

## **EBRD Methodology for Assessment of Greenhouse Gas Emissions**

### **Guidance for consultants working on EBRD-financed projects**

#### **Introduction to the scope of EBRD GHG assessments**

##### **1. Projects covered by GHG assessment**

EBRD has assessed the impact on greenhouse gas (GHG) emissions of its direct investments (loan and equity) since 2003. Summaries have been published in the Bank's annual Environmental or Sustainability Reports since that date. Although in most years all direct investment projects with emissions exceeding 20 kt CO<sub>2</sub>e per annum have been assessed, the focus has been on large projects, i.e. those emitting > 100 kt per annum, mainly in the energy and industrial sectors, which dominate the portfolio GHG footprint. Some sectors (see GN1) are screened out on the basis of low GHG impact. Some direct investments involving corporate loans and most projects supported through financial intermediaries (FI) are generally not assessed as there is insufficient information on the precise nature of these investments.

From November 2008, the Bank's Environmental and Social Policy mandates, *inter alia*, clients to procure and report the data necessary for GHG assessment for projects whose emissions are expected to exceed 100 kt CO<sub>2</sub>e (see 6 below).

##### **2. Scope of emissions assessed**

Direct emissions from within the project boundary together with the estimated emissions associated with the generation of grid electricity used by the project are included in the assessment. Other upstream emissions associated with the provision of materials used by the project or downstream emissions from the use of the goods and services generated by the project are not included.<sup>1</sup>

##### **3. Project GHG and ΔGHG**

In keeping with the Bank's *transition* mandate, the assessment has sought to estimate the *change* in GHG emissions (ΔGHG) brought about by investments. This is the difference between the emissions following the implementation of the project investment and the emissions that would have occurred in its absence. Estimation of the post-investment emissions is relatively straightforward and amenable to routine monitoring during the project lifetime. In contrast, definition and estimation of the *baseline* or *reference* emissions, reflecting the emissions that would have occurred in the absence of the investment, are not well defined. The concept of baseline or reference emissions may be interpreted in a variety of ways. Baseline or reference emissions are not amenable to measurement. They must be based on a set of assumptions, which may range from the very simple to the highly complex. There is generally no 'right answer'. EBRD has followed a simple approach.

##### **4. Project and baseline (reference) emissions and project boundaries**

For projects seeking to benefit from Kyoto Protocol carbon trading mechanisms (e.g. CDM) project and baseline emissions assessments are undertaken by specialists using methodologies

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<sup>1</sup> Using the definitions adopted by the GHG Protocol of the WBCSD/WRI, direct emissions are termed 'Scope 1', emissions from grid electricity used are 'Scope 2' while other upstream and downstream emissions are 'Scope 3'.

approved by the UNFCCC. For other projects, the project emission is taken as the annual emission occurring once the project has been fully implemented; the baseline emission is a representative pre-project emission, usually zero where the project is a green-field development or the facility annual emissions pre-investment where the project comprises upgrading or refurbishment. In general, estimates of project GHG and  $\Delta$ GHG aggregated (or averaged) over the lifetime of the project (actual or investment lifetime) have not been made, although such estimates could easily be calculated if required. The project boundary is generally defined as the geographical boundary of the facility but may need to include associated facilities where these exist solely to serve the project<sup>2</sup>. Where a project involves, say, a change from in-house production to external sourcing of a feedstock, project boundaries may need to be drawn to include external operations to ensure no fundamental difference in 'service provision' between the baseline and the project. Where a project is a direct replacement for some, or all, of another, separate, existing facility (e.g. one owned by the same entity) this latter facility may be brought within the project boundary, provided the closure is certain to take place within a short time of project implementation.

## 5. GHG Performance metrics

To date, project GHG and  $\Delta$ GHG have related to the whole project on the premise that the project would be unlikely to proceed without the Bank's involvement. However, as more financing institutions declare their GHG footprints, the danger of multiple counting of project emissions grows. There is thus a case for scaling emission totals according to the Bank's proportion of the total project investment. It is recommended that in future both project total and scaled emissions be presented.

EBRD investments invariably improve the efficiency of production even where increased production outweighs this, leading to an increase in overall emissions. It is thus helpful to demonstrate this benefit by presenting GHG per unit of product output for the project and baseline cases as well as absolute GHG emissions.

## 6. EBRD Environmental and Social Policy requirements

From November 2008, the revised (May 2008) EBRD Environmental and Social Policy includes the following requirements:

Environmental and Social Policy, paragraph 40: *The EBRD will publish an annual Sustainability Report on its activities including . . . aggregate information on greenhouse gas emissions . . .*

Performance Requirement 1 (PR1) Environmental and Social Appraisal and Management, Paragraph 7: *. . . The appraisal will also consider potential transboundary and global issues, such as . . . greenhouse gas emissions . . .*

Performance Requirement 3 (PR3) Pollution Prevention Abatement: Paragraph 3: *The objectives of this Performance Requirement (PR) are . . . to promote the reduction of project-related greenhouse gas emissions.*

Performance Requirement 3 (PR3) Pollution Prevention Abatement: Paragraph 17-19 (plus footnotes):

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<sup>2</sup> This conditional extension of the project boundary to encompass other facilities is consistent with the definition of 'area of influence' over which EBRD projects must be appraised, according to paragraph 6 of Performance Requirement 1 of EBRD's Environmental and Social Policy, May 2008

17. The client will promote the reduction of project-related greenhouse gas (GHG) emissions in a manner appropriate to the nature and scale of project operations and impacts.

18. During the development of projects that are expected to or currently produce significant quantities of GHGs (*see footnote 6*) the client will procure and report the data necessary to enable both an assessment of baseline (pre-investment) GHG emissions and an estimate of post-implementation GHG emissions. Guidance on data requirements should be sought from the Bank. The GHG assessment will cover direct emissions from the facilities owned or controlled within the physical project boundary, together with those from any external operations on which the project is dependent, including indirect emissions associated with the offsite production of power used by the project. An indication of the size of project likely to generate emissions of 100,000 tonnes of CO<sub>2</sub> equivalent can be found in Annex A of IFC's Pollution Prevention and Abatement Guidance Note 3 ([http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/pol\\_GuidanceNote2007\\_3/\\$FILE/2007+Updated+Guidance+Note\\_3.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/pol_GuidanceNote2007_3/$FILE/2007+Updated+Guidance+Note_3.pdf))

Guidance on the definition of project boundary should also be sought from the Bank (*see footnote 7*). Quantification of the parameters needed to evaluate GHG emissions (*see footnote 8*) will be conducted annually during the life of the project.

19. In addition, the client will assess technically and financially feasible and cost-effective options to reduce its carbon intensity during the design and operation of the project, and pursue appropriate options.

Footnotes:

*6 The significance of a project's contribution to GHG emissions varies between industry sectors. Guidance on the amounts of GHG emissions likely to be associated with projects in different sectors is given in EBRD Methodology for Assessment of Greenhouse Gas Emissions – Guidance for consultants working on EBRD-financed projects (GN0). The significance threshold for this Performance Requirement is generally 100,000 tons of CO<sub>2</sub> equivalent per year for the aggregate emissions of direct sources and indirect sources associated with purchased electricity for own consumption. However, a lower emission threshold may be appropriate where a project aims to bring about large improvements in production efficiency. Clients are encouraged to consult the Bank in such cases on whether data procurement for GHG assessment will be required.*

*7. Guidance on data requirements and the definition of project boundary are provided, respectively, in the Bank's Environmental Audit and Appraisal Protocols and EBRD Methodology for Assessment of Greenhouse Gas Emissions – Guidance for consultants working on EBRD-financed projects (GN1) .*

*8. For example the quantities of fuel or electricity usage.*

## **7. Contents of this guidance**

This document contains guidance for EBRD-appointed consultants or in-house practitioners on applying the EBRD Methodology for Assessment of Greenhouse Gas Emissions.

