under the following conditions:

(a) The recycling facility includes E-waste sorting and processing of at least the non-ferrous metals fraction of the waste. Other common materials (ferrous metals, aluminium, plastics, glass) can be processed at the facility after sorting or be shipped to third party processors;

(b) It is possible to measure and record the final output of the recycling facility, i.e. the weight of materials leaving the recycling facility;

(c) It is possible to measure and record the amount of fuel and electricity consumed by the recycling activities performed at the facility;

[1] E-waste comprises end-of-life, discarded, surplus, obsolete, or damaged electrical and electronic equipment (EEE).

[2] Other materials found in E-waste~~, such as glass,~~ can be potentially recycled. Project participants are encouraged to submit a revision of this methodology to include additional materials proposing conservative default values for specific emission factors (or specific energy consumption) for the production from virgin raw materials.

(d) The output material(s) shall be sold directly to a manufacturing facility, or to a chain of intermediary processors, or retailers that are able to transfer the recycled materials to a final identifiable manufacturing facility;

(e) The emission reductions under this methodology will accrue to any one of the following:

(i) The recycling facility; or

(ii) The processing facility; or

(iii) The collectors of E-waste.

4. In order to avoid double counting of emission reductions, a contractual agreement between the collectors of E-waste, the recycling facility and the processing facility shall indicate that only one of them will claim emission reductions:

(a) This methodology applies to the recycling process of the following materials[3] recovered from E-waste:

(i) Metals: Aluminium, steel, copper, gold, silver, palladium, tin, lead;

(ii) Plastics: Acrylonitrile Butadiene Styrene (ABS), High Impact Polystyrene (HIPS);

(iii) Glass: Glass cullets from e-waste component parts.

(b) Emission reductions can only be claimed for the difference between: (a) the energy used for the production of ~~metals and plastics from~~ virgin materials; and (b) the production of the same ~~metals and plastics~~ materials from E-waste recycling;

(c) The methodology excludes collection of the scraps generated from the production process of primary/secondary/finished metal and materials or in the processing of the finished metal and materials into final products, and it covers only post-consumer obsolete scrap. Project proponents shall provide evidence that the materials recycled under the project activity are recovered only from end-of-life E-wastes;

(d) Project proponents shall demonstrate that the properties of the ~~metals and plastics~~ materials produced from E-waste recycling are the same as those ~~of the metals and plastics~~ from virgin materials. ~~For recycled metals and plastics,~~ The project proponents shall provide documentation (e.g. chemical composition test results or quality certificates) proving that the properties of the ~~metals and plastics~~ materials produced are comparable according to standard testing methods for each material;

(e) Project proponents shall also demonstrate ex ante, using official government data, third party independent surveys and research, academic research/papers, independent market research that the baseline recycling rate of E-waste (including

[3] Project participants are encouraged to submit a revision of this methodology to include additional metals and materials proposing conservative default values for specific emission factors (or specific energy consumption) for the production from virgin raw materials.

formal and informal sector)[4] is equal to or smaller than 20% of the total amount of E-waste (estimated based on volume or weight basis) that can be potentially recycled in the region/country. In case multiple studies are available showing different pictures/facts/results (including governmental and non-governmental sources), the most conservative one shall be used. Where the baseline recycling rates exceed 20%, project proponents shall demonstrate that the project activity leads to significantly higher rates of recycling in the region/country, including the below proofs at a minimum:

(i) Project activity does not divert E-waste from any historically existing informal or formal recycling activity;

(ii) Technologies capable of separating higher amounts of individual metals from unit quantity of E-waste are employed by the project activity as compared to prevalent technologies in the pre-project situation;

(iii) Recycling infrastructure set up by the project activity can potentially lead to at least 50% increase[5] of recycling rates of E-waste in the region/country within the first three years of operation of the facilities.

5. If the conditions mentioned above are satisfied, emission reductions can be claimed for all of E-waste recycled by the project activity. However, if the above conditions are not met, project proponents shall exclude copper and noble metals[6] (i.e. gold, silver and palladium) from the calculation of the emission reductions. Plastics, iron and aluminium remain eligible.

6. Project proponents shall demonstrate, using three years[7] historic data (e.g. market data, official statistics) prior to the start date of the project activity, that the finished products (ABS, HIPS, glass and metals) were manufactured in the host country of the CDM project activity using either the quantity of virgin raw materials produced in country or virgin raw materials imported from another non-Annex I country. This analysis may be limited to only those finished products where recycled materials have proven to be a technically viable option (i.e. those types of products that are expected to be the end products produced from materials recycled as part of the project activity).

7. As an alternative to the requirement stipulated in paragraph 6 above, the project proponents may choose to adjust the baseline emissions by using the baseline correction factor (B_i) as described under section 5.2.

[4] The data shall include the total in-country generated amount of E-waste that would be recycled by both formal and informal sector, including the amount that would be exported to be recycled abroad.

[5] For example, E-waste generation in Country A in the baseline is 100,000 tonnes/year, out of which 25,000 tonnes/year was recycled which amounts to 25% annual recycling rate. Now, the project activity will create infrastructure to enable recycling capacity of 60,000 tonnes per year by the third year of operation of the facilities, which amounts to 50% annual recycling rate if the annual amount of E-waste generation in the third year of operation of the facilities is expected to be 120,000 tonnes/year. In this example the rate of recycling has increased by 100%.

[6] This is to mitigate the likelihood of business-as-usual recycled quantities being included for emission reduction calculation.

[7] A minimum of one-year data would be required if the facility is less than three years old.

8. This methodology is not applicable in cases where recycling of E-waste is required by local regulations and the existing mandatory policy/regulation has a high level of enforcement.

9. Measures are limited to those that result in aggregate emission reductions of less than or equal to 60 kt CO_2 equivalent annually.

2.3. Entry into force

10. The date of entry into force is the date of the publication of the EB ### meeting report on # Month 2025.

2.4. Applicability of sectoral scopes

11. For validation and verification of CDM projects and programme of activities by a designated operational entity (DOE) using this methodology, application of sectoral scope 13 is mandatory.

3. Normative references

12. This methodology is based on the proposed small-scale methodology "SSC-NM072: Recovery and recycling of materials from E-waste" submitted by Carbon Credit Capital LLC.

13. Project participants shall apply the general guidelines for the SSC CDM methodologies, information on additionality (attachment A to appendix B) provided at: <http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html> mutatis mutandis.

14. This methodology also refers to the latest approved versions of the following approved methodologies:

    (a) "AMS-III.AJ.: Recovery and recycling of materials from solid wastes;"

    (b) "TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion;"

    (c) "TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation;"

    (d) "TOOL07: Tool to calculate the emission factor for an electricity system."

