CLEAN DEVELOPMENT MECHANISM

**TOOL15**

# Methodological tool

# Upstream leakage emissions associated with fossil fuel use

Version 02.0

**United Nations**
Framework Convention on
Climate Change

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# 1. Introduction

1. This tool provides methodological guidance to determine leakage upstream emissions associated with the use of fossil fuels.

# 2. Scope, applicability, and entry into force

## 2.1. Scope

2. This tool provides a procedure to calculate leakage upstream emissions associated with the use of fossil fuels.

## 2.2. Applicability

3. The tool is applicable to calculate leakage upstream emissions associated with fossil fuel use in either or both the baseline scenario and project activity.

4. Upstream emissions associated with fossil fuel use are:

    (a) Fugitive emissions of $CH_4$ and $CO_2$, including venting, flaring and physical leakage from equipment;

    (b) $CO_2$ emissions from combustion of fossil fuels;

    (c) $CO_2$ emissions associated with consumption of electricity.

5. Other greenhouse gas (GHG) emissions sources, such as those associated with the construction of equipment are relatively small and therefore not considered.

6. The tool has two options to determine these emissions: Option (A) provides simple default emission factors for different types of fossil fuels and Option (B) calculates emission factors based on emissions for each upstream emissions stage. Option (B) requires identifying the relevant upstream emissions stages and the corresponding emission factor for each stage, which may be a default value or calculated, such as according to the 2006 IPCC Tier 2 or 3 methodology.

7. This tool is applicable to the following types of fossil fuels, which can be categorized to be either based on natural gas, oil or coal:

8. Natural gas:

    (i) Natural gas;

    (ii) Natural gas liquids (mixtures of primarily pentanes and heavier hydrocarbon);

    (iii) Propane, butane, and other types of liquefied petroleum gas (LPG);

    (iv) Liquefied natural gas (LNG);

    (v) Compressed natural gas (CNG);

      (b)     Oil:

            (i)     Light fuel oil (diesel);

            (ii)    Heavy fuel oil (bunker or marine type);

            (iii)   Gasoline;

            (iv)   Kerosene (household and aviation);

            (v)    Propane, butane, and other types of liquefied petroleum gas (LPG);

      (c)     Coal:

            (i)     Coal;

            (ii)    Lignite.

9.     Methodologies which refer to this tool should state:

      (a)     The fossil fuel type(s), as listed above, for which upstream emissions should be determined. For the situation that the fossil fuel is defined at the project level, instead of in the methodology, and does not exactly match a type listed above, then the closest approximation shall be selected in terms of the fuel characteristics (e.g. natural gas, oil or coal based fuel) and fossil fuel lifecycle stages (see Table 1 in the appendix);

      (b)     Procedures to determine the amount of each fossil fuel type(s) used in the baseline or project situation on a net calorific value (NCV);

      (c)     Whether there is a possibility that leakage upstream emissions values are less than 0, such as for project activities in which a fossil fuel in the baseline situation is displaced with a renewable fuel in the project situation. Otherwise, if negative values are calculated using this tool, then they are assumed to equal 0. In any case, net leakage should always be considered as zero when net leakage effects are negative.

## 2.3.  Entry into force

10.    The date of entry into force is the date of the publication of the EB 81 meeting report on 28 November 2014.

# 3.   Normative references

11.    This methodological tool refers to the latest approved version of the following tools:

      (a)     "Tool to calculate baseline, project and/or leakage emissions from electricity consumption";

      (b)     "Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion".

12.    The applicability conditions of these tools also apply.

13. For more information regarding the tools, as well as their consideration by the Executive Board (hereinafter referred to as the Board) of the clean development mechanism (CDM) please refer to <http://cdm.unfccc.int/goto/MPappmeth>.

14. This methodological tool also refers to the following documents:

(a) Alberta Energy Research Institute. 2009. Life Cycle Assessment Comparison of North American and Imported Crudes Prepared by Jacobs Consultancy and Life Cycle Associates LLC;

(b) API. 2009. Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry. Pp. 807. Available at: <http://www.api.org/ehs/climate/new/upload/2009_GHG_COMPENDIUM.pdf.>;

(c) Centre for Liquefied Natural Gas. 2009. Life Cycle Assessment of GHG Emissions from LNG and Coal Fires Generation Scenarios: Assumptions and Results. Prepared by PACE. VA;

(d) CEFIC. 2011. Guidelines for Measuring and Managing CO2 Emissions from Freight Transport Operations. Issue 1/March 2011. pp. 19. Available at: <www.cefic.org>;

(e) ICF International. 2011. APPENDIX B: Life Cycle Greenhouse Gas Emissions of Petroleum Products from WCSB Oil Sands Crudes Compared with Reference Crudes. A report prepared for Cardno ENTRIX, the U.S. Department of State's third-party environmental contractor for the Keystone XL Project environmental review. pp. 57;

(f) His-Jen Chen and Yeh-Chion Lin. 2001. Case Studies on Optimum Reflux Ratio of Distillation Towers in Petroleum Refining Processses. Tamkang Journal of Science and Engineering. V 4, n 2 pp 105-110;

(g) IPCC. 2006. Guidelines for National Greenhouse Gas Inventories. Volumes 1 to 5. Available at:<http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>;

(h) Jaramillo, P., W. Griffin, H. Matthews. Comparative Life Cycle Carbon Emissions of LNG Versus Coal Gas for Electricity Generation;

(i) Summers, D.R., K.G. Moore and R. Maisonneuve. 2002. Properly Designed High Performance Trays Increase Column Efficiency and Capacity. Presented at the AIChE Spring National Meeting, March 12, 2002. New Orleans, Louisiana.10 pp. (Table 3);

(j) Toyota Motor Corporation. 2004. Well-to-Wheel Analysis of Greenhouse Gas Emissions of Automotive Fuels in the Japanese Context. Well-to-Tank Report. Prepared by Mizuho Information & Research Institute, Inc.

