Draft revision to the approved baseline and monitoring methodology AM0050

"Feed switch in integrated Ammonia-urea manufacturing industry"

I. SOURCE, DEFINITIONS AND APPLICABILITY

Source

This methodology is based on NM0165-rev "Feed switchover from Naphtha to Natural Gas (NG) at Phulpur plant of IFFCO", whose baseline study and project design document were prepared by IFFCO - Indian Farmers Fertilizer Cooperative Ltd., India.

For more information regarding the proposal and its consideration by the Executive Board (hereinafter referred to as the Board) of the clean development mechanism (CDM)~~Executive Board~~ please refer to case NM0165-rev on <http://cdm.unfccc.int/goto/MPappmeth>.

This methodology also refers to the latest version of the following tools:

- Combined tool to identify the baseline scenario and demonstrate additionality";[1]
- ~~"Tool to calculate the emission factor for an electricity system";~~
- "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion";
- "Tool to calculate baseline, project and/or leakage emissions from electricity consumption";
- "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of a crediting period".

Selected approach from paragraph 48 of the CDM modalities and procedures

"Existing actual or historical emissions, as applicable"

Definitions

For the purpose of this methodology, the following definitions apply:

Integrated ammonia-urea manufacturing facilities. An integrated ammonia-urea manufacturing facility is a facility where ammonia and urea production is colocated and ammonia and carbon dioxide from ammonia plant is used for urea manufacturing.

Existing hydrocarbon feedstock/Existing feedstock. Existing hydrocarbon feedstock is the feedstock which has been used in the intergrated ammonia-urea manufacturing facility for last three years before the project activity.

Applicability

This methodology is applicable to feed switch project activities in existing integrated ammonia-urea manufacturing facilities. In the project activity, natural gas is used solely, or in addition to existing hydrocarbon feedstock (i.e. naphtha, heavy oils, coal, lignite & coke ~~etc~~) as feed which has a lower carbon

[1] Please refer to: <http://cdm.unfccc.int/goto/MPappmeth>.

to hydrogen ratio than existing hydrocarbon feedstock ~~naphtha~~, which is the current practice in the plant. The emissions reductions are achieved as a result of a reduction in excess carbon, over and above that needed for the production of urea, leading to less CO_2 being released into the atmosphere.

This methodology is applicable to:

- Integrated ammonia-urea manufacturing facilities ~~industries~~ that involve partial or total switching from existing hydrocarbon feedstock ~~naphtha~~ to natural gas, as a feedstock with a lower carbon to hydrogen ratio (CHR) than that indicated in the baseline ~~(naphtha)~~;
- Integrated ammonia-urea manufacturing facilities ~~plants~~ that are not constrained by local regulations and/or programs from using existing feedstock~~naphtha~~as feed, neither obliged to use natural gas (NG) and/or liquefied natural gas (LNG) as feed;
- Project activities that do not result in the increase of the production capacity beyond 10% of the capacity existing before the project activity;
- Natural gas is sufficiently available in the region or country, e.g. future natural gas based capacity additions, comparable in size to the project activity, are not constrained by the use of natural gas in the project activity;[2]
- Integrated ammonia-urea manufacturing facility ~~plant~~ in which the carbon in the existing ~~naphtha~~ feedstock used prior to implementation of the project activity is in excess of that needed in the urea production process. The excess carbon in the feed is emitted as CO_2 to the atmosphere;
- The integrated ammonia-urea manufacturing ~~plant~~ facility is an existing plant with a historical operation of at least three years prior to the implementation of the project activity;
- Project activities that do not result in changes in the production process (e.g. as a result of product change) other than the feed switch;
- If the use of natural gas in project activity results in a situation where the natural gas does not have sufficient carbon to meet the requirement of urea production, then the balance CO_2 required for use in urea production is recovered with the use of a Carbon Dioxide Recovery Plant (CDR) from CO_2 in flue gases emitted from an existing source of fossil fuel combustion for energy purposes within the project boundary. The CO_2 in the flue gases would have been emitted into the atmosphere in the absence of the project activity;
- The source of thermal energy for processing the feed is the combustion of fossil fuels in boilers both in the baseline scenario as well as in the project activity;
- Prior to the implementation of the project activity, no natural gas has been used in the integrated ammonia-urea manufacturing facility ~~plant~~.
- ~~The quantity of steam and electricity required for the ammonia production process is not affected by the project activity, i.e. it is the same with the use of naphtha and natural gas.~~