4. Definitions

15. The definitions contained in the Glossary of CDM terms shall apply.

16. For the purpose of this methodology the following definitions apply:

    (a) **Electrical and electronic equipment (EEE)**: includes large and small household appliances; IT and telecommunications equipment; consumer equipment; lighting equipment; electrical and electronic tools; toys, leisure and sports equipment; medical devices; monitoring and control instruments; and automatic dispensers. It includes all components, subassemblies and consumables that are part of the product at the time of discarding[8];

(b) **Primary ~~metal or~~ material**: ~~metal or~~ material produced directly from mined ore or from virgin raw materials;

(c) **Secondary ~~metal or~~ material**: ~~metal or~~ material produced utilizing in part or entirely recycled ~~metal or~~ materials;

(d) **E-waste sorting**: the separation of collected E-waste into different categories of recyclable materials to facilitate further processing. The categories may include (but are not limited to): plastics, ferrous metals, non-ferrous metals, and glass. The sorting process may include manual sorting and segregation and/or further separation through physical, mechanical and electromagnetic processes. Sorted material requires further processing to complete the recycling process; in some cases, this is done within the recycling facility, otherwise sorted E-waste fractions are sold to third parties specialized processing facilities;

(e) **E-waste processing**: processing of sorted materials, converting them into secondary materials substituting virgin materials. The process can include manual, mechanical, electro-chemical processes and technologies;

(f) **Recycling facility**: facility(ies) that include at least E-waste sorting activities. Some recycling facilities may also include E-waste processing;

(g) **Processing facility**: facility(ies) that include E-waste processing only to obtain secondary materials that are equivalent to virgin materials. These facilities do not sort E-waste;

(h) **Manufacturing facility**: end-user of recycled materials or facility(ies) that includes industrial processes which transform the secondary materials that are equivalent to virgin materials sent from recycling or processing facility(ies) into finished products;

(i) **Formal E-waste recycling**: E-waste recycling activities planned, sponsored, financed, carried out or regulated and/or recognized by the formal local authorities or their agents, usually through contracts, licenses or concessions.

5. Baseline methodology

5.1. Project boundary

17. The project boundary is the physical geographical sites of:

(a) Waste collection sites;

(b) The recycling and processing facility(ies) where the E-waste is sorted and processed up to the stage where secondary materials become equivalent to virgin materials;

[8] Directive of the European Union <http://ec.europa.eu/environment/waste/weee/legis_en.htm>.

(c) Virgin material production chain, including mining facilities and refining plants[9].

5.2. Baseline emissions

18. Baseline emissions are determined based on the equation below and include:

(a) For the production of plastics, the emissions associated with energy consumption for the production of plastic pellets from virgin plastic materials;

(b) For the production of metals, emissions associated with energy consumption for the production from virgin materials;

(c) For the production of glass, emissions associated with energy consumption for the production from virgin materials.

$$BE_y = BE_{metals,y} + BE_{plastics,y} + BE_{glass,y} \quad \text{Equation (1)}$$

Where:

BE_y	=	Total baseline emissions in year *y* (tCO_2e)
$BE_{metals,y}$	=	Baseline emissions in year *y* associated with the recycling of metals (tCO_2e)
$BE_{plastics,y}$	=	Baseline emissions in year *y* associated with the recycling of plastics (tCO_2e)
$BE_{glass,y}$	=	Baseline emissions in year *y* associated with the recycling of glass (tCO_2e)

19. Only the baseline emissions which would take place in non-Annex I countries shall be credited. Therefore, in the case where requirements stipulated under paragraph 6 cannot be met, the baseline emissions calculated for the total amount of recycled materials obtained in the project activity are discounted by a correction factor "B_i", calculated as the ratio of the production of the material "*i*" in non-Annex I countries and the total production of this material in the world. See the Table 2 below. These correction factors shall be updated at each renewal of the crediting period, and project participants shall use the values from the latest version of the methodology at renewal of the crediting period.

Table 2. Baseline correction factor for production of ~~metals or plastics~~ materials from virgin materials

~~Metal/Plastic~~Material	B_i correction factor based on the share of the production in non-Annex I countries[a]
Aluminium	0.72
Steel	0.68
Copper	0.75

[9] Virgin material production is formally included in the project boundary, even though it is not necessary to identify the production sites, because the emission reductions are based on the assumption that virgin material production is displaced due to the project activity.

~~Metal/Plastic~~Material	**B_i correction factor based on the share of the production in non-Annex I countries[a]**
Gold	0.68
Silver	0.74
Palladium	0.47
Tin	0.97
Lead	0.69
ABS	0.56
HIPS	0.56
Glass	0.67

(a) For details on how the values of B_i were determined, please refer to Appendix 1.

5.2.1. Baseline emissions associated with the recycling of metals

20. Baseline emissions for the production of primary metals from virgin ~~inputs~~ raw materials ~~metal~~ *i* ~~from inputs~~ are calculated using equation (2).

$$BE_{metals,y} = \sum_i Q_{i,y} \times B_i \times SE_i$$ Equation (2)

Where:

i	=	Indices for metal type *i*
$Q_{i,y}$	=	Quantity of metal type *i* recycled and sent to a processing or manufacturing facility in year *y* (t)[10]
B_i	=	B_i correction factor based on the share of the production in non-Annex I countries
SE_i	=	Specific CO_2e emission factor for production of metal *i*, measured in tCO_2e/t. Take values specified in Table 3

21. Baseline emissions for the production of primary metals from virgin ~~inputs~~ raw materials are calculated making the following conservative assumptions. These values shall be updated at each renewal of the crediting period, and project participants shall use the values from the latest version of the methodology at renewal of the crediting period.

Table 3. Specific CO_2e emission factor for production of metals

Metal	**Specific CO_2e emission factor for production of metals (tCO_2e/tonne of output metal)**
Aluminium	8.40[(a)]

[10] For aluminium and steel which is sent to a processing facility, impurities associated with the metal that is sold should be accounted for and discounted, or a net-to-gross adjustment factor of 0.8 shall be applied to the $Q_{i,y}$.

Metal	Specific CO_2e emission factor for production of metals (tCO_2e/tonne of output metal)
Steel	1.27[(b)]
Copper	2.8
Gold	11,000
Silver	140
Palladium	7,200
Tin	16
Lead	2.1

(a) For details on how the specific CO_2e emission factor for the production of aluminium was determined, please refer to Appendix 2.

(b) For details on how the specific CO_2e emission factor for the production of steel was determined, please refer to Appendix 3.