# 4. Definitions

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

16. For the purpose of this tool, the following definitions apply:

(a) **Upstream emissions** - GHG emissions associated with the production, processing, transmission, storage and distribution of a fossil fuel, beginning with the extraction of raw materials from the fossil fuel origin and ending with the delivery of the fossil fuel to the site of use;

(b) **Upstream emissions stage** - the segmentation of upstream emissions into stages based on distinct activities occurring within a stage. Upstream emissions stages are interdependent and lead from one to the next, typically consisting of production, processing, transmission, storage and distribution. Upstream emissions stages may be broadly generalized for types of fossil fuel. However, only some of the upstream emission stages may apply to a particular fossil fuel because of location and application-specific circumstances. For example, a particular natural gas may go directly from the production stage to the distribution stage, without going through any processing, transmission or storage upstream emissions stages;

(c) **Fossil fuel origin** - this refers to the location and type of reservoir(s) or mine(s) from which the fossil fuel originates. The type of reservoir differentiates key characteristics which influence upstream emissions. For natural gas based fossil fuels the types of reservoirs include sweet, sour, coal-bed, shale or associated gas. For coal-based fuels the types of mines include underground or surface.

# 5.   Parameters

17.   This tool provides procedures to determine the following parameter:

**Table 1.      Parameters**

| Parameter | SI Unit | Description |
|---|---|---|
| $LE_{US,y}$ | t $CO_2$e/yr | Leakage upstream emissions in year $y$ |

18.   The following data are required by this tool. The underlying methodology shall provide the procedures to estimate the following parameters.

**Table 2.      Parameters**

| Parameter | SI Unit | Description |
|---|---|---|
| $FC_{PJ,x,y}$ | TJ/yr | Quantity of fossil fuel type $x$ used in the project situation in year $y$ (on a NCV basis) |
| $FC_{BL,x,y}$ | TJ/yr | Quantity of fossil fuel type $x$ used in the baseline situation in year $y$ (on a NCV basis) |

# 6. Methodological steps to calculate leakage upstream emissions

19. Leakage upstream emissions shall be determined using one of the following two options:

    (a) Option (A): simple approach based on default emission factors; or

    (b) Option (B): detailed approach based on the upstream emissions stages.

20. In the case that part of the upstream emissions occur within the project boundary of the CDM project activity (e.g. the project activity is implemented in a refinery), then project participants shall apply Option (B). Otherwise, project participants may choose between Option (A) and Option (B). The project participants should document in the CDM-PDD and monitoring reports which approach is applied. The approach may be changed during the crediting period, however, a combination of Options (A) and (B) is not allowed in the same monitoring period.

## 6.1. Option (A): Simple approach based on default emission factors

21. Leakage upstream emissions are calculated as follows:

$$LE_{US,y} = \sum_{x} EF_{US,x,default} \times \left( FC_{PJ,x,y} - FC_{BL,x,y} \right)$$

Equation (1)

22. If $LE_{US,y}$ is calculated as a value of less than 0, then a value of 0 shall be used instead, unless the methodology referencing this tool specifies that negative values for $LE_{US,y}$ are permitted.

    Where:

| | | |
|---|---|---|
| $LE_{US,y}$ | = | Leakage upstream emissions in year $y$ (t $CO_2$e/yr) |
| $FC_{PJ,x,y}$ | = | Quantity of fossil fuel type $x$ used in the project situation in year $y$ (TJ/yr) |
| $FC_{BL,x,y}$ | = | Quantity of fossil fuel type $x$ used in the baseline situation in year $y$ (TJ/yr) |
| $EF_{US,x,default}$ | = | Default emission factor for upstream emissions associated with consumption of fossil fuel type $x$ (t $CO_2$e/TJ) |
| $x$ | = | Fossil fuel types used in the project and/or baseline situation and for which upstream emissions should be determined |

23. Select $EF_{US,x,default}$ from Table 3 for the corresponding fossil fuel type $x$. In this table, a simple default emission factors is provided for each fossil fuel type, not distinguishing factors for different fossil fuel origin except for coal based fuels. For this fuel type, there are default emission factors provided if it is known that the coal based fuel is wholly sourced from an underground mine or mine(s) located in the host country of the project activity. Default factors are also provided for the situation that this information is not available.

24.    These default values have been determined using the approach for Option B.[1]

**Table 3.    Default emission factors for upstream emissions for different types of fossil fuels ($EF_{US,x,default}$)**

| Fossil fuel type | | Default emission factor (t $CO_2$e/TJ) |
|---|---|---|
| Natural Gas (NG) | | 2.9 |
| Natural Gas Liquids (NGL) | | 2.2 |
| Liquefied Natural Gas (LNG) | | 16.2 |
| Compressed Natural Gas (CNG) | | 10 |
| Light Fuel Oil (Diesel) | | 16.7 |
| Heavy Fuel Oil (Bunker or Marine Type) | | 9.4 |
| Gasoline | | 13.5 |
| Kerosene (household and aviation) | | 8.5 |
| LPG (including butane and propane) | | 8.7 |
| Coal/lignite (unknown mine location(s) or coal/lignite not 100 per cent sourced from within host country) | Lignite | 2.9 |
| | Surface mine, or any other situation | 2.8 |
| | Underground (100 per cent source) | 10.4 |
| Coal/lignite (coal/lignite 100 per cent sourced from within host country) | Lignite | 6.0 |
| | Surface mine, or any other situation | 5.8 |
| | Underground (100 per cent source) | 21.4 |

## 6.2.    Option (B): Detailed approach based on the upstream emissions stages

25.    This approach estimates upstream emissions by summing the emissions occurring in each upstream emissions stage relevant to the fossil fuel used in the project or baseline situation. This requires identifying:

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[1]   The approach to calculate the default values is to sum together the emission factors for each of the upstream emission stages for fossil fuel type *x*, as listed in Table 1 of the appendix. Natural gas, liquefied natural gas, oil and coal are commodities that are traded globally. The fuels are produced in Annex I countries in various quantities and therefore the emissions produced during the exploration and production, upgrading and/or refining transportation stages are already considered in the national inventories of these Annex I countries. In order to avoid double counting, each emission factor (for natural gas, liquefied natural gas, oil and coal) is multiplied by a correction factor which accounts for the exporting activity from Annex I countries, applying data published by the U.S Energy Information Administration, International Energy Statistics and BP Statistical Review of World Energy. The correction factors for natural gas based fossil fuel types (Except LNG), liquefied natural gas, oil based fossil fuel types and coal/lignite are the following respectively: 0.26, 0.85, 0.76 and 0.48.

(a) Fossil fuel type(s) and origin;

(b) Upstream emissions stages that are applicable to each fossil fuel type and origin; and

(c) Emission factors corresponding to each applicable upstream emissions stage.