[2] In some situations, there could be price-inelastic supply constraints (e.g. limited resources without possibility of expansion during the crediting period) that could mean that a project activity displaces natural gas that would otherwise be used elsewhere in an economy, thus leading to possible leakage. Hence, it is important for the project proponent to document that supply limitations will not result in significant leakage as indicated.

II. BASELINE METHODOLOGY

Project boundary

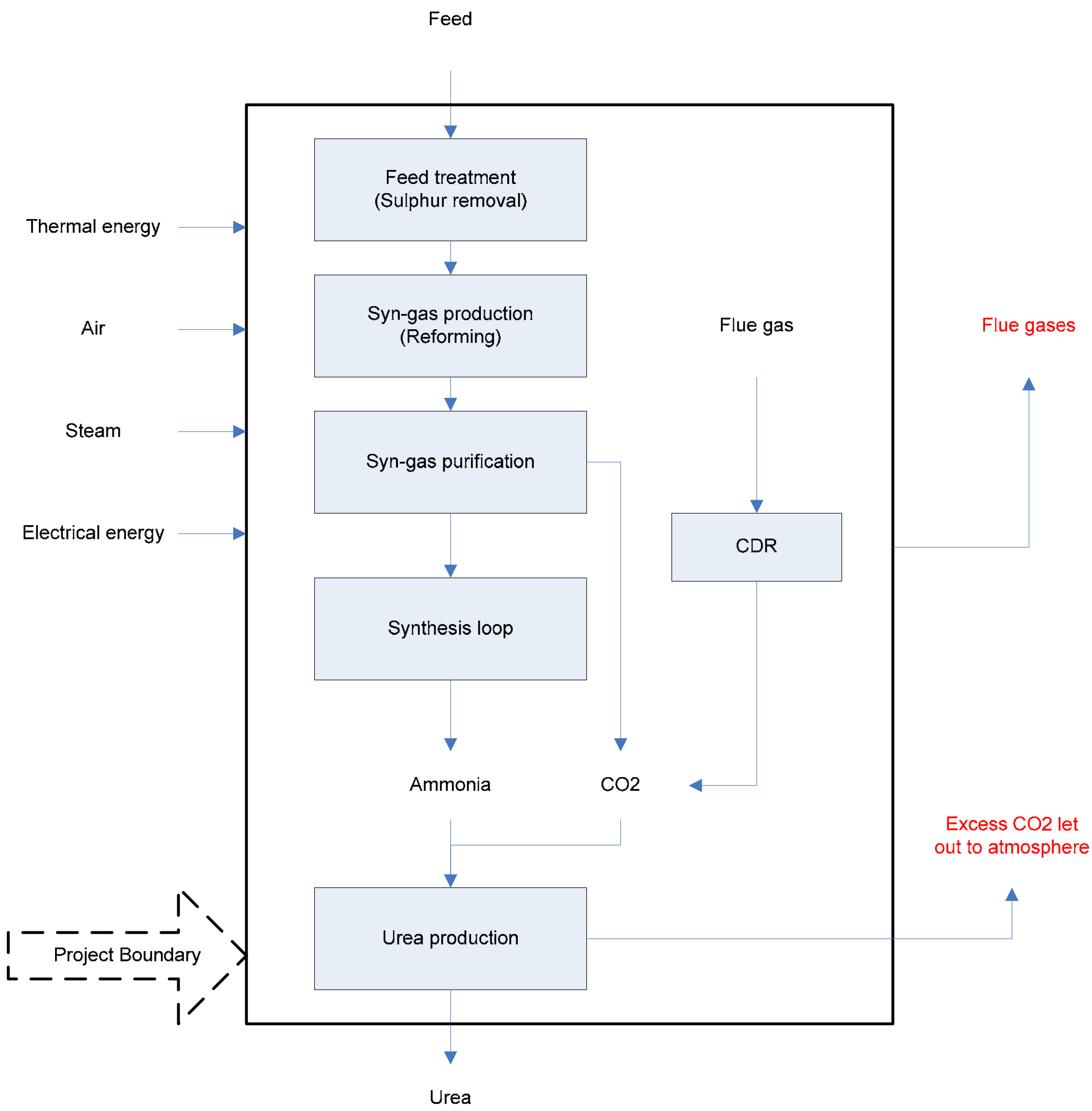

Table 1: Emissions sources included in or excluded from the project boundary

	Source	Gas	Included?	Justification/Explanation
Baseline	Processing of feed	CO_2	Yes	Main emission source. CO_2 is produced in the reforming of the feed and is partially recovered for use in the production of urea. CO_2 in excess of required amount is released to the atmosphere
		CH_4	No	Negligible fugitive CH_4 emissions may occur during the processing of the feed. These emissions (if any) would be essentially the same as in the project activity. Therefore, they are excluded for simplification
		N_2O	No	Not applicable
	Fuel used in furnaces (thermal energy)	CO_2	Yes	Main emission source (flue gases) due to the combustion of fossil fuel to provide thermal energy for feed treatment (sulphur removal in hydrotreater and primary desulphurization unit) and the syn-gas production (reforming). Any CO_2 recovered from flue gases resulting from combustion of fossil fuel is deducted from this emission source
		CH_4	No	Excluded for simplification, this is conservative
		N_2O	No	Excluded for simplification, this is conservative
	Fuel used in boilers (Steam generation)	CO_2	Yes~~No~~	May be an important emission source. ~~These emissions are expected to be the same or higher as compared to the project scenario. Excluded for simplification and because this is conservative~~
		CH_4	No	Excluded for simplification, this is conservative ~~These emissions are expected to be the same or higher as compared to the project scenario. Excluded for simplification and because this is conservative~~
		N_2O	No	Excluded for simplification, this is conservative ~~These emissions are expected to be the same or higher as compared to the project scenario. Excluded for simplification and because this is conservative~~
	Electricity requirement	CO_2	Yes~~No~~	May be an important emission source. ~~These emissions are expected to be the same or higher as compared to the project scenario. Excluded for simplification and because this is conservative.~~