The methodology outlined seeks to ensure that greenhouse gas emission assessments are carried out in a systematic manner, using data whose sources are documented and recording all assumptions and methods of calculation. However, no generalised methodology can hope to meet the needs of every project; inevitably, the consultant will find occasion where he or she needs to use his or her own professional judgement. In such instances, any assumptions made and any departures taken from the recommended methods should be recorded.

This methodology is intended for use on all projects for the purposes of estimating the impact of project implementation on overall GHG emissions and identifying during project appraisal opportunities for GHG reduction. For projects seeking JI or CDM accreditation under the

Kyoto Protocol Mechanisms, an analysis will be required following protocols approved by the UNFCCC for such projects. These requirements are not covered by this guidance.

Six Guidance Notes are provided to assist Consultants in applying the Methodology: GN 0 identifies project types for which GHG assessment is generally not required. GN 1 covers the principles involved in setting the scope of the assessment. GN 2–5 provide technical guidance on the identification of principal direct and indirect emission sources and the recommended methods for estimating greenhouse gas emissions:

GN 0 Initial GHG Screening

GN 1 Assessment Scope

GN 2 Direct emission sources from various industrial sectors

GN 3 Direct GHG Emissions: Data Requirements and Recommended Methods of Calculation

GN 4 Estimation of indirect emissions from imported electricity and heat

GN 5 Global Warming Potentials for calculation of total GHG (CO<sub>2</sub> equivalent) emissions

## EBRD GHG ASSESSMENT METHODOLOGY GUIDANCE NOTE

### GN 0 Initial GHG Screening

The Bank needs to know the overall level of GHG emissions from operation of facilities with which, through investment, it will become associated, and the change in emissions brought about by the investment. All projects should therefore be subject to initial screening to assess the likely scale of GHG emissions involved. The purpose of screening is to provide an early indicator of the likely importance of the project as a contributor to the Bank's GHG footprint and the scope that might exist for GHG reduction initiatives. The screening process allocates a project to an emission category reflecting the scale of existing or, in the case of new-build projects, future emissions from the facilities where the investment is to be made. (Note that the category does not necessarily reflect the scale of change in GHG emissions that the project will bring about.) The following categories are based on previous analysis of typical Bank projects:

- Negligible (no GHG assessment necessary)
- Low (< 20 kt/y CO<sub>2</sub>-equivalent per year. See GN 5 for relative importance of different GHGs and their CO<sub>2</sub>-equivalence (CO<sub>2</sub>-e))
- Medium-Low (20 – 100 kt CO<sub>2</sub>-e /y)
- Medium-High (100 kt – 1 Mt CO<sub>2</sub>-e /y)
- High (>1 Mt CO<sub>2</sub>-e /y)

#### *Negligible emission category*

For the purposes of GHG assessment for the Bank, projects involving the following activities are categorised as *Negligible*, with no GHG assessment required:

- Telecommunications
- Wood processing using wood waste as the principal fuel
- Civil construction projects
- Drinking water supply networks
- Industrial waste water treatment
- Municipal waste water treatment where sewage sludge is digested or incinerated

#### *Low emission category (< 20 kt CO<sub>2</sub>e pa)*

Typical Bank investments in the following areas are likely to have *Low* emissions, although in some cases the size of project may result in emissions above the 20 kt threshold. It would be more acceptable to use default emission parameters in the evaluation of these projects than in the evaluation projects screened in the Medium and High categories:

- Property developments (offices, hotels, retail)
- Municipal facilities, including waste water treatment involving sludge landfill without methane flaring/collection
- Light industrial facilities (non-energy intensive, e.g. assembly)
- Food manufacturing facilities
- Agricultural processing facilities
- Road development schemes (only assessed if traffic modelling studies available)

*Medium-Low category (20 - 100 kt CO<sub>2</sub>e pa)*

- Municipal solid waste landfill
- Brick, tyre, manufacture
- Locomotive, ship, transport fleet purchases
- Power transmission line upgrades (GHG savings) (may be Medium-High, depending on generation mix and scale of investment)

*Medium-High category (100 kt – 1 Mt CO<sub>2</sub>e pa)*

- Power transmission line upgrades (GHG savings) (may be Medium-Low, depending on generation mix and scale of investment)
- Fuel production and processing (may be High for major oil and gas developments)
- Glass manufacturing
- Petrochemicals manufacturing
- Small metal manufacturing and processing plants
- Small cement and lime works
- Small power generating plants
- District heating networks (savings)

*High category (> 1Mt CO<sub>2</sub>e pa)*

- Large fossil-fired power generating plant
- District heat and power systems
- Large metal smelting and processing facilities
- Major oil and gas production/transportation systems
- Large cement works

The above lists are not exhaustive and serve only as an initial guide.

Additional guidance on the likelihood of emissions exceeding the 100 kt CO<sub>2</sub>e pa threshold mandated for GHG assessment in the Environmental and Social Policy is provided in Annex A of IFC's Guidance Note 3 Pollution and Prevention<sup>3</sup>. This may be used to inform initial assessment of whether a project is likely to fall above or below the threshold.

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[http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/pol\\_GuidanceNote2007\\_3/\\$FILE/2007+Updated+Guidance+Note\\_3.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/pol_GuidanceNote2007_3/$FILE/2007+Updated+Guidance+Note_3.pdf)

**EBRD GHG ASSESSMENT METHODOLOGY GUIDANCE NOTE****GN 1 Assessment Scope**1. Greenhouse Gases

For many projects, carbon dioxide emissions will constitute the bulk of the greenhouse gas emissions. However, some combustion and industrial processes release amounts of other GHGs which have significant global warming potential. Guidance Note GN 2 lists significant GHG emissions from a wide range of processes. Assessment should be undertaken for those gases listed against project-relevant processes, using the calculation methods set out in Guidance Note GN 3. If consultants have valid reasons for departing from the recommended methods of assessment and calculation, these must be clearly stated.

2. Project Boundary

The default project boundary should be the physical (geographical) boundary of the project facility. Consideration should be given to extending the boundary in the following circumstances:

- where upstream or downstream processes directly linked with the project, and which exist/operate only as a result of the project, have GHG emissions which are likely to be significant relative to project GHG emissions (e.g. a dedicated mining operation that would otherwise not exist, or an associated waste or by-product utilisation facility)
- where an integral part of the business of the project is contracted out to a third party operator on whom the operation of the project is dependent.

It is essential that the project boundary definition is applied consistently to the project and to the baseline/reference scenario (see below) to ensure that a valid comparison of 'with-project' and 'without-project' emissions can be made.

3. Baseline or Reference Scenario

The Baseline or Reference Scenario emissions are the hypothetical emissions that would prevail in the absence of the project.

For projects not seeking JI or CDM accreditation, a static baseline is considered adequate. An assessment should therefore be made of the emissions that would have continued to occur in the absence of the project at a single point in time at or near the time of project commissioning. For a plant upgrade project, the baseline will typically be the emissions from the plant prior to upgrade. For a new facility, the baseline will ideally be the emissions from other operations that are certain to be displaced by the operation of the new facility. Attempts should be made to secure a clear and reliable statement of such closures. If no such firm commitments exist, a conservative approach for new facility projects should be taken, assuming all the emissions are additional – i.e. zero emissions for the pre-project baseline. For reasons of consistency between project assessments and resource requirements, it is not proposed that time-dependent baselines, with annually changing values, be calculated (as would be required for JI/CDM projects).

Once the Baseline has been established, the GHG emissions associated with the baseline should be calculated using the EBRD methodology. This will require data and information

about existing emissions from the facilities that will be modified or replaced by the project. It is essential that the methods used to calculate the baseline and post-investment emissions are consistent to ensure valid comparison of emissions.

#### 4. Direct and Indirect Emissions

Direct emissions are those from processes occurring within the physical project boundary, together with those emissions from any integral component of the project which, although located elsewhere, has been included within the project boundary as defined in 2 above. Where the scope of project activity differs between the project and the baseline it may be necessary for consistency to include in either the project or baseline assessment an emission source that would otherwise be excluded. An example would be where a feedstock previously manufactured on site is to be imported as part of the new project. In this case, emissions from the external manufacture of the feedstock should be included as direct project emissions, or, alternatively, emissions from on-site manufacture should be excluded from the baseline emissions.