26. Upstream leakage emissions are then calculated as follows:

$$LE_{US,y} = \sum_{x} \sum_{i} \sum_{j} EF_{i,j,x,y} \times \left( FC_{PJ,x,j,y} - FC_{BL,x,j,y} \right)$$

Equation (2)

Where:

| | | |
|---|---|---|
| $LE_{US,y}$ | = | Leakage upstream emissions in year $y$ (t $CO_2$e/yr) |
| $EF_{i,j,x,y}$ | = | Emission factor for upstream emissions stage $i$ associated with consumption of fossil fuel type $x$ from fossil fuel origin $j$ applicable to year $y$ (t $CO_2$e/TJ) |
| $FC_{PJ,x,j,y}$ | = | Quantity of fossil fuel type $x$ from fossil fuel origin $j$ used in the project situation in year $y$ (TJ/yr) |
| $FC_{BL,x,j,y}$ | = | Quantity of fossil fuel type $x$ from fossil fuel origin $j$ used in the baseline situation in year $y$ (TJ/yr) |
| $x$ | = | Fossil fuel types for which upstream emissions are determined |
| $i$ | = | Upstream emissions stage |
| $j$ | = | Fossil fuel origin(s) in year $y$ |

### 6.2.1. Step 1. Identifying the fossil fuel origin *j*

27. The fossil fuel origin is needed to determine the emission factor for an upstream emissions stage using Option (B) and may also be useful for identifying the applicable upstream emissions stages for each fossil fuel type.

28. For oil based fossil fuel types, the fossil fuel origin is global.[2] For coal based fossil fuel types, the fossil fuel origin is also global, unless the fossil fuel origin is clearly identified as a mine located within the host country. For all other situations and fossil fuel types the fossil fuel origin must be determined. Where it is not possible to identify the fossil fuel origin, then it should be determined based on reasonable and conservative assumptions for the region or jurisdiction. For instance, if a fossil fuel type used in the project activity could potentially be sourced from one of several fossil fuel origins, then it can be assumed to have only one fossil fuel origin as long as this is justified to be conservative. The basis for determining the fossil fuel origin, and if relevant the justification of why any

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[2] A global fossil fuel origin represents the situation that it is not possible to confirm the exact source of the fossil fuel that would be replaced or used as a result of a CDM project activity, given that oil and its products are globally traded commodity. In which exact location oil production is increased or decreased as a result of a CDM project activity may depend on many factors, such as the marginal production costs, the location of the host country, the current prices for raw oil, or geopolitical factors. For example, a project activity located in an oil producing country may not necessarily impact the oil production in that country but could instead increase or decrease the export or import of oil.

assumptions are conservative, shall be documented in the CDM project design document (CDM-PDD) and monitoring reports.

29. Each year it shall be checked if the fossil fuel origin(s) has changed, and if it has changed, then the Option (B) procedure must be updated.

30. As a check, the sum of the fossil fuel consumption of each fossil fuel origin for fossil fuel type *x* shall equal the quantity of fossil fuel *x* consumed in the baseline and project situations, as follows:

$$FC_{PJ,x,y} = \sum_j FC_{PJ,x,j,y}$$

Equation (3)

and

$$FC_{BL,x,y} = \sum_j FC_{BL,x,j,y}$$

Equation (4)

Where:

$FC_{PJ,x,j,y}$    = Quantity of fossil fuel type *x* from fossil fuel origin *j* used in the project situation in year *y* (TJ/yr)

$FC_{BL,x,j,y}$    = Quantity of fossil fuel type *x* from fossil fuel origin *j* used in the baseline situation in year *y* (TJ/yr)

$FC_{PJ,x,y}$    = Quantity of fossil fuel type *x* used in the project situation in year *y* (TJ/yr)

$FC_{BL,x,y}$    = Quantity of fossil fuel type *x* used in the baseline situation in year *y* (TJ/yr)

*x*    = Fossil fuel types for which upstream emissions are determined

*j*    = Fossil fuel origin(s) in year *y*

## 6.2.2. Step 2. Identifying upstream emissions stages

31. The upstream emissions stages *i* that are potentially applicable for each fossil fuel type and origin are listed in Table 1 of the appendix. Those stages that shall always be assumed to apply for a given fossil fuel type are identified as a mandatory upstream emissions stage. Otherwise, the stage may or may not apply depending on the project specific circumstance and fossil fuel origin. If there is uncertainty as to whether a particular stage is applicable, then for fuel consumption that is higher in the project situation than the baseline, then it shall be assumed to apply, and otherwise it shall be assumed to not apply.

## 6.2.3. Step 3. Identifying the emission factor corresponding to each upstream emissions stage ($EF_{i,j,x,y}$)

32. For fossil fuel types with a global fossil fuel origin or an origin identified to be located in an Annex 1 country, then the emission factor corresponding to specified upstream emissions stages *i* are calculated as follows:

(a) For oil-based fuels, because their fossil fuel origin j is global, the emission factors for the exploration and production, upgrading and/or refining and transportation stages shall be selected from the list of default emission factors in Table 1 of the appendix (selecting an average, where a range in values is given), and multiplied by 0.76[1];

(b) For coal based fuels with a fossil fuel origin j that is global, the emission factor for each upstream emission stage shall be selected from the list of default emission factors in Table 1 of the appendix and multiplied by 0.48[1];

(c) For natural gas based fossil fuel types (except LNG), with a fossil fuel origin $j$ that is global, the emission factor for each upstream emission stage shall be selected from the list of default emission factors in Table 1 of the appendix and multiplied by 0.26[1];

(d) For liquefied natural gas, the emission factor for each upstream emission stage shall be selected from the list of default emission factors in Table 1 of the appendix and multiplied by 0.85[1];

(e) For a natural gas based fuel with a fossil fuel origin $j$ located in an Annex 1 country, and the case that fuel consumption of type $x$ from this origin $j$ is higher in the baseline situation than in the project situation, then the emission factor is 0 for the exploration and production, and processing stages.

33. For all other situations project participants may select for each upstream emissions stage $i$, from either Option (1) or Option (2) to determine the emission factor corresponding to each upstream emissions stage (e.g. different options may be selected for each upstream emission stages of fossil fuel type $x$ from fossil fuel origin $j$):

(a) Option (1): select a default emission factor from Table 1 of the appendix;

(b) Option (2): determine a refined emission factor that is specific to the project activity.