		CH_4	No	Excluded for simplification, this is conservative ~~These emissions are expected to be the same or higher as compared to the project scenario. Excluded for simplification and because this is conservative~~

	Source	Gas	Included?	Justification/Explanation
		N_2O	No	Excluded for simplification, this is conservative ~~These emissions are expected to be the same or higher as compared to the project scenario. Excluded for simplification and because this is conservative~~
Project Activity	Processing of feed	CO_2	Yes	Main emission source. CO_2 is produced in the reforming of the feed and is recovered for the production of urea. CO_2 in excess of that required for urea production, if any, is released into atmosphere
		CH_4	No	Negligible fugitive CH_4 emissions may occur during the processing of the feed. These emissions (if any) would be essentially the same as in the baseline scenario. Therefore, they are excluded for simplification
		N_2O	No	Not applicable
	Fuel used in furnaces (thermal energy)	CO_2	Yes	Main emission source due to the combustion of fossil fuels. The project activity will result in lower thermal energy required as sulphur is negligible in NG/LNG. Any CO_2 recovered from flue gases resulting from combustion of fossil fuel is deducted from this emission source
		CH_4	No	These emissions are expected to be the same or lower as compared to the baseline scenario
		N_2O	No	These emissions are expected to be the same or lower as compared to the baseline scenario
	Fuel used in boilers (Steam generation)	CO_2	~~No~~Yes	May be an important emission source. ~~These emissions are expected to be the same or lower as compared to the baseline scenario. In case these emissions are higher than the baseline scenario this should be included.~~
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small~~These emissions are expected to be the same or lower as compared to the baseline scenario.~~
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small~~These emissions are expected to be the same or lower as compared to the baseline scenario~~
	Electricity requirement	CO_2	Yes~~No~~	May be an important emission source. ~~These emissions are expected to be the same or lower as compared to the baseline scenario. In case these emissions are higher than the baseline scenario this should be included.~~
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small~~These emissions are expected to be the same or lower as compared to the baseline scenario~~
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small~~These emissions are expected to be the same or lower as compared to the baseline scenario~~