Direct emissions should comprise the relevant principal energy and process emissions listed in GN 2.

Indirect emissions are those which arise solely as a result of the project's existence but which occur outside the project boundary. This definition could be interpreted in a 'cradle-to-grave' manner, including all upstream emissions, e.g. those associated with fuel and feedstock production, and downstream emissions, e.g. those associated with product use. However, such a life-cycle approach is not considered practical or appropriate. In most cases assessment of indirect emissions may reasonably be restricted to the emissions associated with electricity or heat imports where these provide a significant source of energy for the project. (Specific guidance on the estimation of emissions arising from the production of imported electricity and heat is given in GN 4). The assessor should, nevertheless, always consider whether any features of the project give rise to other significant indirect emissions which need to be evaluated – for example the creation of a new feedstock production facility dedicated to supplying the project, if this has not already been incorporated within the defined project boundary. Note, however, that emissions from third party use of marketed fuels and products arising from a project are conventionally regarded as third party emissions and not as indirect emissions from the project. These are therefore not regarded as indirect emissions in the methodology and are not assessed.

As in the case of direct emissions, there must be consistency between project (post-investment) and baseline over the scope of indirect emissions included.

#### 5. Adequacy of data

Annual GHG emissions may in principle be derived, with varying accuracy, from a range of primary or secondary data sources. Project documentation may often appear to provide sufficient data to enable a choice of calculation method, although assumptions used in deriving secondary data are not always adequately stated in project documents. Inconsistency between alternative calculation methods may then arise. Assessors should, where possible, aim to use methods of calculation based on primary rather than secondary data, thereby minimising the need to use non-project-specific default parameters. The following Table gives guidance on action that should be taken to validate data sources and render them adequate for use in the GHG assessment. The Table is not exhaustive, but indicates the type of data screening that should be implemented to ensure robust emission calculations.

Potential data from which annual GHG emissions may be estimated	Necessary data validation
Statements of actual or projected annual total of each GHG emission over project lifetime	Primary data on which calculation is based must be obtained from formal project documentation / project sponsors to check and verify values stated
Emission rates (e.g. tonnes/hour) of each GHG	Primary data (on fuel and heat rate) on which calculation is based must be obtained from formal project documentation / project sponsors. Data on projected annual operating hours must also be obtained to enable annual emissions calculation.
Annual fuel or feedstock consumption	Likely to be secondary data derived from plant heat rate and assumptions about load factor (hours of operation). Consumption calculations must be checked and raw data verified.
Fuel or feedstock carbon content (used with annual consumption figures to evaluate CO <sub>2</sub> emission)	Basis of fuel/feedstock composition quotation (e.g. 'as received' or 'dry ash-free') must be known to correctly calculate fraction of carbon in tonne fuel/feedstock delivered. Likely annual variability in fuel/feedstock composition should be assessed and any likely future changes in fuel composition identified.
Default emission factors (i.e tonnes of GHG emitted per tonne fuel, or per unit energy, or per unit product)	Emission calculation based on default emission factors should only be used as a last resort where project-specific data are unavailable. Recognised reference source for emission factors (e.g. IPCC – see GN 3) should be cited.

## 6. Specific Emissions / Emissions per unit of output

Where a new facility has a substantially higher output than the facilities displaced and thus contributes to an increase in the overall service provision, the project emissions may exceed the baseline emissions even though the project may be operating at much greater efficiency. Where a change in service provision occurs, it is not considered appropriate to scale the baseline emission upwards to match the new service level as this distorts the net greenhouse gas emissions impact of the project. Instead, the assessment should include a calculation of GHG emissions per unit of output from the facility (e.g. t CO<sub>2</sub> / KWhe, t CO<sub>2</sub> / tonne product) to demonstrate the efficiency improvement.

**EBRD GHG ASSESSMENT METHODOLOGY  
IMPLEMENTATION GUIDANCE NOTE**
**GN 2**
**GN 2 Direct emission sources from various industrial sectors**

<b>Sector</b>	<b>Major direct emission sources</b>	<b>Notes</b>
<b>Energy resource exploration and refinery/processing projects</b>  (EBRD Natural Resources)	Fossil Fuel combustion: CO <sub>2</sub> Flaring: CO <sub>2</sub> Leakage, fugitive emissions, venting: CH <sub>4</sub> Coal mining releases: CH <sub>4</sub>	
<b>Energy conversion and distribution projects</b>  (EBRD Power Projects)	Fossil Fuel combustion: CO <sub>2</sub> Fossil Fuel combustion in fluidised beds: CO <sub>2</sub> + N <sub>2</sub> O Biomass Fuel combustion: CH <sub>4</sub> + N <sub>2</sub> O Electricity transmission equipment: SF <sub>6</sub> Flue Gas Desulphurisation: CO <sub>2</sub>	CO <sub>2</sub> emissions from biomass combustion assumed to be GHG neutral as part of biological cycle
<b>Energy efficiency and conservation projects</b>  (EBRD Energy Efficiency)	Fossil Fuel combustion: CO <sub>2</sub> Fossil Fuel combustion in fluidised beds: CO <sub>2</sub> + N <sub>2</sub> O Biomass Fuel combustion: CH <sub>4</sub> + N <sub>2</sub> O	CO <sub>2</sub> emissions from biomass combustion assumed to be GHG neutral as part of biological cycle
<b>Industrial production projects</b>  <ul style="list-style-type: none"> <li>- Aluminium</li> <li>- Other non-Fe metals</li> <li>- Iron &amp; steel</li> <li>- Nitric Acid</li> <li>- Ammonia</li> <li>- Adipic Acid</li> <li>- Cement</li> <li>- Lime</li> <li>- Bricks/tiles</li> <li>- Glass</li> <li>- Pulp &amp; Paper</li> <li>- Refrig'n/Air conditioning</li> </ul> (EBRD Sector and Country Teams)	Fuel combustion (CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O) as per energy emissions above plus the following <b>PROCESS</b> emissions, which may or may not be partially controlled:  CO <sub>2</sub> , PFCs (CF <sub>4</sub> , C <sub>2</sub> F <sub>6</sub> ,) & possibly SF <sub>6</sub> if used as cover gas CO <sub>2</sub> if C used as reducing agent or CO <sub>3</sub> in , & possibly SF <sub>6</sub> CO <sub>2</sub> from reducing agent, from carbonate flux & C loss ore to steel N <sub>2</sub> O CO <sub>2</sub> from regeneration of CO <sub>2</sub> -stripping solvent N <sub>2</sub> O from ketone-alcohol reaction with HNO <sub>3</sub> CO <sub>2</sub> from calcining of limestone to produce lime for clinker prod'n CO <sub>2</sub> from calcining of limestone None CO <sub>2</sub> from limestones where used in process Process emissions are biomass related and considered CO <sub>2</sub> -neutral HFCs from manufacture of HFCs, and from system leakage/disposal	In iron production, fossil fuel carbon plays dual role of fuel and reducing agent: hence need to ensure double counting is avoided
<b>Municipal and Environmental Infrastructure projects</b>  <ul style="list-style-type: none"> <li>- solid waste landfill</li> <li>- solid waste inciner'n</li> <li>- waste-water treatment</li> </ul> (EBRD MEI)	CH <sub>4</sub> CO <sub>2</sub> (from fossil-derived waste) + N <sub>2</sub> O CH <sub>4</sub>	CO <sub>2</sub> from landfill and from biomass-derived waste incineration assumed to be GHG neutral as part of biological cycle. (CH <sub>4</sub> from waste incineration considered by IPCC to be insignificant)
<b>Transport projects</b>  (EBRD Transport)	Fuel combustion: CO <sub>2</sub> Fuel combustion – gasoline + 3-way cat: CO <sub>2</sub> + N <sub>2</sub> O	CO <sub>2</sub> accounts for 97% of transport GHG emissions. N <sub>2</sub> O may be a significant contributor from gasoline cars with 3-way catalysts.