5.2.2. Baseline emissions associated with the recycling of plastics

22. Baseline emissions for the production of plastic type *i* from virgin ~~inputs~~ materials are calculated based on the consumption of plastics produced in the host party as well as imported, using the following equation:

$$BE_{plastics,y} = \sum_{i} Q_{i,y} \times L_i \times (w_{i,in-country,y} \times SE_{i,in-country,y} + w_{i,imported,y} \times SE_{i,imported,y}$$ Equation (3)

Where:

$BE_{plastics,y}$	=	Baseline emissions for plastics recycling in year *y* (tCO_2/year)
i	=	Indices for material type *i* (i = 1,2 for ABS and HIPS)
$Q_{i,y}$	=	Quantity of plastic type *i* recycled in year *y* (t/y)
L_i	=	Net to gross adjustment factor to cover degradation in material quality and material loss in the processing of the sorted material. Use 0.75 if the recycling facility includes only E-waste sorting; use 1 if the recycling facility includes both E-waste sorting and E-waste processing
$w_{i,in-country,y}$	=	Percentage of plastics produced in the host country out of total plastics consumed in year *y* (%)
$SE_{i,in-country,y}$	=	Specific emissions in the baseline for the production of virgin plastics type *i* in the host party in year *y* (tCO_2/t_i)
$w_{i,imported,y}$	=	Percentage of imported plastics out of total plastics consumed in year *y* (%)
$SE_{i,imported,y}$	=	Specific emissions in the baseline for virgin plastics type *i* imported in year *y* (tCO_2/t_i)

23. Specific emissions in the baseline for the production of virgin plastics type *i* in the host party in year *y* are determined based on the following equation:

$$SE_{i,in-country,y} = \left(SEC_{BL,i} \times EF_{BL,el,y}\right) + \left(SFC_{BL,i} \times EF_{BL,FF,CO2}\right) \qquad \text{Equation (4)}$$

Where:

$SEC_{BL,i}$	=	Specific electricity consumption in the production of virgin material type *i* (MWh/t_i), take value specified in Table 3
$EF_{BL,el,y}$	=	Emission factor for the ~~baseline~~ electricity consumption ~~source~~ for virgin plastics production in the host party (tCO_2/MWh), determined based on paragraph 26
$SFC_{BL,i}$	=	Specific fuel consumption for the production of virgin material type *i* (GJ/t_i), take value as specified in Table 3
$EF_{BL,FF,CO2}$	=	CO_2 emission factor of the baseline fossil fuel (tCO_2/GJ). Project participants shall assume that the baseline fuel is natural gas when it's not possible to identify the type of fuel consumed for the production of plastics from virgin materials

24. Specific emissions in the baseline for virgin plastics type *i* imported in year *y* are determined based on the following equation:

$$SE_{i,imported,y} = \sum_{i} B_i \times \left(SEC_{BL,i} \times EF_{el,imported} + SFC_{BL,i} \times EF_{FF,imported,CO2}\right) \qquad \text{Equation (5)}$$

Where:

B_i	=	Correction factor based on the share of the production in non-Annex I countries. Use values from Table 3
$EF_{el,imported}$	=	Emission factor for the baseline electricity consumption for the portion of plastics that is imported (tCO_2/MWh). Apply a default value of 0.24 tCO_2/MWh
$EF_{FF,imported,CO2}$	=	CO_2 emission factor for fossil fuel (tCO_2e/GJ). Assume that natural gas supplies the energy needed to produce the virgin plastics imported if it is not possible to identify the fuel type

25. The values of the parameters $SEC_{BL,i}$ and $SFC_{BL,i}$ are indicated in the table below:

Table 4. Values of specific energy and fuel consumed for the production of different plastics types from virgin materials

Plastic types	$SEC_{Bl,i}$ (MWh/t_i)[(a)]	$SFC_{Bl,i}$ (GJ/t_i)[(a)]
ABS	1.94	15
HIPS	0.38	15

[(a)] The following conservative assumptions were made:

1. The main components of ABS are ethylene and polypropylene and the main components of HIPS are ethylene, styrene and butadiene.
2. The energy needed for the production of the virgin monomers Ethylene, Propylene Styrene and Butadiene through thermal cracking of olefins is supplied by natural gas;

3. A conservative value of 15 GJ/tons of energy needed to produce ethylene was selected from Table 4.3 of the report "Tracking Industrial Energy Efficiency and CO_2 emissions" prepared by the International Energy Agency (IEA, 2007) and applied for the production of the other monomers;
4. The energy needed for the production of the polymers (polymerization + extrusion) is supplied by electricity. According to the American Chemistry Council – ACC[11]:
   (a) For ABS, a value of electricity consumption equals to 7 GJ (rounded down from 7.09 GJ from grid + 0.32 GJ from cogeneration), converted to 1.94 MWh/t, was taken from Table J-3;
   (b) For HIPS, a value of electricity consumption equals to 1.35 GJ (1.24 GJ from grid + 0.11 GJ from cogeneration), converted to 0.38 MWh/t, was taken from Table H-4.
5. The remaining steps of virgin pellet production (melting and shaping, pelletizing, compounding) require relatively negligible amounts of energy and hence are ignored.

26. The emission factor for the baseline electricity consumption source for virgin plastics production in the host country (parameter $EF_{BL,el,y}$) shall be determined based on the weighted average consumption of electricity from the electric grid(s) and from captive power plant(s) as indicated in the equation below. Project participants may choose to fix this parameter ex ante and update at the renewal of the crediting period or monitor this parameter ex post. If the parameter is fixed ex ante, it shall be calculated using the most recent data available. Otherwise, a default value of 0.24 tCO_2/MWh[12] shall be applied:

$$EF_{BL,el,y} = \frac{\sum_k EF_{BL,grid,k,y} \times EC_{BL,grid,k,y} + \sum_j EF_{BL,captive,j,y} \times EC_{BL,captive,j,y}}{\sum_k EC_{BL,grid,k,y} + \sum_j EC_{BL,captive,j,y}}$$ Equation (6)

Where:

$EF_{BL,grid,k,y}$	=	Emission factor of the grid *k* supplying electricity to produce virgin plastics in the host country in year *y* (tCO_2/MWh)
$EC_{BL,grid,k,y}$	=	Electricity consumed from the grid *k* to produce virgin plastics in the host country in year *y* (MWh)
$EF_{BL,captive,j,y}$	=	Emission factor of the captive power plant *j* supplying electricity to produce virgin plastics in the host country (tCO_2/MWh)
$EC_{BL,captive,j,y}$	=	Electricity consumed from the captive power plant *j* to produce virgin plastics in the host country in year *y* (MWh)

27. If the project participants cannot identify the sources to determine the baseline emissions from plastics produced in the host party, a simplified approach can be applied assuming that all plastics consumed in the host party is imported and a weight of 0 is assigned to $w_{produced,y}$ and 1 to $w_{import,y}$ in equation 4.

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[11] Cradle-to-Gate Life Cycle Inventory of Nine Plastic Resins and Four Polyurethane Precursors, prepared by Franklin Associates for the Plastics Division of the *American Chemistry Council (ACC)*. Available at <https://plastics.americanchemistry.com/LifeCycle-Inventory-of-9-Plastics-Resins-and-4-Polyurethane-Precursors-APPS-Only/>, accessed on 12 May 2021.

[12] This default value is determined assuming electricity is supplied by a natural gas cogeneration plant with an efficiency of 83% (the efficiency is sourced from the Table 2 of the Appendix of the "TOOL09: Determining the baseline efficiency of thermal or electric energy generation systems").