	Source	Gas	Included?	Justification/Explanation
	Energy consumed by CDR plant	CO_2	Yes	If a CDR plant is also part of the project activity, then the emissions due to the production of energy (steam and electricity) for the operation of this equipment must also be considered
		CH_4	No	Not applicable
		N_2O	No	Not applicable

~~Combined~~ Procedure to identify the baseline scenario and demonstrate additionality

The most plausible baseline scenario and the additionality shall be identified and determined according to the latest version of the "Combined tool to identify the baseline scenario and demonstrate additionality".

~~Step 1: Identification of alternative scenarios~~

~~Step 1a. Define alternative scenarios to the proposed CDM project activity~~

In applying Step 1 of the tool, identify all alternative scenarios that are available to the project participants and that provide outputs or services with comparable quality, properties and application areas as the proposed CDM project activity.

These alternative scenarios shall include, inter alia:

- The continuation of current practice, i.e. usage of existing feedstock ~~naphtha~~ alone as feed for the production of urea, resulting in CO_2 surplus~~es~~ that are released to the atmosphere;
- Partial substitution of existing feedstock ~~naphtha~~ with NG/LNG so as to reduce the CO_2 surplus~~es~~ released to atmosphere for similar output of urea;
- Complete switchover from ~~Naphtha~~existing feedstock to NG/LNG resulting in the reduction of CO_2 surplus~~es~~ and equivalent emissions for similar output of urea;
- Usage of ~~naphtha~~existing feedstock as feed and production of CO_2 surplus~~es~~, but with capture of the CO_2 surplus~~es~~ for its use in other applications, which would otherwise be released to the atmosphere.~~, for its use in other applications~~.

Note that the alternatives proposed are only indicative. Project proponents may identify other alternatives.

~~Sub-step 1b. Consistency with mandatory applicable laws and regulations:~~

~~Eliminate alternatives that are not in compliance with all applicable legal and regulatory requirements.~~

~~Step 2: Investment Analysis~~

~~Compare the economic attractiveness without considering the impacts of the CDM for all alternatives that are remaining by applying Step 3 of the "Combined tool to identify the baseline scenario and demonstrate additionality" agreed by the CDM Executive Board. National policies or regulations or other benefits that are related to the increase of the production capacity, which may have an effect on the types of feed used, should also be taken into consideration.~~

This methodology is only applicable if the "usage of existing feedstock ~~naphtha~~ alone as feed for the production of urea, resulting in CO_2 surpluses that are released to the atmosphere" throughout the crediting period is the most plausible baseline scenario.

Note: the methodology cannot be used if the most plausible baseline scenario is the use of both existing feedstock ~~naphtha~~ and NG/LNG as feedstock.

~~Step 3: Common practice analysis~~

~~Demonstrate that the project activity is not a common practice in the relevant country and sector. The common practice analysis is to be carried out as follows:~~

~~Sub-step 3a. Analyze other activities similar to the proposed project activity:~~

~~Provide an analysis of any other feed switch activity implemented previously or currently underway that is similar to the proposed project activity. Other activities are considered similar if they are in the same country/region, and take place in a comparable environment with respect to regulatory framework, investment climate, access to technology, access to financing, etc. Other CDM project activities are not to be included in this analysis. Provide quantitative information where relevant.~~

~~Sub-step 3b. Discuss any similar options that are occurring:~~

~~If similar activities are widely observed and commonly carried out, it calls into question the claim that the proposed project activity is financially unattractive. Therefore, if similar activities are identified above, then it is necessary to demonstrate why the existence of these activities does not contradict the claim that the proposed project activity is financially unattractive. This can be done by comparing the proposed project activity to the other similar activities, and pointing out and explaining essential distinctions between them that explain why the similar activities enjoyed certain benefits that rendered it financially attractive (e.g. subsidies or other financial flows) to which the proposed project activity is subject.~~