**EBRD GHG ASSESSMENT METHODOLOGY  
IMPLEMENTATION GUIDANCE NOTE****GN 3****GN 3 Direct GHG Emissions: Data Requirements and Recommended Methods of Calculation**

Data input requirements and methods of calculation are provided for the following sector or cross-sector emission sources. Note that the Stationary Combustion calculations will need to be carried out for any project in which where fuels are burned to provide energy.

- ❑ Stationary Fossil Fuel Combustion (CO<sub>2</sub>)
- ❑ Stationary Fossil Fuel Combustion in Fluidised Beds (N<sub>2</sub>O)
- ❑ Stationary Biomass Fuel Combustion (CH<sub>4</sub> and N<sub>2</sub>O)
- ❑ Oil / Gas production and processing (CO<sub>2</sub> and CH<sub>4</sub>)
- ❑ Coal Mining (CH<sub>4</sub>)
- ❑ Electricity Transmission (SF<sub>6</sub>)
- ❑ Flue Gas Desulphurisation (CO<sub>2</sub>)
- ❑ Aluminium Production (CO<sub>2</sub>)
- ❑ Aluminium Production (PFCs)
- ❑ Iron and Steel Production (CO<sub>2</sub>)
- ❑ Nitric Acid Production (N<sub>2</sub>O)
- ❑ Ammonia Production (CO<sub>2</sub>)
- ❑ Adipic Acid Production (N<sub>2</sub>O)
- ❑ Cement (Clinker) Production (CO<sub>2</sub>)
- ❑ Lime Production (CO<sub>2</sub>)
- ❑ Glass Manufacture (CO<sub>2</sub>)
- ❑ Refrigeration/Air conditioning/Insulation industry (HFCs)
- ❑ Solid Waste Landfill (CH<sub>4</sub>)
- ❑ Municipal Solid Waste Incineration (CO<sub>2</sub> and N<sub>2</sub>O)
- ❑ Municipal Waste Water Treatment (CH<sub>4</sub>)
- ❑ Transport (CO<sub>2</sub>)
- ❑ Transport (N<sub>2</sub>O)

**Note for Users:**

*The methods of calculation and default data provided in this Guidance Note are, unless otherwise stated, based on approaches recommended by the 1996 IPCC Guidelines for National Greenhouse Gas Inventories and IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. The former document has been updated by the 2006 edition referenced below which should be consulted to check for any changes in default parameters if these are employed, although for most purposes, the parameters tabulated based on the 1996 IPCC guidance should be adequate.*

*2006 IPCC Guidelines for National Greenhouse Gas Inventories (5 volumes)*

*<http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>*

*For many of the sectors covered, the WRI/WBCSD GHG Protocol\* provides spreadsheet tools based on the same calculations as presented here. Users of the EBRD Methodology may choose to use these tools where appropriate to automate the calculations or to construct a project-specific spreadsheet for this purpose. However, in order to have a formal record of the basis of the GHG assessment calculations, the assessment should show clearly the data employed and their sources and the calculations performed.*

*\* <http://www.ghgprotocol.org>*

Sector Emission	Input Data Requirements	Calculation Method	Notes																				
<p><b>Stationary fossil fuel combustion - CO<sub>2</sub></b></p>	<p>(i) Annual fuel use in energy units, or mass units</p> <p>(ii) Carbon intensity of fuel (tC/TJ) or (iii) Carbon content of fuel (tC/t fuel) or (iv) Calorific Value of fuel (TJ/t fuel)</p> <p>(v) Carbon Fraction oxidised</p> <p>Where site-specific data unavailable, use default emission factors::</p> <p>For (ii): Carbon intensity</p> <table border="0"> <tr> <td>Coal</td> <td>25.8 tC/TJ</td> </tr> <tr> <td>Lignite</td> <td>27.6 tC/TJ</td> </tr> <tr> <td>Oil</td> <td>20.0 tC/TJ</td> </tr> <tr> <td>Gas</td> <td>15.3 tC/TJ</td> </tr> </table> <p>For (iii): Carbon content</p> <table border="0"> <tr> <td>Coal</td> <td>0.61 tC/t fuel</td> </tr> <tr> <td>Oil</td> <td>0.84 tC/t fuel</td> </tr> <tr> <td>Gas</td> <td>0.80 tC/t fuel</td> </tr> </table> <p>NB Default C content of crude oil may be derived from:  <math>C (\% \text{ wt}) = 76.99 + (10.9 \times \text{SG}) - (0.76 \times \text{sulphur} (\% \text{ wt}))</math>                      where <math>\text{SG} = 141.5 / (\text{API} + 131.5)</math></p> <p>For (v): Carbon fraction oxidised:</p> <table border="0"> <tr> <td>Coal</td> <td>0.98</td> </tr> <tr> <td>Oil</td> <td>0.99</td> </tr> <tr> <td>Gas</td> <td>0.995</td> </tr> </table>	Coal	25.8 tC/TJ	Lignite	27.6 tC/TJ	Oil	20.0 tC/TJ	Gas	15.3 tC/TJ	Coal	0.61 tC/t fuel	Oil	0.84 tC/t fuel	Gas	0.80 tC/t fuel	Coal	0.98	Oil	0.99	Gas	0.995	<p>CO<sub>2</sub> (t) =</p> <p>Fuel energy use (TJ) x Carbon Intensity (tC/TJ) x Carbon fraction oxidised x 3.664</p> <p>Or</p> <p>Fuel mass use (t) x carbon content (tC/t fuel) x Carbon fraction oxidised x 3.664</p> <p>Or</p> <p>Fuel mass use (t) x calorific value (TJ/t) x Carbon Intensity (tC/TJ) x Carbon fraction oxidised x 3.664</p> <p>Note default carbon content values are the same as the product of a default calorific value and a default carbon intensity</p>	<p>NB Default carbon content data are less reliable than default carbon intensity data and should only be used as last resort when no information on fuel energy content available.</p> <p>(Note factor 3.664 is the ratio of the molecular weights of CO<sub>2</sub> and C (44/12))</p>
Coal	25.8 tC/TJ																						
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<p><b>Stationary fossil fuel combustion in Fluidised Beds – N<sub>2</sub>O</b></p>	<p>(i) Fuel energy input (derive from data above)</p> <p>(ii) Default emission factor: 0.096 t N<sub>2</sub>O / TJ energy input</p>	<p>N<sub>2</sub>O (t) = Fuel energy input x emission factor</p>	
<p><b>Stationary biomass fuel combustion - CH<sub>4</sub> and N<sub>2</sub>O</b></p>	<p>(i) Fuel energy input (derive from data above)</p> <p>(ii) Default emission factors: CH<sub>4</sub>: Energy/manufacturing : 0.03 t CH<sub>4</sub> / TJ energy input Commercial/residential: 0.3 t CH<sub>4</sub> / TJ energy input N<sub>2</sub>O: All sectors: 0.004 t N<sub>2</sub>O / TJ energy input</p>	<p>CH<sub>4</sub> (t) = Fuel energy input x emission factor</p> <p>N<sub>2</sub>O (t) = Fuel energy input x emission factor</p>	
<p><b>Oil/gas production and processing – CO<sub>2</sub> and CH<sub>4</sub></b></p>	<p>(i) CO<sub>2</sub> from on-site gas and oil combustion and flared gas emissions derived as per stationary combustion above</p> <p>(ii) vented gas – energy or mass or volume units</p> <p>(iii) flared gas - energy or mass or volume units</p> <p>(iv) CH<sub>4</sub> content of gas (% wt or volume)</p> <p>(iv) % efficiency of flaring</p> <p>(v) estimates of on-site fugitive emissions</p> <p>Note: For volume to mass conversion note that 16g CH<sub>4</sub> occupies 22.4 litres at STP. Use gas law to convert to STP if data given at non standard temperature and pressure (pv = RT)</p>	<p>CH<sub>4</sub> (t) = Mass gas vented x CH<sub>4</sub> (% wt) + Mass gas flared x (100 - % efficiency of flaring) x CH<sub>4</sub> (% wt) + fugitive emissions x CH<sub>4</sub> (% wt)</p> <p>(Note: Published default emission rates related to oil production show very wide variation and are not recommended for use. If no site data available, data acquisition plan should be implemented.)</p>	<p>For guidance on potential sources of fugitive emissions, refer to BP Amoco Environmental Performance Group Reporting Guidelines (<a href="http://www.bp.com/downloads/273/Environmentalguidelines2000.doc">http://www.bp.com/downloads/273/Environmentalguidelines2000.doc</a>)</p>