34. The data needed to support the development of refined emission factors may be difficult to obtain and the refined approach will typically only be practical for either fossil fuel origins that can be identified as a particular reservoir or mine or for upstream emissions stages that have few activities and the emission sources are easy to identify.

### 6.2.3.1. Option (1). Default emission factors

35. Select $EF_{i,j,x}$, from the list of default emission factors for upstream emissions stages in Table 1 of the appendix. Where the default emission factor is given as a range of values, follow the instructions given in the table notes on how to choose the appropriate value within the range.

### 6.2.3.2. Option (2). Refined emission factors

36. Developing a refined $EF_{i,j,x}$ requires determining the GHG emissions associated with the following emission sources in the upstream emissions stage:

(a) For oil and natural gas based fossil fuels:

   (i) Fossil fuel consumption ($E_{Fuel,i,j,x,t}$);

(ii)    Purchased electricity consumption ($E_{Electricity,i,j,x,t}$);

(iii)    Flaring ($E_{Flaring,i,j,x,t}$);

(iv)    Venting ($E_{Venting,i,j,x,t}$);

(v)    Leaks from equipment ($E_{Leaks,i,j,x,t}$);

(vi)    Storage losses ($E_{Storage\ Losses,i,j,x,t}$);

(b)    For coal based fossil fuels:

(i)    Fugitive methane emissions ($E_{Fugitive,i,j,x,t}$);

(ii)    Fossil fuel consumption ($E_{Fuel,i,j,x,t}$);

(iii)    Purchased electricity consumption ($E_{Electricity,i,j,x,t}$).

37.    The calculation of the emission factor(s) shall be updated at the renewal of the crediting period or if the fossil fuel origin *j* changes.

38.    To calculate the emission factor, the total GHG emissions from the upstream emissions stage during a representative time period *t* are divided by the amount of the fossil fuel output by the upstream emissions stage during the same time period *t* ($FP_{i,j,x,t}$). Sufficient data should be used to ensure balanced weighting of any variations in emission intensities, such as due to seasonal variations in production and process performance. The time period *t* should therefore be at least one year.

39.    The emission factor is calculated using equation (5) for oil and natural gas based fossil fuels and equation (6) for coal. A simplified approach is given in equation (7) for the situation that the key activities of an upstream emissions stage comprise only transportation.

40.    Refined emission factor for an upstream emissions stage associated with oil or natural gas based fuels are calculated as follows:

$$
EF_{i,j,x,y} = \frac{1}{FP_{i,j,x,t}}
$$

Equation (5)

$$
\times \left( E_{Fuel,i,j,x,t} + E_{Flaring,i,j,x,t} + E_{Venting,i,j,x,t} \right.
$$

$$
\left. + E_{Leaks,i,j,x,t} + E_{StorageLosses,i,j,x,t} + E_{Electricity,i,j,x,t} \right)
$$

Where:

$EF_{i,j,x,y}$      = Emission factor for upstream emissions associated with upstream emissions stage *i* of fossil fuel *x* from fossil fuel origin *j* applicable for year *y* (t $CO_2$e/TJ)

$FP_{i,j,x,t}$      = Fuel output from upstream emissions stage *i* of fossil fuel type *x* from fossil fuel origin *j* in the time period *t* (TJ)

| | | |
|---|---|---|
| $E_{Fuel,i,j,x,t}$ | = | Emissions from consumption within upstream emissions stage $i$ of fossil fuel type $x$ from fossil fuel origin $j$ in the time period $t$ (t $CO_2$e) |
| $E_{Flaring,i,j,x,t}$ | = | Emissions from flaring within upstream emissions stage $i$ of fossil fuel type $x$ from fossil fuel origin $j$ in the time period $t$ (t $CO_2$e) |
| $E_{Venting,i,j,x,t}$ | = | Emissions from venting within upstream emissions stage $i$ of fossil fuel type $x$ from fossil fuel origin $j$ in the time period $t$ (t $CO_2$e) |
| $E_{Leaks,i,j,x,t}$ | = | Emissions from fugitive equipment leaks within upstream emissions stage $i$ of fossil fuel type $x$ from fossil fuel origin $j$ in the time period $t$ (t $CO_2$e) |
| $E_{StorageLosses,i,j,x,t}$ | = | Emissions from storage losses within upstream emissions stage $i$ of fuel type $x$ from fossil fuel origin $j$ in the time period $t$ (t $CO_2$e) |
| $E_{Electricity,i,j,x,t}$ | = | Emissions associated with electricity consumption within upstream emissions stage $i$ of fuel type $x$ from fossil fuel origin $j$ in the time period $t$ (t $CO_2$e) |
| $x$ | = | Fossil fuel types for which upstream emissions are determined |
| $i$ | = | Upstream emissions stage associated with oil and natural gas based fuels |
| $j$ | = | Fossil fuel origin(s) in year $y$ |
| $t$ | = | Time period of at least one year |

41.   Refined emission factor for an upstream emissions stage associated with coal based fuels are calculated as follows:

$$EF_{i,j,x,y} = \frac{1}{FP_{i,j,x,t}} \times \left( E_{Fuel,i,j,x,t} + E_{Fugitives,i,j,x,t} + E_{Electricity,i,j,x,t} \right)$$

Equation (6)

Where:

| | | |
|---|---|---|
| $EF_{i,j,x,y}$ | = | Emission factor for upstream emissions associated with upstream emissions stage $i$ of fossil fuel $x$ from fossil fuel origin $j$ applicable for year $y$ (t $CO_2$e/TJ) |
| $FP_{i,j,x,t}$ | = | Fuel output from upstream emissions stage $i$ of fossil fuel type $x$ from fossil fuel origin $j$ in the time period $t$ (TJ) |
| $E_{Fuel,i,j,x,t}$ | = | Emissions from consumption within upstream emissions stage $i$ of fossil fuel type $x$ from fossil fuel origin $j$ in the time period $t$ (t $CO_2$e) |
| $E_{Fugitives,i,j,x,t}$ | = | GHG emission rate from fugitive sources within upstream emissions stage $i$ of fuel type $x$ from fossil fuel origin $j$ in the time period $t$ (t $CO_2$e) |

| | | |
|---|---|---|
| $E_{Electricity,i,j,x,t}$ | = | Emissions associated with electricity consumption within upstream emissions stage $i$ of fuel type $x$ from fossil fuel origin $j$ in the time period $t$ (t $CO_2$e) |
| $x$ | = | Fossil fuel types for which upstream emissions are determined |
| $i$ | = | Upstream emissions stage associated with coal based fuels |
| $j$ | = | Fossil fuel origin(s) in year $y$ |
| $t$ | = | Time period of at least one year |

