CLEAN DEVELOPMENT MECHANISM

AMS-III.BA.

Small-scale Methodology

Recovery and recycling of materials from E-waste

Version 02.0

Sectoral scope(s): 13

United Nations
Framework Convention on
Climate Change

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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
Type of GHG emissions mitigation action	Energy efficiency: Reduction of production of metals and plastics 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] 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;

(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;

[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.

(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);

(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 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 produced from E-waste recycling are the same as those of the metals and plastics from virgin materials. For recycled metals and plastics, project proponents shall provide documentation (e.g. chemical composition test results or quality certificates) proving that the properties of the metals and plastics 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 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

[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.

[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.

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 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:

(a) Project proponents shall demonstrate that the proposed project activity does not collect and recycle the E-waste imported from other countries, but from in-country sources;

(b) 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.

6. 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

7. The date of entry into force is the date of the publication of the EB 100 meeting report on 31 August 2018.

2.4. Applicability of sectoral scopes

8. 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.

[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.

3. Normative references

9. 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.

10. 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.

11. 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) “TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation”;

    (c) “TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”.

4. Definitions

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

13. 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 which are part of the product at the time of discarding;[7]

    (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 material;

    (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 project activity, otherwise sorted E-waste fractions are sold to specialized processing facilities;

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

(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) where a combination of E-waste sorting and processing takes place;

(g) **Processing facility** - facility(ies) that only process pre-sorted material (Case B in paragraph 24) to obtain recycled materials, i.e. marketable secondary 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 processed 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

14. 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 materials equivalent to virgin materials are produced;

(c) Virgin material production chain, including mining facilities and refining plants.[8]

5.2. Baseline

15. Baseline emissions are calculated as:

$$BE_y = BE_{m,y} + BE_{p,y} \quad \text{Equation (1)}$$

Where:

BE_y	=	Total baseline emissions in year *y* (tCO_2e)
$BE_{m,y}$	=	Baseline emissions in year *y* from recycling metals, see below (tCO_2e)
$BE_{p,y}$	=	Baseline emissions in year *y* from recycling plastics, see below (tCO_2e)

16. Baseline emissions include emissions associated with energy consumption for the production of metals and plastics from virgin raw materials. Only the baseline emissions which would take place in non-Annex I countries shall be credited. Therefore, the baseline

[8] 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 because of the project activity.

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 from virgin materials

Metal/Plastic	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
Gold	0.68
Silver	0.74
Palladium	0.47
Tin	0.97
Lead	0.69
ABS	0.56
HIPS	0.56

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

5.2.1. Baseline emissions from recycling of metals

17. Baseline emissions for the production of metal *i* from virgin inputs are calculated using equation (2).

$$BE_{m,y} = \sum_{i} [Q_{i,y} \times B_i \times SE_i] \quad \text{Equation (2)}$$

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)[9]
B_i	=	B_i correction factor based on the share of the production in non-Annex I countries

[9] 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 $Q_{i,y}$.

SE_i = Specific CO_2e emission factor for production of metal *i*, measured in tCO_2e/t. Take values specified in Table 3.

18. Baseline emissions for the production of primary metals from virgin inputs 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)]
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 from recycling of plastics

19. Baseline emissions for the production of plastic type *i* from virgin inputs are calculated as:

$$BE_{p,y} = \sum_i [Q_{i,y} \times L_{p,i} \times B_i \times (SEC_{Bl,i} \times EF_{el,y} + SFC_{Bl,i} \times EF_{FF,CO2})] \quad \text{Equation (3)}$$

Where:

i = Indices for material type *i* (ABS, HIPS)

$Q_{i,y}$ = Quantity of plastic type *i* recycled and sent to the processing or manufacturing facility in year *y* (t)

$L_{p,i}$ = Net to gross adjustment factor to cover degradation in material quality and material loss in the processing of the sorted material. Use 0.75[10] if $Q_{i,y}$ is the sorted plastic sent to the processing facility, Use 1 if $Q_{i,y}$ is the processed plastic sent to the manufacturing facility

B_i = B_i correction factor based on the share of the production in non-Annex I countries

[10] As per AMS-III.AJ, version 03, para. 10.