<b>Coal mining CH<sub>4</sub></b>	<p>(i) Annual mass of coal mined</p> <p>(ii) CH<sub>4</sub> emission per tonne coal mined</p> <p>(iii) CH<sub>4</sub> emission per tonne coal post-mining</p> <p>Where site-specific data unavailable, use default emission rates:</p> <p>For (ii): underground coal: 10 – 25 m<sup>3</sup> CH<sub>4</sub> / t coal surface-mined coal: 0.3 – 2 m<sup>3</sup> CH<sub>4</sub> / t coal</p> <p>For (iii): underground, post-mining: 0.9 - 4 m<sup>3</sup> CH<sub>4</sub> / t coal surface-mined, post-mining: 0 – 0.2 m<sup>3</sup> CH<sub>4</sub> / t coal</p> <p>Default factors relate to 20°C , 1 atmosphere, at which 1 m<sup>3</sup> CH<sub>4</sub> weighs 0.67 kg</p>	<p>CH<sub>4</sub> (t) =</p> <p>Coal mined (t) x (emission per tonne mined + emission per tonne post-mining) x 0.00067</p>	
<b>Electricity Transmission SF<sub>6</sub></b>	(i) Total quantity of SF <sub>6</sub> in switchgear and circuit breakers	<p>SF<sub>6</sub> (t/y) =</p> <p>SF<sub>6</sub> content of equipment (t) x 0.01</p>	IPCC 1996 suggest 1% of existing SF <sub>6</sub> charge lost each year and remaining 70% is lost on destruction at end of 30y life.
<b>Flue gas desulphurisation (limestone based) CO<sub>2</sub></b>	<p>(i) Annual usage of limestone (t)</p> <p>(ii) calcium carbonate content (% wt)</p> <p>(iii) magnesium carbonate content (% wt)</p>	<p>CO<sub>2</sub> (t) =</p> <p>Annual usage (t) x [ (% CaCO<sub>3</sub> x 12/100) + (% MgCO<sub>3</sub> x 12/84) ] x 3.664</p>	Assumes all carbonate converted to CO <sub>2</sub> . If % carbonate unconverted figure available from gypsum and waste solids analyses, emission figure can be reduced accordingly
<b>Aluminium production CO<sub>2</sub></b>	<p>(i) Annual use of reducing agent consumed in mass units</p> <p>(ii) % carbon in reducing agent or (iii) C emission factor of reducing agent (t CO<sub>2</sub> / t reducing agent)</p> <p>Where site-specific data unavailable, use default emission factors: For (i): Al manufacture CO<sub>2</sub> emission factor ( t CO<sub>2</sub> / t Al): Soderberg - 1.8; Pre-baked anode – 1.5</p> <p>For (iii): coal - 2.5 tCO<sub>2</sub>/ t coal; coke from coal – 3.1 tCO<sub>2</sub>/ t coke petroleum coke – 3.6 tCO<sub>2</sub>/ t petcoke; pre-baked anodes and coal electrodes – 3.6 tCO<sub>2</sub>/ t anode</p>	<p>CO<sub>2</sub> (t) =</p> <p>Annual use of reducing agent x %C x 3.664</p> <p>Or</p> <p>Annual use of reducing agent x emission factor (tCO<sub>2</sub> per tonne reducing agent)</p> <p>or</p> <p>(Mass aluminium produced x emission factor)</p>	<p>Add 5% to process CO<sub>2</sub> emissions to account for CO<sub>2</sub> emission in anode pre-baking process</p> <p>WBCSD/WRI Aluminium worksheet, IPCC 1996</p>

<p><b>Aluminium production PFCs</b></p>	<p>(i) Annual mass Al produced (t)</p> <p>(ii) Annual PFC emissions (CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub>) per tonne Al produced based on site-specific analysis of 'anode effects' in smelting process</p> <p>Site-specific emission factors should be determined as emissions are very variable from one plant to another. IPCC 1996 gives guidance. If no site-specific data available, use default emission factors per tonne Al produced, but recognise the wide uncertainty in value. WRI/WBCSD suggest:</p> <p>Soderberg: CF<sub>4</sub>: 0.6 kg / t Al; C<sub>2</sub>F<sub>6</sub>: 0.06 kg / t Al</p> <p>Pre-baked (centre worked): CF<sub>4</sub>: 0.31 kg / t Al; C<sub>2</sub>F<sub>6</sub>: 0.04 kg / t Al</p>	<p>CF<sub>4</sub> (kg) =</p> <p>Annual mass Al produced x CF<sub>4</sub> emission factor</p> <p>C<sub>2</sub>F<sub>6</sub> (kg) =</p> <p>Annual mass Al produced x C<sub>2</sub>F<sub>6</sub> emission factor</p>	<p>The contribution of PFCs may be the major contribution to GHG emissions from this sector. Site-specific expertise on 'anode effect' emissions should always be sought when assessing aluminium projects. Also see discussion of available information in IPCC 1996.</p>
<p><b>Iron and Steel production CO<sub>2</sub></b></p>	<p>(i) Annual use of reducing agent consumed in mass units (net of fuel use)</p> <p>(ii) % carbon in reducing agent or (iii) CO<sub>2</sub> emission factor of reducing agent</p> <p>(iv) annual carbonate flux (dolomite/limestone) use in mass units</p> <p>(v) calcium carbonate content of flux (% wt)</p> <p>(vi) magnesium carbonate content of flux (% wt)</p> <p>(vii) Annual mass of ore used and annual mass of iron and steel produced</p> <p>(viii) % carbon in each of ore, iron produced, steel produced</p> <p>Where site-specific data not available, use default emission factors:</p> <p>For (i): iron/steel manufacture C emission factor: 1.6 t CO<sub>2</sub> / t iron or steel produced</p> <p>For (iii): coal - 2.5 tCO<sub>2</sub>/ t coal: coke from coal – 3.1 tCO<sub>2</sub>/ t coke petroleum coke – 3.6 tCO<sub>2</sub>/ t petcoke</p>	<p>CO<sub>2</sub> (t) =</p> <p>Annual mass reducing agent used (t) x % C x 3.664 or Annual mass reducing agent used (t) x emission factor</p> <p>+</p> <p>Annual flux usage (t) x [ (% CaCO<sub>3</sub> x 12/100) + (% MgCO<sub>3</sub> x 12/84) ] x 3.664</p> <p>+</p> <p>(Annual mass of ore used (t) x % carbon content in ore – annual mass metal produced (t) x % carbon in metal ) x 3.664</p> <p>OR</p> <p>Annual mass iron and steel produced (t) x 1.6</p>	<p>WBCSD/WRI Iron &amp; Steel worksheet IPCC 1996</p>