~~Essential distinctions may include a serious change in circumstances under which the proposed CDM project activity will be implemented when compared to circumstances under which similar activities have been carried out. For example, promotional policies may have ended, leading to a situation in which the proposed CDM project activity would not be implemented without the incentives provided by the CDM. The change must be fundamental and verifiable.~~

~~If all steps are satisfied, then the project is considered additional.~~

Baseline emissions

Baseline emissions are calculated as follows:

$$\cancel{BE_y = BE_{Feed,y} + BE_{Heat,y}} \quad \cancel{(1)}$$

$$BE_y = BE_{unadj,y} \times \min(1, \frac{P_{Urea,BL,k}}{P_{Urea,PJ,y}}) \quad \textbf{(1)}$$

Where:

$\cancel{BE_{Feed,y}}$ $BE_{unadj,y}$	Unadjusted baseline emissions in year *y* ~~Emissions due to the use of naphtha as feed for the production of urea~~, in tCO_2
$\cancel{BE_{Heat,y}}$ $P_{Urea,BL,k}$	Average urea production in the most recent three years prior to the implementation of the project activity, in tonnes ~~Emissions due to the production of thermal energy used in the furnaces (feed treatment and reforming), in tCO_2.~~
$P_{Urea,PJ,y}$	Production of urea in each year *y* of the crediting period, in tonnes

$$BE_{unadj,y} = BE_{Feed,y} + BE_{Heat,y} \quad (2)$$

Where:

$BE_{Feed,y}$	Emissions due to the use of existing feedstock as feed for the production of urea, in tCO_2
$BE_{Heat,y}$	Emissions due to the production of thermal energy ~~used~~ in the furnaces (feed treatment and reforming), in tCO_2

Emissions due to the use of existing feedstock ~~naphtha~~ as feed ($BE_{Feed,y}$)

The emissions due to the use of existing feedstock ~~naphta~~as feed for the production of urea are calculated as follows:

$$\cancel{BE_{Feed,y} = BE_{Naphtha,y} - BS_{Urea,y}}$$

$$BE_{Feed,y} = BE_{Existing\ feedstock,y} - BS_{Urea,y} \quad (3\cancel{2})$$

Where:

$\cancel{BE_{Naphtha,y}}$ $E_{Existing\ feedstock,y}$	Quantity of CO_2 that would be produced from existing feedstock~~naphtha~~ in the baseline, in tCO_2
$BS_{urea,y}$	Equivalent CO_2 quantity of the carbon (C) that is ~~included~~ contained in the ~~product of~~ urea ~~in the urea production process~~produced, in tCO_2

The quantity of CO_2 that would be produced from existing feedstock~~naphtha~~ in the baseline is calculated as:

$$\cancel{BE_{Naphtha,y} = \frac{44}{12} \cdot P_{Urea,PJ,y} \cdot SFC_{Naphtha} \cdot CF_{Naptha,BL}}$$

$$BE_{Existing\ feedstock,y} = \frac{44}{12} \times P_{Urea,PJ,y} \times SFC_{Existing\ feedstock} \times CF_{Existing\ feedstock,BL} \quad (4\cancel{3})$$

Where:

$P_{Urea,PJ,y}$	Production of urea in each year *y* of the crediting period, in tonnes
$\cancel{SFC_{Naphtha}}$ $SFC_{Existing\ feedstock}$	Specific feed consumption ratio for the production of urea in the three most recent years previous to the implementation of the project activity, tonnes of existing feedstock ~~naphta~~/tonnes of urea
$\cancel{CF_{Naptha,BL}}$ $CF_{Existing\ feedstock,BL}$	Carbon fraction of existing feedstock~~naphta~~ used in the baseline as feedstock, in tonnes of carbon/tonnes of existing feedstock~~naphtha~~
44/12	Ratio between the molecular weights of CO_2 and carbon, mass units/mass units

The specific feed consumption ratio is calculated as follows:

$$SFC_{Existing\ feedstock} = \frac{\sum_{k=1}^{3} F_{Existing\ feedstock,BL,k}}{\sum_{k=1}^{3} P_{Urea,BL,k}} \qquad (5\ \cancel{4})$$

Where:

$P_{Urea,BL,k}$	Production of urea in each ~~one~~ of the three most recent years k previous to the implementation of the project activity, in tonnes
$F_{Existing\ feedstock,BL,k}$	Quantity of ~~naphtha~~existing feedstock used as feed in each ~~one~~ of the three most recent years k previous to the implementation of the project activity, in tonnes

In case more than one feedstock is used $CF_{Existing\ feedstock,BL,}$ is the lowest carbon fraction of feedstock used for the three most recent years k previous to the implementation of the project activity.