42. A simplified equation is provided below to determine the refined emission factor for upstream emissions stages that only comprise transportation activities. As well as updating the emission factor at the renewal of the crediting period or if the fossil fuel origin changes, the emission factor shall also be recalculated if the mode of transportation $r$ changes, or for the case that there is more than one transport mode $r$ and the relevant proportion of fuel transported by these modes changes.

$$EF_{i,j,x,y} = \frac{\sum_r (EF_{FT,r,default} \times FP_{i,j,x,r,t} \times DT_{i,j,x,r,t})}{NCV_x \times FP_{i,j,x,t}}$$
Equation (7)

Where:

| | | |
|---|---|---|
| $EF_{i,j,x,y}$ | = | Emission factor for upstream emissions associated with upstream emissions stage $i$ of fossil fuel $x$ from fossil fuel origin $j$ applicable for year $y$ (t $CO_2$e/TJ) |
| $EF_{FT,r,default}$ | = | Emission factor for the emissions associated with energy consumed in transporting fossil fuel by mode $r$ (t $CO_2$e/t km) |
| $FP_{i,j,x,r,t}$ | = | Fossil fuel type $x$ from fossil fuel origin $j$ transported in upstream emissions stage $i$ by mode $r$ in the time period $t$ (TJ) |
| $DT_{i,j,x,r,t}$ | = | Distance that fossil fuel $x$ from fuel origin $j$ was transported by mode $r$ in upstream emissions stage $i$ in the time period $t$ (km) |
| $NCV_x$ | = | Net calorific value of the fossil fuel $x$ (TJ/t) |
| $FP_{i,j,x,t}$ | = | Fuel output from upstream emissions stage $i$ of fossil fuel type $x$ from fossil fuel origin $j$ in the time period $t$ (TJ) |
| $x$ | = | Fossil fuel types for which upstream emissions are determined |
| $i$ | = | Upstream emissions stage that comprises only transport activity |
| $j$ | = | Fossil fuel origin(s) in year $y$ |
| $r$ | = | Transport modes in year $y$ |
| $t$ | = | Time period of at least one year |

43. Select $EF_{FT,r,default}$ from Table 4 for the corresponding transport mode $r$. In the case that a fuel type $x$ is used both in the project activity and in the baseline, then the default emission factor for the baseline shall be applied where the fuel consumption under the baseline exceeds the fuel consumption under the project activity. Otherwise, the default emission factor for the project situation shall be applied.

**Table 4.** Default emission factors for different modes of petroleum transportation ($EF_{FT,r,default}$)

| Transport mode | Default emission factor for baseline situation (t $CO_2$/t km) | Default emission factor for project situation (t $CO_2$/t km) |
|---|---|---|
| Road transport [1] | 76 x $10^{-6}$ | 129 x $10^{-6}$ |
| Rail transport | 22 x $10^{-6}$ | 22 x $10^{-6}$ |
| Barge transport | 31 x $10^{-6}$ or 0 if trip consists of international shipping[*] | 31 x $10^{-6}$ |
| Short sea | 16 x $10^{-6}$ or 0 if trip consists of international shipping[*] | 16 x $10^{-6}$ |
| Deep-sea tanker | 5 x $10^{-6}$ or 0 if trip consists of international shipping[*] | 5 x $10^{-6}$ |
| Intermodal road/rail | 26 x $10^{-6}$ | 26 x $10^{-6}$ |
| Intermodal road/barge | 34 x $10^{-6}$ | 34 x $10^{-6}$ |
| Intermodal road/short sea | 21 x $10^{-6}$ | 21 x $10^{-6}$ |
| Pipelines (Crude oil and refined product transport)[2] | 2.8 x $10^{-6}$ | 5.9 x $10^{-6}$ |
| Pipelines (Natural gas transmission)[3] | 5 x $10^{-6}$ | 65 x $10^{-6}$ |
| Pipeline (Natural gas distribution)[4] | 0.4 x $10^{-6}$ | 0.6 x $10^{-6}$ |

[a] Source: *CEFIC. 2011. Guidelines for Measuring and Managing CO2 Emissions from Freight Transport Operations. Issue 1/March 2011. pp. 19.*,

1. Emission factor for the baseline situation has been obtained from empirical data from European vehicles (Les émissions de CO2 par les poids lourds français entre 1996 et 2006 ont augmenté moins vite que les volumes transportés. Commissariat Général au Développement Durable. # 25, 2009). The emission factor for the project situation has been derived based on custom design transient speed-time-gradient drive cycle (adapted from the international FIGE cycle), vehicle dimensional data, mathematical analysis of loading scenarios, and dynamic modeling based on engine power profiles, which, in turn, are a function of gross vehicle mass (GVM), load factor, speed/acceleration profiles and road gradient.

2. Based on detailed greenhouse gas emissions data and system data available for one major pipeline transporter of crude oil and refined petroleum products for different pipeline networks that operated in North America.

3. Based on detailed greenhouse gas emissions data and system data available for two natural gas transmission pipeline systems in North America.

4. Based on detailed greenhouse gas emissions data and system data available for two natural gas distribution pipeline systems in North America.

* Baseline emissions associated with international shipping are ignored in this tool, because emission reduction commitments set under the Kyoto Protocol do not include emissions by international shipping.

### 6.2.3.2.1. Determining the emissions from emission sources

44. Emissions associated with electricity consumption ($E_{Electricity,i,j,x,y}$) shall be determined using the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". Emissions associated with fossil fuel consumption ($E_{Fuel,i,j,x,y}$) shall be

determined using the "Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion".

45.    Project participants may choose between two options to determine the emissions from the remaining emission sources ($E_{Flaring,i,j,x,y}$, $E_{Venting,i,j,x,y}$, $E_{Leaks,i,j,x,y}$, $E_{StorageLosses,i,j,x,y}$, $E_{Fugitive,i,j,x,y}$):

    (a)    Option (i): use the applicable Tier 2 or 3 calculation procedures in the IPCC 2006 Guidelines;[3] or

    (b)    Option (ii): reference the emission rate from reputable published emissions inventories where these exist (for example, country-specific and industry-specific emission inventories published by national reporting entities and industry associations, confirming that these have been developed using a IPCC Tier 2 or Tier 3 approach).