5.2.3. Baseline emissions associated with the recycling of glass

28. Baseline emissions for the production of glass from virgin materials are calculated using following equation:

$$BE_{glass,y} = Q_{glass,y} \times L_{glass} \times B_i \times SEC_{Bl,glass} \times EF_{el,PJ,y} \qquad \text{Equation (7)}$$

Where:

$Q_{glass,y}$	=	Quantity of glass cullets recycled by the project activity in year *y* (t)
L_{glass}	=	Net to gross adjustment factor to cover degradation in material quality and material loss in the production process of the final product using the recycled material (use 0.88)
$SEC_{Bl,glass}$	=	Specific electricity consumption for the production of raw materials displaced by the glass recycling (MWh/t)
$EF_{el,PJ,y}$	=	Emission factor of the electric grid supplying electricity to the recycling facility in year *y* (tCO_2/MWh)

29. The following conservative assumptions were made to determine the baseline emissions for the production of glass from virgin raw materials:

(a) Glass cullets will displace only the preparation and mixing of raw materials before the melting stage;

(b) The only source of energy consumed by the preparation and mixing of raw materials is electricity – no fossil-fuels are used.

30. The remaining steps of glass production are not considered because the use of glass cullets does not avoid melting and the subsequent steps of the glass manufacturing process (i.e. forming and post-forming).

31. For the specific electricity consumption (SEC), representative regional/local values may be used. If regional/local data are not available, a default value of 0.026 MWh/t_{glass} shall be used [13].

5.3. Project emissions

32. Project emissions are calculated using the equation below. As per paragraph 5, if project proponents exclude copper and noble metals (i.e. gold, silver and palladium) from the baseline calculation, they may also exclude them from the project emission calculation:

$$PE_y = PE_{r,y} + PE_{p,y} \qquad \text{Equation (8)}$$

Where:

PE_y	=	Project emissions in year *y* (tCO_2e)

[13] Methods for calculating SEC values can be found in the document *"Revision of AMS-III.AJ methodology to cover glass – Conservativeness study for the baseline calculation"*, prepared by ALLCOT Group, available at http://cdm.unfccc.int/UserManagement/FileStorage/NC0TF6YEJU8GMVIK49D1LBSWP3HRO2.

$PE_{r,y}$	=	Project emissions from sorting and processing of E-waste in the recycling facility in year *y* (tCO_2e)
$PE_{p,y}$	=	Project emissions from processing of E-waste in the third party processing facility in year *y* (tCO_2e). For project activities where the recycling facility includes E-waste sorting and processing, this parameter is equal to 0

5.3.1. Case A: E-waste is sorted and processed up to the production of the virgin-equivalent material in the recycling facility

33. For projects that fall under Case A, project emissions are calculated using the following equation:

$$PE_{r,y} = EC_{PJ,y} \times EF_{el,PJ,y} + \sum_{f} \left(FC_{f,PJ,y} \times NCV_{f,y} \times EF_{f,CO2,y} \right)$$ Equation (9)

Where:

$EC_{PJ,y}$	=	Electricity consumed by the recycling facility in year *y* (MWh)
$EF_{el,PJ,y}$	=	Emission factor of the ~~electric grid supplying electricity to project~~ electricity consumption at the recycling facility in year *y* (tCO_2/MWh)
$FC_{f,i,PJ,y}$	=	Fossil fuel type *f* consumed by the recycling facility in year *y* (unit of mass or volume)
$NCV_{f,y}$	=	Net caloric value of the fossil fuel consumed by the recycling facility in year *y* (GJ/unit of mass or volume)
$EF_{,CO2,y}$	=	CO_2 emission factor of the fossil fuel consumed by the recycling facility in year *y* (tCO_2/GJ)

34. If the recycling plant is claiming emission reductions for only part of recycled materials (e.g. only for plastics and not for metals), project emissions may be allocated to each mass unit of segregated material by gross sales revenues, that is apportioning the emissions proportional to the market prices of plastics and their respective throughput. The market prices may be either monitored ex post or be determined once for the crediting period. This rule can be applied only if transparent and reliable information on market prices is available. The following formulas may be used to allocate electricity and fuel consumption to each mass unit of recycled materials *i* by market prices and to calculate project emissions:

$$EC_{i,PJ,y} = EC_{PJ,y} \times \frac{Q_{i,y} \times \$_{i,y}}{\sum_s \left(Q_{s,y} \times \$_{s,y} \right)}$$ Equation (10)

$$FC_{f,i,PJ,y} = FC_{f,PJ,y} \times \frac{Q_{i,y} \times \$_{i,y}}{\sum_s \left(Q_{s,y} \times \$_{s,y} \right)}$$ Equation (11)

$$PE_{r,y} = \sum_{i} Q_{i,y} \times \left[EC_{i,PJ,y} \times EF_{el,PJ,y} + \sum_{f} \left(FC_{f,i,PJ,y} \times NCV_{f,y} \times EF_{f,CO2,y} \right) \right]$$ Equation (12)

Where:

i	=	Indices for output material type *i* (metals and plastics listed at paragraph (4(a))
s	=	Indices for each material sorted at the recycling facility
$EC_{i,PJ,y}$	=	Share of electricity consumption of the recycling facility apportioned to the production of the output material type *i* in year *y* (MWh)
$FC_{f,i,PJ,y}$	=	Share of fossil fuel type *f* consumption at the recycling facility apportioned to the production of the output material type *i* in year *y* (unit mass or volume)
$Q_{s,y}$	=	Quantity of material type *s* recycled in the recycling facility in year *y* (t)
$\$_{i,y}$	=	Market price of the recycled material type *i* in year *y*
$\$_{s,y}$	=	Market price of the recycled material type *r* in year *y*

5.3.2. Case B: E-waste is only sorted in the recycling facility and is further processed up to the production of the virgin-equivalent material in third-parties facilities

35. For projects that fall under Case B, project emissions from the sorting of E-waste are determined based on equations from item 5.4.1, where $EC_{PJ,y}$ and $FC_{f,PJ,y}$ represent the consumption of electricity and fuel for the sorting process only.

36. Project emissions from processing of E-waste in third parties processing facility are calculated using the following equation:

$$PE_{p,y} = \sum_{i} Q_{i,y} \times EFP_{i} \times EF_{el,PJ,y}$$ Equation (13)

Where:

EFP_{i}	=	Energy consumption factor for E-waste processing of material *i* (MWh/t). Use values provided below

Table 5. Specific energy consumption factor for E-waste processing (MWh/t)

~~Metal/Plastic~~ Material	Specific energy consumption ~~factor~~ for E-waste processing (MWh/t)
Aluminium	0.66
Steel	0.90
ABS	0[14]
HIPS	0[14]

5.4. Leakage

37. No leakage due to project activities is expected, therefore no calculation is required.

5.5. Emission reductions

38. The emission reductions achieved by the project activity shall be determined as the difference between the baseline emissions and the project emissions and leakage using the following equation:

$$ER_y = BE_y - PE_y - LE_y \tag{14}$$

Where:

ER_y	=	Emission reductions in year *y* (tCO_2e)
BE_y	=	Baseline emissions in year *y* (tCO_2e)
PE_y	=	Project emissions in year *y* (tCO_2e)
LE_y	=	Leakage emissions in year *y* (tCO_2e)

6. Monitoring methodology

6.1. List of parameters monitored

Data / Parameter table 1.