<p><b>Nitric Acid production N<sub>2</sub>O</b></p>	<p>(i) Annual mass of nitric acid produced</p> <p>(ii) N<sub>2</sub>O emission factor for plant (kg / t nitric acid produced)</p> <p>(iii) fractional abatement (y) achieved by any abatement technology employed (e.g. selective non-catalytic reduction which reduces N<sub>2</sub>O as well as NO<sub>x</sub>)</p> <p>As emissions are technology-dependent, emission measurements should be made. Where no measurement data available use default emission factors:</p> <p>For (ii): 2 – 9 kg N<sub>2</sub>O / t nitric acid produced (see IPCC 1996)</p>	<p>N<sub>2</sub>O (kg) =</p> <p>Annual mass nitric acid produced (t) x emission factor (kg N<sub>2</sub>O per t nitric acid) x (1-y)</p>	<p>N<sub>2</sub>O produced as a by-product of high temperature catalytic oxidation of ammonia.</p>
<p><b>Ammonia production CO<sub>2</sub></b></p>	<p>(i) Annual mass of feedstock used</p> <p>(ii) carbon content (% wt) of feedstock</p> <p>If site-specific data not available, use default emission factor:</p> <p>For (i): 1.5 t CO<sub>2</sub> per tonne NH<sub>3</sub> produced</p>	<p>CO<sub>2</sub> (t) =</p> <p>Annual mass of gas used (t) x carbon content x 3.664</p> <p>Or</p> <p>Annual mass NH<sub>3</sub> produced (t) x 1.5</p>	<p>Ammonia produced by catalytic steam reforming of natural gas. All carbon in feedstock assumed converted to CO<sub>2</sub> which is vented to atmosphere. Check that CO<sub>2</sub> is not recovered and used elsewhere without release to atmosphere.</p>
<p><b>Adipic Acid production N<sub>2</sub>O</b></p>	<p>(i) Annual mass of adipic acid produced (t)</p> <p>(ii) Default emission factor: 300 kg/ t adipic acid produced</p> <p>(iii) fractional abatement (y) achieved by any abatement technology employed (e.g. selective non-catalytic reduction which reduces N<sub>2</sub>O as well as NO<sub>x</sub>)</p>	<p>N<sub>2</sub>O (kg) =</p> <p>Annual mass adipic acid produced (t) x 300 x (1 - y)</p>	<p>Produced as a by-product by nitric acid oxidation of cyclohexanone-cyclohexanol mixture</p>
<p><b>Cement (clinker) process CO<sub>2</sub></b></p>	<p>(i) Annual mass of clinker produced (t)</p> <p>(ii) fractional lime (CaO) content of clinker</p> <p>Where site-specific data not available, use default emission factors:</p> <p>For (i): If only mass of cement produced known use 0.635 t CaO per tonne cement</p> <p>For (ii): If lime fraction in clinker not known, use 0.646</p>	<p>CO<sub>2</sub> (t) =</p> <p>Annual mass clinker produced x fractional lime content x [44/56]</p> <p>OR</p> <p>Annual mass clinker produced (t) x 0.646 x [44/56]</p> <p>Or</p> <p>Annual mass cement produced (t) x 0.635 x [44/56]</p>	<p>The lime (CaO) content of clinker results from the decomposition of CaCO<sub>3</sub> to CaO + CO<sub>2</sub>. Thus for each mole of CaO in clinker, one mole of CO<sub>2</sub> is released</p> <p>Add 2-5% to total CO<sub>2</sub> release to account for kiln cement dust lost from system (use 2% if recycling of dust occurs or 5% if no recycling)</p>

<b>Lime production CO<sub>2</sub></b>	<p>(i) Annual mass of lime produced (t)</p> <p>(ii) fractional CaO content of lime produced</p> <p>(iii) fractional MgO content of lime produced or (iv) fractional CaO.MgO content of lime produced</p> <p>If site-specific data not available, use default emission factors:</p> <p>For (ii)-(iv): 0.79 t CO<sub>2</sub> per tonne lime produced from calcite (CaCO<sub>3</sub>) or 0.91 t CO<sub>2</sub> per tonne lime produced from dolomite (CaCO<sub>3</sub>.MgCO<sub>3</sub>)</p>	<p>CO<sub>2</sub> (t) =</p> <p>Annual mass of lime produced (t) x [ fraction CaO x 44/56 + fraction MgO x 44/40]</p> <p>or</p> <p>Annual mass of lime produced (t) x [ fraction CaO x 44/56 + %fraction CaO.MgO x (2x44)/96]</p> <p>OR</p> <p>Annual mass lime produced (t) x 0.79 (or 0.91)</p>	<p>2 moles of CO<sub>2</sub> produced for each mole of dolomitic lime (CaO.MgO) produced from dolomite (CaCO<sub>3</sub>.MgCO<sub>3</sub>)</p> <p>Reductions should be applied if lime purity less than 100%</p>
<b>Glass</b>	<p>Where limestone used in process, assess process emissions using limestone methodology detailed above.</p>		
<b>Refrigeration / Air conditioning / Insulation Industry HFCs</b>	<p>A variety of industrial processes involve refrigeration and air conditioning and thus indirectly employ HFCs. It is recommended that only where the manufacture and use of such equipment is a major aspect of a project should an assessment be undertaken. In such cases the user is referred to IPCC 1996 Reference Manual for recommended sector -specific calculation methods.</p>		
<b>Municipal Solid Waste landfill CH<sub>4</sub></b>	<p>Methane emissions from landfill are time-dependent over the active lifetime of the facility and after closure. Emission rates are a complex function of waste characteristics, including composition, moisture content and age, and the design of the landfill.</p> <p>First order decay models have been developed to estimate time-dependent emissions (see WRI/WBCSD methodology and IPCC 1996) but are considered too complex for EBRD non-JI/CDM projects.</p> <p>It is recommended that the IPCC 1996 Default Methodology Tier 1 be used. This evaluates the <u>total potential yield of methane from the waste deposited</u>. This may be expressed as an average annual emission, but will not reflect actual emissions in any particular year. The following data are required for insertion in the estimation formula:</p>	<p>CH<sub>4</sub> (t/y) =</p> $[ MSW_T \times L_0 - R ] \times [ 1 - OX ]$ <p>where L<sub>0</sub>, the <i>methane generation potential</i> in t CH<sub>4</sub> / t MSW<sub>T</sub> is calculated as:</p> $L_0 = MCF \times DOC \times DOC_F \times F \times (16/12)$	<p>The CO<sub>2</sub> fraction of landfill gas and CO<sub>2</sub> from landfill gas flaring are assumed to be GHG neutral as part of the biological cycle.</p>