46.    Document in the CDM-PDD and monitoring reports:

    (a)    Activities within the stage that are associated with each emission source, and boundary of, the upstream emissions stage *i* (to assist with this, information is given in Table 1 of the appendix about potential activities and emission sources that occur within each upstream emissions stage);

    (b)    The calculation of emissions for each emission source.

# 7.  Monitoring methodology

## 7.1.  Monitoring procedures

47.    No monitoring is required for application of this tool.

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[3]  *Volume 2 - Energy* of the *IPCC 2006 Guidelines* is designed to assess GHG emissions contributions from sources that include those associated with an upstream emission stage. The guidelines provide separate procedures for assessing GHG emission contributions due to fugitive emissions and energy use. Methods for estimating fugitive emissions are provided in *Volume 2, Chapter 4 - Fugitive Emissions*. To apply a Tier 2 or Tier 3 methodology to a specific emissions stage requires determining the amount of fossil fuel and purchased electric power consumption by that stage, as well as the relevant activity data (such as the technology associated with venting, flaring, storage losses, and fugitive equipment leaks). For coal mining the method involves applying country or mine specific emission factors to the mining and ore preparation stages. For oil and natural gas systems, it is necessary to apply more complicated procedures involving bottom-up approaches. Examples of these are referenced in the IPCC 2006 Guidelines, such as the API Compendium and similar guidelines published by other relevant industry associations.

## 7.2. Data and parameters not monitored

**Data / Parameter table 1.**

| Data / Parameter: | $NCV_x$ |
|---|---|
| Data unit: | TJ/t |
| Description: | Net calorific value of the fossil fuel $x$ |
| Source of data: | Use IPCC default net calorific values (country-specific, if available), that reasonably represent local circumstances. Choose the values in a conservative manner and justify the choice |
| Measurement procedures (if any): | Table 1.2 of Volume 2 – Energy, IPCC 2006 Guidelines, converting values to TJ/t |
| Any comment: | - |

**Data / Parameter table 2.**

| Data / Parameter: | $DT_{i,j,x,r,t}$ |
|---|---|
| Data unit: | km |
| Description: | Distance that fossil fuel $x$ from fuel origin $j$ was transported by mode $r$ in upstream emissions stage $i$ in the time period $t$ |
| Source of data: | Relevant transportation statistics may be available from national statistics or transportation departments, or from relevant trade associations |
| Measurement procedures (if any): | Document the basis for the applied values |
| Monitoring frequency: | GHG emissions from international shipping must be ignored, because they are excluded from reduction targets under the Kyoto Protocol. Thus, exclude the length of any international transportation segments when assessing the value of $DT_{i,j,x,r,t}$ |

**Data / Parameter table 3.**

| Data / Parameter: | $FP_{i,j,x,y}$ |
|---|---|
| Data unit: | TJ/yr |
| Description: | Fuel output from upstream emissions stage $i$ of fossil fuel type $x$ from fossil fuel origin $j$ in the time period $t$ |
| Source of data: | Relevant production statistics may be available from national statistics or energy departments, or from relevant trade associations |
| Measurement procedures (if any): | Document the basis for the applied values |
| Any comment: | - |

# Appendix.    Default emission factors for upstream emissions stages

1.    Information about potential key activities and emission sources that occur within each upstream emissions stage is presented in Table 1 of this appendix for context. This information can also assist with the determination of refined emission factors, if the project proponent selects this option instead of using default emission factors.

**Table 1.**    **Default upstream emission factors presented by upstream emissions stage for each type of fossil fuel**

| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source | | | Default emission factor --------------- (t $CO_2$e/TJ) | Mandatory stage | Option to calculate refined emission factor | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | | | | |
| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source | Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Option to calculate refined emission factor | Reference | | |
| Natural Gas (NG) | NG Exploration & Production | Drilling, well testing & servicing, field gas gathering (including compression and hydrate control), and produced water separation and disposal, plus associated gas conservation at oil production facilities | Moderate to high | Zero to moderate | Small to moderate | 3.4 | Yes | yes | Detailed California-Modified GREET[1] Pathway for Liquefied Natural Gas (LNG) from North American and Remote Natural Gas Sources |

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[1]  The greenhouse gases, regulated emissions, and energy use in transportation model (GREET).

| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source ------------------------------------------------------ | | | Default emission factor --------------- (t $CO_2$e/TJ) | Mandatory stage | Option to calculate refined emission factor | Reference |
|---|---|---|---|---|---|---|---|---|
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | | | | |
| | NG Processing | Separation, sweetening, dehydration, hydrocarbon dew point control, produced water disposal and compression | Moderate to high | Zero to moderate | Small to moderate | 4 | No | yes | Detailed California-Modified GREET Pathway for Liquefied Natural Gas (LNG) from North American and Remote Natural Gas Sources |
| | NG Storage | NG re-compression back into the transmission system and potentially dehydration and processing | Moderate to high | Small to moderate | Small to moderate | 1.6 | No | yes | GREET Model |
| | NG Distribution | Pressure letdown from the transmission system and transport in medium and low pressure pipelines to the end users | Zero to small | Zero to small | Small to moderate | 2.2 | No | yes | GREET Model |

| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source | | | Default emission factor | Mandatory stage | Option to calculate refined emission factor | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | (t $CO_2$e/TJ) | | | |
| Natural Gas Liquids (NGL) | NGL Exploration & Production | Storage of NGL at field facilities and gas processing plants, as well as transportation to central facilities (i.e. by truck, rail, ship and/or pipelines) | Small to moderate | Zero to small | Moderate | 3.4 | Yes | yes | Detailed California-Modified GREET Pathway for Liquefied Natural Gas (LNG) from North American and Remote Natural Gas Sources |
| | NGL Stabilization & Treating | Vapour pressure control and potentially treating to remove reduced sulphur compounds | Small to moderate | Zero to small | Small to moderate | 2.1 | No | yes | Assumed to be the same as a de-butanizer |
| | NGL Transportation | Potentially by truck, rail, ship and/or pipelines | Small to moderate | Small to moderate | Nil | 2.8 | Yes | yes | AERI[2] (2009) |

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[2]  Alberta Energy Research Institute (AERI).