Data / Parameter:	$Q_{i,y}$
Data unit:	Metric tons
Description:	Quantity of material *i* recycled and sent to a processing or manufacturing facility in year *y* (i=1,2,3,4,5,6,7,8,9,10 for aluminium, steel, copper, gold, silver, palladium, tin, lead, ABS and HIPS)
Source of data:	Records of material recycled at the recycling facility
Measurement procedures (if any):	Direct weighing and recording of the weight, cross check with company records e.g. invoices

[14] As per AMS-III.AJ., emissions associated with transportation of recyclable materials and processing/manufacturing under the project activity are considered as equivalent to the corresponding emissions for the virgin materials and therefore ignored in this methodology.

Monitoring frequency:	Each time the sorted/processed material leaves the recycling facility
QA/QC procedures:	Records are cross-checked against sales receipts
Any comment:	-

Data / Parameter table 2.

Data / Parameter:	$Q_{glass,y}$
Data unit:	Metric tons
Description:	Quantity of glass recycled and sent to a processing or manufacturing facility in year *y*
Source of data:	Records of material recycled at the recycling facility
Measurement procedures (if any):	Direct weighing and recording of the weight, cross check with company records e.g. invoices
Monitoring frequency:	Each time the sorted/processed material leaves the recycling facility
QA/QC procedures:	Records are cross-checked against sales receipts
Any comment:	-

Data / Parameter table ~~2~~ 3.

Data / Parameter:	$w_{i,in-country,y}$
Data unit:	%
Description:	Percentage of plastics produced in the host party out of total plastics consumed in year *y*
Source of data:	Sectoral reports, peer-reviewed studies or national/sectoral statistics
Measurement procedures (if any):	-
Monitoring frequency:	Annual
QA/QC procedures:	-
Any comment:	-

Data / Parameter table ~~3~~ 4.

Data / Parameter:	$w_{i,imported,y}$
Data unit:	%
Description:	Percentage of imported plastics out of total plastics consumed in year *y*
Source of data:	Sectoral reports, peer-reviewed studies or national/sectoral statistics
Measurement procedures (if any):	-
Monitoring frequency:	Annual
QA/QC procedures:	-
Any comment:	-

Data / Parameter table ~~4~~ 5.

Data / Parameter:	$EF_{BL,grid,k,y}$
Data unit:	tCO_2/MWh
Description:	Emission factor of the electric grid supplying electricity to the recycling facility in year *y*
Source of data:	The monitoring provisions of the parameter $EF_{grid,CM,y}$ from the latest version of the TOOL07 apply
Measurement procedures (if any):	The monitoring provisions of the parameter $EF_{grid,CM,y}$ from the latest version of the TOOL07 apply
Monitoring frequency:	The monitoring provisions of the parameter $EF_{grid,CM,y}$ from the latest version of the TOOL07 apply
QA/QC procedures:	The monitoring provisions of the parameter $EF_{grid,CM,y}$ from the latest version of the TOOL07 apply
Any comment:	The monitoring provisions of the parameter $EF_{grid,CM,y}$ from the latest version of the TOOL07 apply

Data / Parameter table ~~5~~ 6.

Data / Parameter:	$EF_{el,PJ,y}$
Data unit:	tCO_2/MWh
Description:	Emission factor of the electric grid supplying electricity to the recycling facility in year *y*
Source of data:	The monitoring provisions of the parameter $EF_{grid,CM,y}$ from the latest version of the TOOL07 apply
Measurement procedures (if any):	The monitoring provisions of the parameter $EF_{grid,CM,y}$ from the latest version of the TOOL07 apply
Monitoring frequency:	The monitoring provisions of the parameter $EF_{grid,CM,y}$ from the latest version of the TOOL07 apply
QA/QC procedures:	The monitoring provisions of the parameter $EF_{grid,CM,y}$ from the latest version of the TOOL07 apply
Any comment:	The monitoring provisions of the parameter $EF_{grid,CM,y}$ from the latest version of the TOOL07 apply

Data / Parameter table ~~6~~7.

Data / Parameter:	$EC_{BL,grid,k,y}$
Data unit:	MWh
Description:	Electricity consumed from the grid *k* to produce virgin plastics in the host country in year *y*
Source of data:	The monitoring provisions of the parameter $EC_{BL,k,y}$ from the latest version of the TOOL05 apply
Measurement procedures (if any):	The monitoring provisions of the parameter $EC_{BL,k,y}$ from the latest version of the TOOL05 apply
Monitoring frequency:	The monitoring provisions of the parameter $EC_{BL,k,y}$ from the latest version of the TOOL05 apply
QA/QC procedures:	The monitoring provisions of the parameter $EC_{BL,k,y}$ from the latest version of the TOOL05 apply

Any comment:	The monitoring provisions of the parameter $EC_{BL,k,y}$ from the latest version of the TOOL05 apply

Data / Parameter table ~~7~~8.

Data / Parameter:	$EF_{BL,captive,j,y}$
Data unit:	tCO_2/MWh
Description:	Emission factor of the captive power plant *j* supplying electricity to produce virgin plastics in the host country
Source of data:	The provisions to determine the parameter $EF_{EL,k,y}$ from the latest version of the TOOL05 apply
Measurement procedures (if any):	The monitoring provisions of the parameter $EF_{EL,k,y}$ from the latest version of the TOOL05 apply
Monitoring frequency:	The monitoring provisions of the parameter $EF_{EL,k,y}$ from the latest version of the TOOL05 apply
QA/QC procedures:	The monitoring provisions of the parameter $EF_{EL,k,y}$ from the latest version of the TOOL05 apply
Any comment:	The monitoring provisions of the parameter $EF_{EL,k,y}$ from the latest version of the TOOL05 apply

Data / Parameter table ~~8~~9.

Data / Parameter:	$EC_{BL,captive,j,y}$
Data unit:	MWh
Description:	Electricity consumed from the captive power plant *j* to produce virgin plastics in the host country in year *y*
Source of data:	The monitoring provisions of the parameter $EC_{BL,k,y}$ from the latest version of the TOOL05 apply
Measurement procedures (if any):	The monitoring provisions of the parameter $EC_{BL,k,y}$ from the latest version of the TOOL05 apply
Monitoring frequency:	The monitoring provisions of the parameter $EC_{BL,k,y}$ from the latest version of the TOOL05 apply
QA/QC procedures:	The monitoring provisions of the parameter $EC_{BL,k,y}$ from the latest version of the TOOL05 apply
Any comment:	The monitoring provisions of the parameter $EC_{BL,k,y}$ from the latest version of the TOOL05 apply

Data / Parameter table ~~9~~10.

Data / Parameter:	$EC_{PJ,y}$
Data unit:	MWh
Description:	Electricity consumed by the recycling facility in year *y*
Source of data:	The monitoring provisions of the parameter $EC_{PJ,j,y}$ from the latest version of the TOOL05 apply
Measurement procedures (if any):	The monitoring provisions of the parameter $EC_{PJ,j,y}$ from the latest version of the TOOL05 apply.
Monitoring frequency:	The monitoring provisions of the parameter $EC_{PJ,j,y}$ from the latest version of the TOOL05 apply

QA/QC procedures:	The monitoring provisions of the parameter $EC_{PJ,j,y}$ from the latest version of the TOOL05 apply
Any comment:	-

Data / Parameter table ~~10~~11.