$SEC_{Bl,i}$	=	Specific electricity consumption for the production of plastics type *i* made from virgin material (MWh/t), take value specified in Table 4
$EF_{el,y}$	=	Emission factor for grid electricity (tCO_2e/MWh), determined in accordance with the provisions in the most recent version of the methodological tool “Tool to calculate the emission factor for an electricity system”
$SFC_{Bl,i}$	=	Specific fuel consumption for the production of plastics type *i* made from virgin material (GJ/t), take value as specified in Table 4
$EF_{FF,CO2}$	=	CO_2 emission factor for fossil fuel (tCO_2e/GJ)

20. Baseline emissions associated with energy consumption for the production of plastic are calculated according to the framework indicated in AMS-III.AJ “Recovery and recycling of materials from solid wastes”. Plastic recycling is limited to ABS, HIPS, since these are the most common plastics found in E-waste.

21. 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 types of plastics from virgin materials

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

[a] The following conservative assumptions were made:

1. For the production of ABS, it was assumed that natural gas supplies the process energy required for the steam reforming producing ammonia and the steam cracking necessary to produce ethylene and propylene (the main components of ABS). For the production of HIPS, it was assumed that natural gas supplies the process energy required for the thermal cracking to produce ethylene, styrene and butadiene and other olefins contained in the plastic;
2. It was assumed that the process energy for polymerization and extrusion is supplied with electricity;
3. The remaining steps of virgin pellet production (melting and shaping, pelletizing, compounding) require relatively negligible amounts of energy and hence are ignored.

5.3. Leakage

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

5.4. Project activity emissions

23. Project emissions are calculated using equation (4). 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.

$$PE_y = PE_{r,y} + PE_{p,y} \quad \text{Equation (4)}$$

Where:

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

$PE_{r,y}$	=	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 processing facility in year *y* (tCO_2e)

24. Project emissions calculation is dependent on the type of activities performed at the recycling facility.

(a) **<u>Case A</u>:** the project activity owns and manages the recycling and processing facilities up to the production of the virgin-equivalent material:

$$PE_y = PE_{r,y} \quad \text{Equation (5)}$$

(i) Project emissions include emissions from electricity and fuel consumption at the recycling and processing facilities for all the materials sorted and processed. Emissions for each output material are calculated as per equation (7), as the electricity and fuel consumption apportioned to each material, multiplied by the respective electricity or fuel emission factor. The total project emissions are calculated as the aggregate emissions produced by all materials recycled.

(b) **<u>Case B</u>:** The project activity owns and manages the recycling and processing facility, but the materials are further processed by third parties up to the production of the virgin-equivalent material. For plastics, the processing up to virgin equivalent plastics shall be directly managed by the project proponents. If processing of plastics is not managed by the project proponents, no emission reductions for plastic recycling are claimed:

$$PE_y = PE_{r,y} + PE_{p,y} \quad \text{Equation (6)}$$

(i) Project emissions include:

a. Emissions from electricity and fuel consumption at the recycling facility for all the materials that are either sorted or sorted and processed in the recycling facility. These are calculated using equation (7), as the electricity and fuel consumption apportioned to each material, multiplied by the respective electricity or fuel emission factor;

b. Additional processing emissions for those materials that are only sorted at the recycling facility and then sent to further processing facilities. Such emissions are calculated according to equation (10) using specific default energy consumption factors provided in Table 5. These values shall be updated at each renewal of the crediting period.

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

Metal/Plastic	Specific energy consumption factor for E-waste processing (MWh/t)
Aluminium	0.66

Metal/Plastic	Specific energy consumption factor for E-waste processing (MWh/t)
Steel	0.90
ABS	0[11]
HIPS	0[13]

25. Project emissions from processing of E-waste in the recycling facility are calculated using equation (7)

$$PE_{r,y} = \sum_i \left[\left(EC_{i,y} \times EF_{el,y} \right) + \left(FC_{i,y} \times NCV_{rec,ff,y} \times EF_{rec,ff,CO2,y} \right) \right] \quad \text{Equation (7)}$$

Where:

$EC_{i,y}$	=	Share of the electricity consumption of the recycling facility apportioned to the production of the output material type *i* in year *y* (MWh)
$FC_{i,y}$	=	Share of the fossil fuel consumption of the recycling facility apportioned to the production of the output material type *i* in year *y* (unit of mass or volume)
$NCV_{rec,ff,y}$	=	Net caloric value of the fossil fuel consumed in the recycling facility in year *y* (GJ/unit of mass or volume)
$EF_{rec,ff,CO2,y}$	=	CO_2 emission factor of the fossil fuel consumed in the recycling plant in year *y* (tCO_2e/GJ)

26. The electricity and fuel consumption at the recycling facility (EC_y, FC_y) shall be directly monitored. The electricity and fuel consumption may be allocated to each mass unit of recycled material *i* ($EC_{i,y}$, $FC_{i,y}$) by market prices, i.e. apportioning the electricity and fuel consumption in proportion to the market prices of metals, plastics, glass, etc. recycled at the facility. 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.