	<p>(i) Annualised mass of MSW to be deposited, <math>MSW_T</math> (t/y) (This figure may be estimated from population served times per capita production for the region)</p> <p>(ii) Methane Correction Factor (MCF) - reflecting the nature of the waste disposal practices and facility type. Recommended values are as follows:</p> <p style="padding-left: 40px;"><i>Managed</i> (i.e. controlled waste placement, fire control, and including some of the following: cover material, mechanical compacting or levelling): MCF = 1  <i>Unmanaged - deep</i> (&gt; 5m waste): MCF = 0.8  <i>Unmanaged - shallow</i> (&lt; 5m waste): MCF = 0.4  <i>Uncategorised</i> (default): MCF = 0.6</p> <p>(iii) Degradable Organic Carbon (DOC) - fraction of MSW that is degradable carbon . To evaluate DOC, local data must be obtained on</p> <p>a) the fractions of MSW that are:</p> <p style="padding-left: 40px;">paper and textile (A);  garden waste and other non-food putrescibles (B);  food waste (C);  wood or straw (D).</p> <p>b) the percentage by weight of degradable organic carbon in each waste type. Default values are</p> <p style="padding-left: 40px;">paper and textile - 40%;  garden waste and other non-food putrescibles - 17%  food waste - 15%;  wood or straw - 30%.</p> <p>The DOC for the total MSW is then given by:</p> $DOC = 0.4A + 0.17B + 0.15C + 0.3D$ <p>(iv) Fraction of DOC dissimilated (<math>DOC_F</math>) - i.e the fraction that is ultimately degraded and released: default = 0.5 - 0.6 (IPCC Good Practice Guidelines))</p> <p>(v) Fraction by volume of <math>CH_4</math> in landfill gas</p> <p>(vi) Mass of <math>CH_4</math> recovered per year for energy use or flaring, R (t/y)</p> <p>(vii) Fraction of <math>CH_4</math> released that is oxidised below surface within the site, OX. Default is OX = 0.1 for well-managed sites, otherwise 0.</p>		
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<p><b>Municipal Solid Waste incineration CO<sub>2</sub> and N<sub>2</sub>O</b></p>	<p>Data required for calculation of CO<sub>2</sub> emissions:</p> <p>(i) Annual amounts of each of MSW, hazardous waste (HW), clinical waste (CW) and sewage sludge (SS) incinerated ( IW<sub>i</sub>) (t)</p> <p>(ii) Fractional carbon content of each waste type CCW<sub>i</sub></p> <p>(iii) Fraction of total carbon that is fossil carbon FCF<sub>i</sub></p> <p>(iv) Efficiency of burn out of each waste type EF<sub>i</sub> (fraction)</p> <p>Default parameters: MSW SS(dry) CW(dry) HW (wet) (IPCC)</p> <table border="1"> <tr> <td>Carbon content</td> <td>0.40</td> <td>0.30</td> <td>0.60</td> <td>0.50</td> </tr> <tr> <td>Fossil C fraction of total carbon</td> <td>0.40</td> <td>0</td> <td>0.40</td> <td>0.90</td> </tr> <tr> <td>Efficiency of comb'n</td> <td>0.95</td> <td>0.95</td> <td>0.95</td> <td>0.995</td> </tr> </table> <p>Additional data required for calculation of N<sub>2</sub>O emissions:</p> <p>(i) N<sub>2</sub>O emission factor for each waste type ( kg / t waste). Where no data are available, the following plant-dependent default values may be used:</p> <p>Default parameters: MSW SS(dry) CW(dry) HW (wet) (IPCC, kg/t)</p> <table border="1"> <tr> <td>Hearth or grate</td> <td>0.0055 - 0.066</td> <td>0.4</td> <td>-</td> <td>-</td> </tr> <tr> <td>Rotating</td> <td>-</td> <td>-</td> <td>-</td> <td>0.21-0.24</td> </tr> <tr> <td>Fluidised bed</td> <td>0.24-0.66</td> <td>0.1-1.5</td> <td>-</td> <td>-</td> </tr> </table>	Carbon content	0.40	0.30	0.60	0.50	Fossil C fraction of total carbon	0.40	0	0.40	0.90	Efficiency of comb'n	0.95	0.95	0.95	0.995	Hearth or grate	0.0055 - 0.066	0.4	-	-	Rotating	-	-	-	0.21-0.24	Fluidised bed	0.24-0.66	0.1-1.5	-	-	<p>CO<sub>2</sub> (t/y) =</p> $\sum_i (IW_i \times CCW_i \times FCF_i \times EF_i \times 3.664)$ <p>N<sub>2</sub>O (kg/y) =</p> $\sum_i [ IW_i \times (\text{emission factor})_i ]$	<p>Given the plant-dependence of emissions and the wide range of default emission factors it must be noted that N<sub>2</sub>O emission calculations are indicative only.</p>
Carbon content	0.40	0.30	0.60	0.50																													
Fossil C fraction of total carbon	0.40	0	0.40	0.90																													
Efficiency of comb'n	0.95	0.95	0.95	0.995																													
Hearth or grate	0.0055 - 0.066	0.4	-	-																													
Rotating	-	-	-	0.21-0.24																													
Fluidised bed	0.24-0.66	0.1-1.5	-	-																													
<p><b>Municipal Waste Water Treatment CH<sub>4</sub></b></p>	<p>Significant CH<sub>4</sub> emissions from wastewater treatment (WWT) only arise from the anaerobic part of the process. Most EBRD projects will involve aerobic WWT systems. However, the sewage sludge from aerobic systems may be treated by land-filling in anaerobic conditions giving rise to CH<sub>4</sub> emissions.</p>	<p>CH<sub>4</sub> (t/y) =</p> $\text{Population} \times 365 \times 0.015 / 1000$ <p>(assuming aerobic WWT system but anaerobic land-filling of sewage sludge)</p>	<p>It is assumed that all industrial waste water in EBRD projects will be regulated and managed to minimise methane emissions.</p> <p>For a more sophisticated treatment of WWT emissions, see IPCC 1996.</p>																														

	<p>The IPCC Good Practice Guide 'Check Method' suggests a default value of 0.06 kg BOD<sub>5</sub> per capita per day for raw sewage production and suggests that about 50% of the BOD<sub>5</sub> in the raw sewage input emerges in sludge. Using IPCC default maximum methane producing capacity of 0.6 g CH<sub>4</sub>/ g BOD<sub>5</sub> and the default fraction of BOD<sub>5</sub> in sludge that degrades anaerobically of 0.8, gives a CH<sub>4</sub> production rate from land-filled sludge of 0.03 x 0.6 x 0.8 = <u>0.015 kg CH<sub>4</sub> per capita per day</u></p> <p>Conversely, if all the degradable carbon produced decomposes anaerobically, then the maximum CH<sub>4</sub> production rate would be 0.06 kg BOD<sub>5</sub> per capita per day x 0.6 g CH<sub>4</sub>/ g BOD<sub>5</sub> = <u>0.036 kg CH<sub>4</sub> per capita per day</u></p>	<p>or</p> <p>Population x 365 x 0.036 / 1000</p> <p>(assuming totally anaerobic WWT system with all methane vented to atmosphere)</p>	<p>Note that if sludge is disposed in more aerobic conditions, the anaerobically degraded fraction will be lower. Also methane release will be eliminated if the sludge is digested in an anaerobic digester with methane capture and use.</p>						
<p><b>Transport CO<sub>2</sub></b></p>	<p>(i) Annual fuel use (t)</p> <p>(ii) Fractional carbon content of fuel,</p> <p>OR</p> <p>(iii) Annual distance travelled by each vehicle type, i</p> <p>(iv) CO<sub>2</sub> emission factor (t CO<sub>2</sub> / km travelled) for each vehicle type</p> <p>If project specific data unavailable, use default emission factors:</p> <p>For (iv) road transport:</p> <table border="0"> <tr> <td>cars (gasoline):</td> <td>0.00027 t CO<sub>2</sub> / km</td> </tr> <tr> <td>light trucks:</td> <td>0.000325 t CO<sub>2</sub> / km</td> </tr> <tr> <td>heavy trucks:</td> <td>0.000535 t CO<sub>2</sub> / km</td> </tr> </table>	cars (gasoline):	0.00027 t CO <sub>2</sub> / km	light trucks:	0.000325 t CO <sub>2</sub> / km	heavy trucks:	0.000535 t CO <sub>2</sub> / km	<p>CO<sub>2</sub> (t) =</p> <p>Annual fuel use (t) x fractional C content x 3.664</p> <p>OR</p> <p><math>\sum_i [ (\text{Annual distance travelled by vehicle type})_i \times (\text{CO}_2 \text{ emissions factor})_i ]</math></p>	<p>WRI/WBCSD</p>
cars (gasoline):	0.00027 t CO <sub>2</sub> / km								
light trucks:	0.000325 t CO <sub>2</sub> / km								
heavy trucks:	0.000535 t CO <sub>2</sub> / km								
<p><b>Transport N<sub>2</sub>O</b></p> <p>(only significant for gasoline vehicles with 3-way catalyst)</p>	<p>(i) Annual fuel use (t)</p> <p>OR</p> <p>(ii) Annual distance travelled by vehicles (km)</p> <p>(iii) Default emission factors: 0.2 - 2.0 kg N<sub>2</sub>O / t fuel or 0.01 - 0.22 g N<sub>2</sub>O / km (higher end of range for older vehicles)</p>	<p>N<sub>2</sub>O (kg) =</p> <p>Annual fuel use (t) x emission factor (kg N<sub>2</sub>O/ t fuel)</p> <p>or</p> <p>Annual distance travelled (km) x emission factor (g N<sub>2</sub>O / km) / 1000</p>							

**EBRD GHG ASSESSMENT METHODOLOGY  
IMPLEMENTATION GUIDANCE NOTE**
**GN 4**
**GN 4 Estimation of emissions from imported electricity and heat**

For most projects it will be adequate to use grid electricity emission factors (gCO<sub>2</sub>/kWh) to estimate the GHG emissions associated with electricity purchased from the grid (row 1 in Table 1). National electricity grid factors are provided in Table 2. If the supply is direct from a known conventional power plant (i.e. not combined heat and power (CHP)), then the following more accurate techniques may be appropriate if these emissions form a significant fraction of the total project emissions and the power plant in question is of a type substantially different from the majority serving the grid (rows 2 and 3 in Table 1).