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| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source | | | Default emission factor | Mandatory stage | Option to calculate refined emission factor | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | ------------- (t CO₂e/TJ) | | | |
| Liquefied Natural Gas (LNG) | NG Exploration & Production | Drilling, well testing & servicing, field gas gathering (including compression and hydrate control), and produced water separation and disposal, plus associated gas conservation at oil production facilities | Moderate to High | Zero to moderate | Small to moderate | 3.4 | Yes | yes | Detailed California-Modified GREET Pathway for Liquefied Natural Gas (LNG) from North American and Remote Natural Gas Sources |
| | NG Processing | Separation, sweetening, dehydration, hydrocarbon dew point control, produced water disposal and compression | Moderate to high | Zero to moderate | Small to moderate | 4 | No | yes | Detailed California-Modified GREET Pathway for Liquefied Natural Gas (LNG) from North American and Remote Natural Gas Sources |

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| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source | | | Default emission factor --------------- (t $CO_2$e/TJ) | Mandatory stage | Option to calculate refined emission factor | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | | | | |
| | NG Transport | NG Transport to LNG plant | Moderate to high | Small | Small to moderate | 0.45 | No | yes | Detailed California-Modified GREET Pathway for Liquefied Natural Gas (LNG) from North American and Remote Natural Gas Sources |
| | NG Liquefaction & LNG Storage | Compression, refrigeration, expansion cooling, storage and management of boil-off losses | Moderate to high | Small to moderate | Small to moderate | 7.4 | Yes | yes | Detailed California-Modified GREET Pathway for Liquefied Natural Gas (LNG) from North American and Remote Natural Gas Sources |

| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source | | | Default emission factor ------------- (t $CO_2$e/TJ) | Mandatory stage | Option to calculate refined emission factor | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | | | | |
| | LNG Transportation | Tanker fuel and management of boil-off losses | Small to moderate | Small | Small to moderate | 3.5 | Yes | yes | Detailed California-Modified GREET Pathway for Liquefied Natural Gas (LNG) from North American and Remote Natural Gas Sources |
| | NG Distribution | Pressure letdown from the transmission system and transport in medium and low pressure pipelines | Zero to small | Zero to small | Small to moderate | 0.26 | No | yes | Detailed California-Modified GREET Pathway for Liquefied Natural Gas (LNG) from North American and Remote Natural Gas Sources |

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| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source ----------------------------------------------------- | | | Default emission factor --------------- (t $CO_2$e/TJ) | Mandatory stage | Option to calculate refined emission factor | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | | | | |
| Compressed Natural Gas (CNG) It is assumed that CNG consists of half NG - derived CNG (11.2) and half LNG - derived CNG (19). | Production of CNG at the final sales point | NG compression from an inlet pressure of 35 to 2070 kPag up to final pressure of 20,700 kPag | Nil | Small to moderate | Small | 2.9 | Yes | yes | Well-to-wheels Analysis of Future Automotive Fuels and Powertrains in the European Context (Concawe) |
| Light Fuel Oil (Diesel) | Crude Oil Exploration & Production | Drilling, well servicing, artificial lift systems, enhanced recovery (e.g., through secondary and tertiary recovery schemes), transport to central treating facilities (i.e., by truck or pipeline) for solids and water removal, water disposal, waste gas disposal, oil sands mining and extraction, bitumen and heavy oil dilution and/or heating | Moderate to high | Zero to high | Small to high | 6.9 | Yes | no | ICF (2011) |

| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source | | | Default emission factor | Mandatory stage | Option to calculate refined emission factor | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | (t $CO_2$e/TJ) | | | |
| | Crude Oil Transportation | Transport of treated crude oil (including heavy oil and bitumen) to upgraders and/or refineries by truck, rail, ship and/or pipeline, plus (where applicable) diluent recycle | Zero to moderate | Zero to moderate | Nil | 1.5 | No | no | AERI(2009) |
| | Petroleum Upgrading and/or Refining | Salt removal, distillation, carbon rejection and/or hydrogen addition, followed by product fractionation, storage and blending | Moderate to large | Moderate | Small to moderate | 12.7 | Yes | yes | AERI(2009) |
| | Refined Product Distribution | Transport to bulk terminals and to retail distribution sites by truck, rail, ship and/or pipeline | Zero to moderate | Zero to small | Nil | 0.9 | Yes | yes | Assumed to be the same as for gasoline |

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| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source | | | Default emission factor ---------------- (t $CO_2$e/TJ) | Mandatory stage | Option to calculate refined emission factor | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | | | | |
| Heavy Fuel Oil (Bunker or Marine Type) | Crude Oil Exploration & Production | Drilling, well servicing, artificial lift systems, enhanced recovery (e.g., through secondary and tertiary recovery schemes), transport to central treating facilities (i.e., by truck or pipeline) for solids and water removal, water disposal, waste gas disposal, oil sands mining and extraction, bitumen and heavy oil dilution and/or heating | Moderate to high | Zero to high | Small to high | 6.9 | Yes | no | ICF (2011) |
| | Transportation | Transport of treated crude oil (including heavy oil and bitumen) to upgraders and/or refineries by truck, rail, ship and/or pipeline | Zero to moderate | Zero to moderate | Nil | 1.5 | No | no | AERI(2009) |

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| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source | | | Default emission factor | Mandatory stage | Option to calculate refined emission factor | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | (t $CO_2$e/TJ) | | | |
| | Upgrading or Refining | Salt removal, distillation, carbon rejection and/or hydrogen addition, followed by product fractionation, storage and blending | Moderate to large | Moderate | Small to moderate | 3.1 | Yes | yes | Toyoto Motor Corporation (2004) |
| | Distribution | Transport to bulk terminals and to retail distribution sites by truck, rail, ship and/or pipeline | Zero to moderate | Zero to small | Nil | 0.9 | Yes | yes | Assumed to be the same as for gasoline |