Data / Parameter:	$FC_{f,PJ,y}$
Data unit:	As per the latest version of the “TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”
Description:	Fossil fuel type *f* consumption of the recycling facility in year *y*
Source of data:	-
Measurement procedures (if any):	As per the latest version of “TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” When applying the tool, requirements for $FC_{i,j,y}$ should apply to the total fossil fuel consumption at the recycling facility
Monitoring frequency:	As per the latest version of “TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”
QA/QC procedures:	As per the latest version of “TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”
Any comment:	-

Data / Parameter table ~~11~~12.

Data / Parameter:	$NCV_{f,y}$
Data unit:	As per the latest version of the “TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”
Description:	Net calorific value of the fossil fuel type *f* consumed in the recycling facility in year *y*
Source of data:	-
Measurement procedures (if any):	As per the latest version of “TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” When applying the tool, requirements for $NCV_{i,y}$ should apply for the net calorific value of the fossil fuel consumed in the recycling facility
Monitoring frequency:	As per the latest version of “TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”
QA/QC procedures:	As per the latest version of “TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”
Any comment:	-

Data / Parameter table ~~12~~13.

Data / Parameter:	$\boldsymbol{EF_{f,CO2}}$; $\boldsymbol{EF_{BL,FF,CO2}}$
Data unit:	As per the latest version of the “TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”

Description:	$EF_{f,CO2}$: CO_2 emission factor of the fossil fuel type *f* consumed at the recycling facility in year *y* $EF_{BL,FF,CO2}$: CO_2 emission factor of the baseline fossil fuel
Source of data:	-
Measurement procedures (if any):	As per the latest version of "TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" When applying the tool, requirements for $EF_{CO2,i,y}$ should apply for the CO_2 emission factor of the fossil fuel consumed at the recycling facility and for the CO_2 emission factor of the baseline fossil fuel
Monitoring frequency:	As per the latest version of "TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"
QA/QC procedures:	As per the latest version of "TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"
Any comment:	-

Data / Parameter table ~~13~~14.

Data / Parameter:	$\$_{i,y}$ and $\$_{r,y}$
Data unit:	Market Currency
Description:	Market price of materials type *i* or material *r* in year *y*
Source of data:	-
Measurement procedures (if any):	Cross check with sale invoices/receipts
Monitoring frequency:	As per section 5.3.2
QA/QC procedures:	-
Any comment:	-

Data / Parameter table ~~14~~15.

Data / Parameter:	Source of material recycled
Data unit:	-
Description:	Evidence that the materials recycled under the project activity are post-consumer obsolete scrap and are recovered only from end-of-life E-wastes
Source of data:	-
Measurement procedures (if any):	As per applicability condition 3(h), e.g. the PDD shall describe the collecting area and identifiable sources of the E-wastes for each recycling plant
Monitoring frequency:	-
QA/QC procedures:	-
Any comment:	-

6.2. Project activity under a programme of activities

39. The methodology is applicable to a programme of activities; no additional leakage estimations are necessary other than that indicated under leakage section above.

Appendix 1. Determination of the baseline correction factor for the share of production of metals, plastics and glass in non-Annex I countries

1. Aluminium

1. Data used to calculate the share of production of aluminium in non-Annex I countries were sourced from the statistics provided by the International Aluminium Institute[1] with the following assumptions:

    (a) Data from 2016 on global aluminium production was used;

    (b) Production in Non-Annex I countries considered those from Africa, Asia (ex China), China Reported, GCC – Gulf Cooperation Council and South America;

    (c) Production in Annex I countries considered those from East & Central Europe, North America, Oceania, West Europe, China Estimated Unreported and Rest of World (ROW) Estimated Unreported (for conservative reasons, these last two production amounts were included as production in Annex I).

2. The results are illustrated in the table below:

Table 1. Share of production of Aluminium in Annex I and non-Annex I countries

Region	Primary Aluminium Production on 2016 (1,000 tons)	Annex I (AI) or Non-Annex I (NAI)	Share of Production
Africa	1,691	NAI	72.35%
Asia (ex China)	3,442		
China	31,641		
GCC	5,197		
South America	1,361		
China Estimated Unreported	1,000	AI	27.65%
East & Central Europe	3,981		
North America	4,027		
Oceania	1,971		
ROW Estimated Unreported	1,800		
West Europe	3,779		

[1] <http://www.world-aluminium.org/statistics/>.

2. Steel

3. Data used to calculate the share of production of steel in non-Annex I countries in 2016 were sourced from the publication *World Steel in Figures 2017*[2], prepared by the World Steel Association, and the results are illustrated in the table below.

Table 2. Share of production of crude steel in Annex I and non-Annex I countries

Region	Annex I (AI) or Non-Annex I (NAI)	Share of Production
Argentina, Brazil, China, Colombia, Egypt, India, Indonesia, Iran, Malaysia, Mexico, North Korea, Oman, Pakistan, Peru, Qatar, Saudi Arabia, Serbia, South Africa, South Korea, Taiwan, Thailand, United Arab Emirates	NAI	68.72%
Australia, Austria, Belgium, Byelorussia, Canada, Czech Republic, Finland, France, Germany, Hungary, Italy, Japan, Kazakhstan, Luxembourg, Netherlands, OTHERS[3], Poland, Portugal, Romania, Russia, Slovak Republic, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, United States	AI	31.28%

3. Plastics

4. Data used to calculate the share of production of plastics in non-Annex I countries were sourced from the 2016 statistics provided by the Plastics Europe – Association of Plastic Manufacturers[4] with the following assumptions:

(a) Data from 2016 on global plastics production was used;

(b) The production encompasses all types of plastics, including ABS, HIPS, PET, HDPE, LDPE and PP;

(c) Production in Annex I countries considered those from NAFTA, Europe, CIS and Japan;

(d) Production in Non-Annex I countries considered those from Latin America, Middle-East, Africa, Rest of Asia and China.

[2] <https://www.worldsteel.org/en/dam/jcr:0474d208-9108-4927-ace8-4ac5445c5df8/World+Steel+in+Figures+2017.pdf>, page 9.

[3] Included as Annex I for conservative reasons.

[4] <http://www.plasticseurope.org/cust/documentrequest.aspx?DocID=67651, page 13>.

5. The results are illustrated in the table below.

Table 3. Share of production of plastics in Annex I and non-Annex I countries

Region	Annex I (AI) or Non-Annex I (NAI)	Share of Production
Latin America	NAI	56.10%
Middle East, Africa		
China		
Rest of Asia		
NAFTA	AI	43.90%
CIS		
Europe		
Japan		

4. Copper

6. Data used to calculate the share of mining of copper in non-Annex I countries were sourced from the statistics provided by the United States Geological Survey[5] using data from 2015. The results are illustrated in the table below.