Table 1 Estimation methods for GHG emissions associated with purchase electricity

Calculation	Data required	Typical units	How used
CO <sub>2</sub> from electricity supplied by power grid  - where neither heat rate nor conversion efficiency of supplying plant known	Annual electrical import (E)  Default C intensity C <sub>ie</sub> (Use regional or national figure appropriate to the power supply)	MWh <sub>e</sub>  tC/MWh <sub>e</sub>	CO <sub>2</sub> emitted = E x C <sub>ie</sub> x 3.664
CO <sub>2</sub> from electricity supplied by conventional fossil fuelled power plant  - where supplying plant heat rate is known	Annual electrical import (E)  Transmission losses (T <sub>1</sub> )  Power plant heat rate (= heat energy input / electrical output) (h)  Default C intensity C <sub>i</sub>	MWh <sub>e</sub>  %  TJ / MWh <sub>e</sub>  tC/TJ	CO <sub>2</sub> = E x ((100+ T <sub>1</sub> )/100) x h x c <sub>i</sub> x 3.664
CO <sub>2</sub> from electricity supplied by conventional fossil fuel power plant  - where supplying plant heat rate not known, but conversion efficiency known	Annual electrical import (E)  Default C intensity C <sub>ie</sub> (assumes C <sub>ie</sub> includes losses and is defined as having assumed a default power plant conversion efficiency = η <sub>default</sub> %) Actual power plant conversion efficiency = η <sub>actual</sub> %)	MWh <sub>e</sub>  tC/MWh <sub>e</sub>	CO <sub>2</sub> = E x C <sub>ie</sub> x η <sub>default</sub> / η <sub>actual</sub> x 3.664

Table 2. Grid Electricity GHG emission factors for use in estimating GHG emissions associated with use of grid electricity. (These figures take account of the losses in transmission between the power stations and the end users.)

[From **Operational Guidelines for Project Design Documents of Joint Implementation projects Volume 1: General guidelines, Version 2.2**, Ministry of Economic Affairs of the Netherlands June 2003. This will be updated and extended as new data become available]

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Belarus	580	574	568	562	555	549	543	537	531	525	518	512	506
Bulgaria	1069	1047	1024	1002	979	957	934	912	890	867	845	822	800
Croatia	784	771	758	745	733	720	707	694	681	668	655	642	629
Czech Republic	830	816	801	787	772	758	743	729	714	700	685	671	656
Estonia	966	947	928	909	889	870	851	832	813	794	775	756	737
Hungary	745	733	721	710	698	686	675	663	651	640	628	616	605
Latvia	476	473	471	468	465	463	460	457	454	452	449	446	444
Poland	910	892	875	858	841	824	807	790	772	755	738	721	704
Romania	777	764	751	738	726	713	700	687	675	662	649	637	624
Russia	627	619	612	604	596	588	581	573	565	557	550	542	534
Slovakia	652	643	635	626	617	609	600	592	583	575	566	557	549
Slovenia	826	811	797	783	768	754	740	725	711	696	682	668	653
Ukraine	996	976	956	936	916	896	876	856	836	816	796	776	756

Table B2 *Baseline carbon emission factors for JI projects reducing electricity consumption (in gCO<sub>2</sub>/kWh)*

Where electricity and/or heat is imported from a combined heat and power plant, the emissions associated with the different power and heat (steam) streams should be apportioned appropriately. The supplier should be asked to provide an emission factor appropriate for the power or heat stream purchased (tonne CO<sub>2</sub> per unit of electricity or heat purchased).

If this is not readily available, the supplier should be asked to carry out the necessary calculation of apportionment, or, at minimum, supply the data to enable this. The method of apportionment should be based on weighting the emissions by the work potential of each electricity and heat stream, as presented in the WRI/WBCSD GHG Protocol (see <http://www.ghgprotocol.org>). This is summarised below.

$$\text{CO}_2 \text{ emission from stream } i = \text{total CO}_2 \text{ emissions} \times W_i / \sum_i W_i,$$

where  $W_i$  is the work potential of stream  $i$  defined as

$$W_i \text{ (GJ)} = (F_i / 1000) \times \{ [ h_i - (T \times S_i) ] - [ h_{\text{ref}} - (T_{\text{ref}} \times S_{\text{ref}}) ] \}$$

where

$F_i$  = mass of steam (tonnes) in stream  $i$

$h_i$  = specific enthalpy of steam flow in stream  $i$  (kJ/kg)

$T_i$  = delivery temperature of steam flow (absolute °K)

$S_i$  = specific entropy of steam flow in stream  $i$  (kJ/kg)

$h_{\text{ref}}$  = specific enthalpy at reference conditions (kJ/kg)

$T_{\text{ref}}$  = reference temperature (absolute °K)

$S_{\text{ref}}$  = specific entropy at reference conditions (kJ/kg)

If it is not possible to acquire the estimation or the data, it is recommended that a conservative (i.e. high GHG emission estimate) is made for electricity based on the emission factor appropriate for the fuel and generation technology assuming no heat production (e.g. gas-fired CCGT or coal-fired conventional pulverised fuel)

**EBRD GHG ASSESSMENT METHODOLOGY  
IMPLEMENTATION GUIDANCE NOTE**
**GN 5**
**GN 5 Global Warming Potentials for calculation of total GHG  
(CO<sub>2</sub> equivalent) emissions**
**Definition of Global Warming Potential**

The global warming potential (GWP) of a greenhouse gas is the number of times more effective a unit mass emission of the gas is compared with a unit mass emission of CO<sub>2</sub>. The GWP of a GHG depends on the period over which the effect is considered because the lifetime of each GHG in the atmosphere is different from that of CO<sub>2</sub>. For example, an emission of CO<sub>2</sub> is likely to remain in the atmosphere on average for about 100 years before transfer through natural processes to the ocean, biosphere or land surface. In contrast methane is chemically transformed to CO<sub>2</sub> with an atmospheric half-life of a decade or so. Thus the integrated effect of a unit emission of methane over a century relative to CO<sub>2</sub> is much less than its effect relative to CO<sub>2</sub> over the decade following its emission.

It is conventional in GHG assessment to use global warming potentials evaluated over a 100 year time horizon in order to standardise the method for aggregating the effects of different GHG emissions. The following table (based on IPCC Second Assessment Report 1995) sets out the GWPs that should be used as factors to convert unit mass emissions of each GHG into CO<sub>2</sub>-equivalent, or CO<sub>2</sub>-e.

GHG	GWP (100 year time horizon) (mass basis)
CO <sub>2</sub>	1
CH <sub>4</sub>	21
N <sub>2</sub> O	310
HFC-23	11,700
HFC-32	650
HFC-41	150
HFC-43	1,300
HFC-125	2,800
HFC-134	1,000
HFC-134a	1,300
HFC-152a	140
HFC-143	300
HFC-143a	3,800
HFC-227ea	2,900
HFC-236fa	6,300
HFC-245ca	560
SF <sub>6</sub>	23,900
CF <sub>4</sub>	6,500
C <sub>2</sub> F <sub>6</sub>	9,200
C <sub>3</sub> F <sub>8</sub>	7,000
C <sub>4</sub> F <sub>10</sub>	7,000
c-C <sub>4</sub> F <sub>8</sub>	8,700
C <sub>5</sub> F <sub>12</sub>	7,500
C <sub>6</sub> F <sub>14</sub>	7,400