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| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source | | | Default emission factor | Mandatory stage | Option to calculate refined emission factor | Reference |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | (t $CO_2$e/TJ) | | | |
| Gasoline | Crude Oil Exploration & Production | Drilling, well servicing, artificial lift systems, enhanced recovery (e.g., through secondary and tertiary recovery schemes), transport to central treating facilities (i.e., by truck or pipeline) for solids and water removal, water disposal, waste gas disposal, oil sands mining and extraction, bitumen and heavy oil dilution and/or heating | Moderate to high | Zero to high | Small to high | 6.9 | Yes | no | ICF (2011) |
| | Transportation | Transport of treated crude oil (including heavy oil and bitumen) to upgraders and/or refineries by truck, rail, ship and/or pipeline | Zero to moderate | Zero to moderate | Nil | 1.5 | No | no | AERI(2009) |

| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source | | | Default emission factor --------------- (t $CO_2$e/TJ) | Mandatory stage | Option to calculate refined emission factor | Reference |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | | | | |
| | Upgrading and/or refining | Salt removal, distillation, carbon rejection and/or hydrogen addition, followed by product fractionation, storage and blending | Moderate to large | Moderate | Small to moderate | 8.4 | Yes | yes | ICF (2011) |
| | Distribution | Transport to bulk terminals and to retail distribution sites by truck, rail, ship and/or pipeline | Zero to moderate | Zero to small | Nil | 0.9 | Yes | yes | ICF (2011) |

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| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source ------------------------------------------------ | | | Default emission factor --------------- (t $CO_2$e/TJ) | Mandatory stage | Option to calculate refined emission factor | Reference |
|---|---|---|---|---|---|---|---|---|
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | | | | |
| Kerosene (household and aviation) | Crude Oil Exploration & Production | Drilling, well servicing, artificial lift systems, enhanced recovery (e.g., through secondary and tertiary recovery schemes), transport to central treating facilities (i.e., by truck or pipeline) for solids and water removal, water disposal, waste gas disposal, oil sands mining and extraction, bitumen and heavy oil dilution and/or heating | Moderate to high | Zero to high | Small to high | 6.9 | Yes | no | ICF (2011) |
| | Transportation | Transport of treated NGL and crude oil (including heavy oil and bitumen) to upgraders and/or refineries by truck, rail, ship and/or pipeline | Zero to moderate | Zero to moderate | Nil | 1.5 | No | no | AERI(2009) |

| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source | | | Default emission factor --------------- (t $CO_2$e/TJ) | Mandatory stage | Option to calculate refined emission factor | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | | | | |
| | Upgrading and/or refining | Salt removal, distillation, carbon rejection and/or hydrogen addition, followed by product fractionation, storage and blending | Moderate to large | Moderate | Small to moderate | 1.9 | Yes | yes | Toyoto Motor Corporation (2004) |
| | Distribution | Transport to bulk terminals and to retail distribution sites by truck, rail, ship and/or pipeline | Zero to moderate | Zero to moderate | Nil | 0.9 | Yes | yes | Assumed to be the same as for gasoline |

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| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source | | | Default emission factor | Mandatory stage | Option to calculate refined emission factor | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | (t $CO_2$e/TJ) | | | |
| LPG (including Propane & Butane) | Crude Oil Exploration & Production | Drilling, well servicing, artificial lift systems, enhanced recovery (e.g., through secondary and tertiary recovery schemes), transport to central treating facilities (i.e., by truck or pipeline) for solids and water removal, water disposal, waste gas disposal, oil sands mining and extraction, bitumen and heavy oil dilution and/or heating | Moderate to high | Zero to high | Small to high | 6.9 | Yes | no | ICF (2011) |
| | Crude Oil Transportation | Transport of treated crude oil (including heavy oil and bitumen) to upgraders and/or refineries by truck, rail, ship and/or pipeline, plus (where applicable) diluent recycle | Zero to moderate | Zero to moderate | Nil | 1.5 | No | no | AERI(2009) |

| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source | | | Default emission factor --------------- (t $CO_2$e/TJ) | Mandatory stage | Option to calculate refined emission factor | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | | | | |
| | Processing of High Vapour Pressure Product Streams at Gas Plants, Upgraders and Refineries | Fractionation (e.g., de-propanizer and/or debutanizer) and storage | Moderate | Small | Nil | 2.1 | Yes | yes | Derived from depropanizer and debutanizer data published by Summers et al (2002) and Chen and Lin (2001) |
| | Distribution | Transport to bulk terminals and to retail distribution sites by truck, rail, ship and/or pipeline | Zero to moderate | Zero to moderate | Nil | 0.9 | Yes | yes | Assumed to be the same as for gasoline |
| Coal | Mining | Mining equipment, seam gas drainage and disposal before and during mining, water drainage and disposal, post mine seam gas emissions, uncontrolled combustion and burning coal dumps | Moderate | Moderate | Moderate | 18.9 (Underground Mines) 3.3 (Surface Mines) | Yes | Only if fossil fuel origin is not *global* | Derived from industry fuel use data and maximum IPCC (2006) default CH4 emission Factors |

| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source ------------------------------------------------ | | | Default emission factor --------------- (t $CO_2$e/TJ) | Mandatory stage | Option to calculate refined emission factor | Reference |
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | | | | |
| | Processing | Crushing, screening, cleaning, drying, disposal of rejects and tailings management | Zero to moderate | Moderate | Small | | Yes | yes | |
| | Transportation | By truck, rail or barge | Moderate | Zero to small | Nil | 2.5 | No | yes | Based on 1000 km transport by truck and 6000 km by marine vessel. Truck and marine vessel factors derived from CEFIC (2011) |
| Lignite | Mining | Mine mobile equipment, seam gas drainage and disposal before and during mining, water drainage and disposal, post mine seam gas emissions, uncontrolled combustion and burning coal dumps | Moderate | Moderate | Moderate | 3.4 | Yes | Only if fossil fuel origin is not *global* | Derived from industry fuel use data and maximum IPCC (2006) default CH4 emission Factors |

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| Fossil fuel type $x$ | Potential upstream emissions stage $i$ | Potential key activities undertaken | Typical relative emission contributions by type of emission source | | | Default emission factor --------------- (t CO$_2$e/TJ) | Mandatory stage | Option to calculate refined emission factor | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | Fossil fuel consumption | Electric power consumption | Fugitives | | | | |
| | Processing | Crushing, screening, cleaning, drying, disposal of rejects and tailings management | Zero to moderate | Moderate | Small | | Yes | yes | |
| | Transportation | By truck, rail or barge | Moderate | Zero to small | Nil | 2.6 | No | yes | Based on 500 km transport by truck. Truck factor derived from CEFIC (2011) |

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## Document information

| Version | Date | Description |
|---|---|---|
| 02.0 | 28 November 2014 | EB 81, Annex 12 |
| | | Revision to highlight that net leakage needs to be considered always as zero in situations where net leakage is calculated as negative. |
| 01.0.0 | 13 September 2012 | EB 69, Annex 12 |
| | | Initial adoption. |

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