Table 4. Share of production of copper (mining) in Annex I and non-Annex I countries

Country	Annex I (AI) or Non-Annex I (NAI)	Share of Productio n
Albania, Argentina, Armenia, Azerbaijan, Bolivia, Botswana, Brazil, Burma, Chile, China, Colombia, Congo, Dominican Republic, Georgia, India, Indonesia, Iran, Kazakhstan, Korea, North, Laos, Macedonia, Mauritania, Mexico, Mongolia, Morocco, Namibia, Oman, Pakistan, Papua New Guinea, Peru, Philippines, Saudi Arabia, Serbia, South Africa, Tanzania, Uzbekistan, Vietnam, Zambia, Zimbabwe	NAI	75.3%
Australia, Bulgaria, Canada, Cyprus, Finland, Poland, Portugal, Romania, Russia, Spain, Sweden, Turkey, United States	AI	24.7%

5. Gold

7. Data used to calculate the share of mining of gold in non-Annex I countries were sourced from the statistics provided by the United States Geological Survey[6] using data from 2015. The results are illustrated in the table below.

[5] Adapted from Table T20, available at: <https://minerals.usgs.gov/minerals/pubs/commodity/copper/myb1-2015-coppe.xlsx>.

[6] Adapted from Table T8, available at: <https://minerals.usgs.gov/minerals/pubs/commodity/gold/myb1-2015-gold.xls>.

Table 5. Share of production of gold (mining) in Annex I and non-Annex I countries

Country	Annex I (AI) or Non-Annex I (NAI)	Share of Production
Afghanistan, Algeria, Argentina, Armenia, Azerbaijan, Bolivia, Botswana, Brazil, Burkina Faso, Burma, Burundi, Cameroon, Central African Republic, Chile, China, Colombia, Republic of Congo, DR Congo, Costa Rica, Côte d'Ivoire, Dominican Republic, Ecuador, Egypt, Eritrea, Ethiopia, Fiji, Gabon, Georgia, Ghana, Guatemala, Guinea, Guyana, Honduras, India, Indonesia, Iran, Kazakhstan, Kenya, Republic of Korea, Kyrgyzstan, Laos, Liberia, Madagascar, Malaysia, Mali, Mauritania, Mexico, Mongolia, Morocco, Mozambique, Namibia, Nicaragua, Niger, Nigeria, Panama, Papua New Guinea, Peru, Philippines, Rwanda, Saudi Arabia, Senegal, Serbia, Sierra Leone, Solomon Islands, South Africa, Sudan, Suriname, Tajikistan, Tanzania, Thailand, Togo, Uganda, Uruguay, Uzbekistan, Venezuela, Vietnam, Zambia, Zimbabwe	NAI	68.71%
Australia, Bulgaria, Canada, Denmark, Finland, French Guiana, Greece, Italy, Japan, New Zealand, Poland, Russia, Slovakia, Spain, Sweden, Turkey, United Kingdom, United States	AI	31.29%

6. Silver

8. Data used to calculate the share of mining of silver in non-Annex I countries were sourced from the statistics provided by the United States Geological Survey[7] using data from 2014. The results are illustrated in the table below.

Table 6. Share of production of silver (mining) in Annex I and non-Annex I countries

Country	Annex I (AI) or Non-Annex I (NAI)	Share of Production
Algeria, Argentina, Armenia, Azerbaijan, Bolivia, Botswana, Brazil, Burkina Faso, Chile, China, Colombia, DR Congo, Côte d'Ivoire, Dominican Republic, Ecuador, Eritrea, Ethiopia, Fiji, Georgia, Ghana, Guatemala, Honduras, India, Indonesia, Kazakhstan, Korea PDR, Republic of Korea, Laos, Malaysia, Mexico, Mongolia, Morocco, Namibia, Nicaragua, Niger, Oman, Pakistan, Panama, Papua New Guinea, Peru, Philippines, Saudi Arabia, Serbia, Solomon Islands, South Africa, Sudan, Tajikistan, Tanzania, Thailand, Uzbekistan, Zambia, Zimbabwe	NAI	74.8%
Australia, Bulgaria, Canada, Finland, Greece, Ireland, Japan, New Zealand, Poland, Portugal, Romania, Russia, Slovakia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States	AI	25.2%

[7] Adapted from Table T8, available at: <https://minerals.usgs.gov/minerals/pubs/commodity/silver/myb1-2014-silve.xlsx>.

7. Tin

9. Data used to calculate the share of mining of tin in non-Annex I countries were sourced from the statistics provided by the United States Geological Survey[8] using data from 2015. The results are illustrated in the table below.

Table 7. Share of production of tin (mining) in Annex I and non-Annex I countries

Country	Annex I (AI) or Non-Annex I (NAI)	Share of Production
Bolivia, Brazil, Burma, Burundi, China, DR Congo, Indonesia, Laos, Malaysia, Nigeria, Peru, Rwanda, Thailand, Uganda, Vietnam	NAI	97.54%
Australia, Portugal, Russia	AI	2.46%

8. Lead

10. Data used to calculate the share of mining of lead in non-Annex I countries were sourced from the statistics provided by the United States Geological Survey[9] using data from 2015. The results are illustrated in the table below.

Table 8. Share of production of lead (mining) in Annex I and non-Annex I countries

Country	Annex I (AI) or Non-Annex I (NAI)	Share of Production
Argentina, Bolivia, Bosnia and Herzegovina, Brazil, Burma, Chile, China, Honduras, India, Iran, Kazakhstan, Korea PDR, Republic of Korea, Macedonia, Mexico, Morocco, Namibia, Peru, South Africa, Tajikistan, Vietnam	NAI	69.61%
Australia, Bulgaria, Canada, Greece, Ireland, Italy, Poland, Russia, Spain, Sweden, Turkey, United Kingdom, United States	AI	30.39%

[8] Adapted from Table T9, available at: <https://minerals.usgs.gov/minerals/pubs/commodity/tin/myb1-2015-tin.xls>.

[9] Adapted from Table T11, available at: <https://minerals.usgs.gov/minerals/pubs/commodity/lead/myb1-2015-lead.xls>.

Appendix 2. Determination of the specific CO_2e emission factors for the production of aluminium

1. Greenhouse gas emissions are associated with the consumption of electricity and fossil fuel for the production of primary aluminium. For conservative reasons, upstream process emissions associated with the production of PFC in the anode are not considered.

1. Determination of specific CO_2 emission factor associated with electricity consumption for Al production

2. To calculate the specific CO_2 emission factor per ton of aluminium associated with the consumption of electricity, global data from the International Aluminium Institute (IAI) were used:

    (a) 596,781 GWh of electricity[1] were consumed from non-Annex I countries to produce 42,724,898 tonnes of aluminium in 2016;

    (b) The electricity consumed from the different sources (grid and captive) in 2016[1] were:

        (i) Hydro: 78,646 GWh;

        (ii) Other renewable: 10 GWh;

        (iii) Nuclear: 80 GWh;

        (iv) Coal: 445,810 GWh;

        (v) Oil: 278 GWh;

        (vi) Natural Gas: 71,918 GWh.