27. The following formulas may be used to allocate electricity and fuel consumption to each mass unit of recycled materials *i* by market prices:

$$EC_{i,y} = EC_y \times \frac{Q_{i,y} \times \$_{i,y}}{\sum_r \left[Q_{r,y} \times \$_{r,y} \right]} \quad \text{Equation (8)}$$

$$FC_{i,y} = FC_y \times \frac{Q_{i,y} \times \$_{i,y}}{\sum_r \left[Q_{r,y} \times \$_{r,y} \right]} \quad \text{Equation (9)}$$

[11] 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.

Where:

i	=	Indices for output material type *i* (metals and plastics listed at paragraph (4(a))
r	=	Indices for each material recycled at the facility
EC_y	=	Electricity consumption at the recycling facility in year *y* (MWh)
FC_y	=	Fossil fuel consumption at the recycling facility in year *y* (unit mass or volume)
$Q_{r,y}$	=	Quantity of material type *r* recycled in the recycling facility in year *y* (t)
$\$_{i,y}$	=	Market price of the recycled material type *i* in year *y*
$\$_{r,y}$	=	Market price of the recycled material type *r* in year *y*

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

$$PE_{p,y} = \sum_{i} [Q_{i,y} \times EFP_i \times EF_{el,y}]$$ Equation (10)

Where:

$PE_{p,y}$	=	Project emissions from processing of E-waste in the processing facility(ies) in year *y* (tCO_2e)
EFP_i	=	Energy consumption factor for E-waste processing of material i (MWh/t). Use values provided in Table 5

6. Monitoring methodology

29. 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 equation (11).

$$ER_y = BE_y - PE_y - LE_y$$ Equation (11)

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)

30. The following parameters shall be monitored and recorded during the crediting period. The applicable requirements specified in the “General Guidelines for SSC CDM methodologies” are also an integral part of the monitoring guidelines specified below and therefore shall be referred by the project participants.

31. The monitoring provisions in the tools referred to in this methodology apply:

(a) The electricity consumption at the recycling facility in year *y* (EC_y) should be monitored as per the latest version of “TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation”. When applying the tool, requirements for $EG_{PJ,grid,y}$ and/or $EG_{PJ,j,y}$ should apply to electricity consumed form the grid and electricity consumed from the captive power plant;

(b) The fossil fuel consumption at the recycling facility in year *y* ($FC_{i,y}$), the net caloric value of the fossil fuel consumed in the recycling facility in year *y* ($NCV_{rec,ff,y}$) and the CO_2 emission factor of the fossil fuel consumed in the recycling plant in year *y* ($EF_{rec,ff,CO2}$) should be monitored 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, requirements for $NCV_{i,y}$ should apply for the net calorific value of the fossil fuel consumed in the recycling facility and requirements for $EF_{CO2,i,y}$ should apply for the CO_2 emission factor of the fossil fuel consumed at the recycling facility.

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:	
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:	
Any comment:	

Data / Parameter table 2.

Data / Parameter:	EC_y
Data unit:	MWh
Description:	Electricity consumption at the recycling facility in year *y*
Source of data:	
Measurement procedures (if any):	As per the latest version of “TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation”. When applying the tool, requirements for $EG_{PJ,grid,y}$ and/or $EG_{PJ,j,y}$ specified in the tool should apply to electricity consumed form the grid and electricity consumed from the captive power plant
Monitoring frequency:	As per “TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation”

QA/QC procedures:	As per "TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation"
Any comment:	

Data / Parameter table 3.

Data / Parameter:	FC_y, / NCV_{FF} / $EF_{FF,CO2}$
Data unit:	As per "TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion".
Description:	FC_y: Fossil fuel consumption at the recycling facility in year *y* NCV_{FF}: Net calorific value of the fossil fuel consumed in the recycling facility in year y $EF_{FF,CO2}$: CO_2 emission factor of the fossil fuel consumed at 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, requirements for $NCV_{i,y}$ should apply for the net calorific value of the fossil fuel consumed in the recycling facility and requirements for $EF_{CO2,i,y}$ should apply for the CO_2 emission factor of the fossil fuel consumed 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 4.

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 paragraph 28
QA/QC procedures:	
Any comment:	

Data / Parameter table 5.

Data / Parameter:	
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

32. 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 plastic 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 plastic 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 Production
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%

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

Country	Annex I (AI) or Non-Annex I (NAI)	Share of Production
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. 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

[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).

these results by 3.6 (conversion from GWh to TJ) and by the CO_2 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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