    (c) The CO_2 emissions associated with the combustion of fossil fuel to generate electricity were determined by (i) dividing the electricity consumed by the efficiency of the best available technology[2] for each type of fuel consumed, and (ii) multiplying these results by 3.6 (conversion from GWh to TJ) and by the CO_2

[1] Source: <http://www.world-aluminium.org/statistics/primary-aluminium-smelting-power-consumption/#data>. Table 2 from the "Life Cycle Inventory Data and Environmental Metrics for the Primary Aluminium Industry" (available at <http://www.world-aluminium.org/media/filer_public/2017/06/28/lca_report_2015_final.pdf>) indicates the share of the different power sources in the different regions.

[2] Source: Table 2 from the Appendix of the TOOL09: "Determining the baseline efficiency of thermal or electric energy generation systems" (if available for the type of power plant).

emission factor[3] of the different types of fuel. The results are illustrated in the table below:

Table 1. Calculation of CO_2 emitted by different power plants supplying electricity to the aluminium industry in 2016

Electricity Source	Electricity consumed (GWh) A	Efficiency of the best available technology B	EF_{CO2} (tCO_2e/TJ) C	CO_2 emitted (tCO_2) D = A / B x 3.6 x C
Hydro	78,646	-	-	-
Other renewable	10	-	-	-
Nuclear	80	-	-	-
Coal	445,810	50% (Ultra-supercritical plant, built after 2012)	94.6	303,650,107
Oil	278	62% (Combined cycle gas turbine plant, built after 2012)	75.5	121,872
Natural Gas	71,918	62% (Combined cycle gas turbine plant, built after 2012)	54.3	22,675,049
TOTAL CO_2 EMITTED (tons)				**326,447,028**

(d) Finally, the specific global CO_2 emission factor (i.e., emissions from electricity consumed to produce one tonne of aluminium) is calculated by dividing the total CO_2 emitted (326,447,028 tCO_2) by the total aluminium produced in non-Annex I countries (42,724,898 tonnes), resulting in **7.64 $tCO_2/t_{Aluminium}$**.

2. Determination of specific CO_2e emission factor associated with fossil fuel consumption for Al production

3. To calculate the specific emissions associated with the consumption of fuel, data from the International Aluminium Institute (IAI) and IPCC were used:

(a) The specific consumption of different types of fuel to produce aluminium on 2016[1] were:

(i) Heavy oil: 57.77 $kg/t_{Aluminium}$;

(ii) Diesel oil: 2.37 $kg/t_{Aluminium}$;

(iii) Natural gas: 172.41 $m^3/t_{Aluminium}$;

(iv) Coal: 569.36 $kg/t_{Aluminium}$.

(b) The CO_2 emissions associated with the combustion of fossil in the aluminium production process in non-Annex I countries were determined by multiplying the

[3] Source: Table 2.2 from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Chapter 2.

specific fuel consumed by the NCV and CO_2 emission factor of each fuel. The results are illustrated in the table below.

Table 2. Calculation of CO_2 emitted from the use of fuel in the production of aluminium

Fuel type	2016 specific consumption[4] A	NCV fuel (GJ/Mg)[5] B	EF_{CO2} ($kgCO_2/GJ$) C	Specific CO_2 emission factor ($tCO_2/t_{Aluminium}$) D = A / 1,000,000 x B x C
Heavy oil	365.04 $kg/t_{Aluminium}$	39.8	72.6	1.05
Diesel	0.39 $kg/t_{Aluminium}$	41.1	75.5	0.00
Natural Gas	322.13 $m^3/t_{Aluminium}$ (225.49 $kg/t_{Aluminium}$)[6]	46.5	54.3	0.57
Coal	1,560.84 $kg/t_{Aluminium}$	21.6	94.6	3.19
TOTAL SPECIFIC CO_2 EMISSION FACTOR (tonnes)				**4.81**

3. Determination of overall specific CO_2e emission factor associated with the aluminium production associated with the consumption of energy

4. The specific CO_2e emission factor associated with the production of primary aluminium from virgin material is sum of emission factors from electricity and fuel consumed determined in the sections above i.e., equal to 7.64 + 4.81, resulting in 12.45 $tCO_2e/t_{Aluminium}$. However, this emission factor needs to be adjusted to account for that around 32.5%[7] of the aluminium produced globally is recycled to the process. Therefore, the specific CO_2e emission factor associated with the production of virgin aluminium is equal to 0.675 x 12.45 = **8.40 $tCO_2e/t_{Aluminium}$**.

[4] Source: IAI – International Aluminium Institute, Appendix A from the 2015 Life Cycle Inventory Data and Environmental Metrics (2017), available at: <http://www.world-aluminium.org/media/filer_public/2017/07/04/appendix_a_-_life_cycle_inventory.xlsx>.

[5] Source: Table 1.2 from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Chapter 1.

[6] Assuming a density of NG equals to 0.7 kg/Nm3, at 0ºC and 1 atm (source: <https://www.engineeringtoolbox.com/gas-density-d_158.html>).

[7] Source: IAI – International Aluminium Institute, Global Aluminium Cycle 2015, available at: <http://www.world-aluminium.org/statistics/massflow/>.

Appendix 3. Determination of the specific CO_2 emission factor for the production of steel

1. Greenhouse gas emissions are associated with the production of pig iron (in processes using advanced blast furnace) and sponge iron (in processes using direct reduction iron consuming natural gas). Upstream process emissions associated with these production processes are not considered for conservativeness. Similarly, the avoided downstream process emissions in BOF (Basic Oxygen Furnace) and EAF (Electric Arc Furnace) associated with physically embedded carbon are ignored.

2. The specific CO_2 emissions for the production of steel from pig iron and sponge iron is determined as the weighted average of the specific emissions of each process (blast furnace and direct iron reduction) based on the share of global production of each process. The table below illustrates the specific emissions, the global share of production of each process and the weighted average specific CO_2 emissions:

Table. Calculation of the specific CO_2 emissions for the production of steel through the advanced blast furnace and DRI processes

Steel product	Specific CO_2 emissions (tCO_2/t_{steel})[a]	Global share of production[b]	Weighted average CO_2 emission factor (tCO_2/t_{steel})
Pig Iron (Advanced Blast furnace)	1.3	0.95	1.27
Sponge Iron (natural gas based DRI)	0.7	0.05	

[a] Source: Table A.III.8, Annex III of the IPCC Fifth Assessment Report – Working Group III, based on the lower bound value determined by IEA (International Energy Agency).

[b] Source: Tables from pages 18 and 19 of the “World Steel in Figures 2017”, report prepared by the World Steel Association, available at <https://www.worldsteel.org/en/dam/jcr:0474d208-9108-4927-ace8-4ac5445c5df8/World+Steel+in+Figures+2017.pdf>.

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Document information

Version	*Date*	*Description*
04.0	6 May 2025	MP 97, Annex 3 To be considered by the Board at EB 125. Revision to include glass as recycling material.
03.0	9 September 2021	EB 111, Annex 9 Revision to ensure consistent methods in determining the emission factors associated with the consumption of fossil fuel and with the consumption of electricity in the production of virgin plastics.
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