The quantity of CO_2 contained in urea produced~~required to produce urea~~ is calculated as follows:

$$BS_{Urea,y} = \frac{44}{60} \times P_{Urea,PJ,y} \qquad (6\ \cancel{5})$$

Where:

44/60	=44/12 x 12/60. 44/12 represents conversion factor from carbon to carbon dioxide and 12/60 is ratio of carbon mass (each urea molecule has one molecule of carbon) to urea mass in one molecule of urea (molecular weight 60)

Emissions due to the fuel used in production of thermal energy in the furnaces ($BE_{Heat,y}$)

The CO_2 emissions from fuel used for production of thermal energy are calculated as follows:

$$\cancel{BE_{Heat,y} = P_{Urea,PJ,y} \cdot SEC_{Naphtha} \cdot EF_{CO2,BL,y}}$$

$$BE_{Heat,y} = P_{Urea,PJ,y} \times SEC_{Existing\ feedstock} \times EF_{CO2,BL,y} \qquad \textbf{(7 \cancel{6})}$$

Where:

$EF_{CO2,BL,y}$	CO_2 emission factor for the baseline fuel that would be used in the furnaces (feed treatment and reforming) in each year y of the crediting period, in tCO_2/TJ
$\cancel{SEC_{Naphtha}}$ $SEC_{Existing\ feedstock}$	Specific thermal energy consumption ratio in the urea production process (feed treatment and reforming) in the ~~three~~ most recent three years previous to the implementation of the project activity, TJ/tonnes of urea

The emission factor for the fuel that would be used in the furnaces ($EF_{CO2,BL,y}$) must be chosen as the lowest of the emission factors among the fuels used in the three most recent years prior to the implementation of the project activity and the fuels used in the relevant year y of the crediting period. In the cases where the fuel is not directly monitored (in gasification of low sulfur heavy stock (LSHS)etc) the feed used as fuel should be considered in $SFC_{existing\ feedstock}$.

For the determination of emission factors, guidance from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories should be followed where appropriate. Project participants may either conduct measurements or they may use accurate and reliable local or national data where available. Where such data is not available, IPCC default emission factors (country-specific, if available any) may be used if they are deemed to reasonably represent local circumstances. All values should be chosen in a conservative manner and the choice should be justified and documented in the CDM-PDD. Where measurements are undertaken, project participants may estimate the emission factors or net calorific values ex ante in the CDM-PDD and should document the measurement results after implementation of the project activity in their monitoring reports.

The specific thermal energy consumption ratio is calculated as follows:

$$SEC_{Existing\ feedstock} = \left[\frac{\sum_k \sum_i (FC_{BL,i,k} \times NCV_{i,k})}{\sum_k P_{Urea,BL,k}} \right] \qquad \textbf{(8 \cancel{7})}$$

Where:

$FC_{BL,i,k}$	Quantity of fuel ~~of~~ type i consumed in the furnaces (feed treatment and reforming) in each ~~one~~ of the most recent three years k previous to the implementation of the project activity, in tonnes
$NCV_{i,k}$	Net calorific value of fuel type i in each ~~one~~ of the most recent three years k previous to the implementation of the project activity, in TJ/tonnes
~~K~~k	The most recent three years prior to the implementation of the project activity
~~I~~i	Fossil fuel types used in the years k

Project emissions

Project activity emissions are calculated as follows:

$$PE_y = PE_{Feed,y} + PE_{Heat,y} + PE_{CDR,y} + PE_{Utility,y} \quad \textbf{(9 ~~8~~)}$$

Where:

$PE_{Feed,y}$	Emissions due to the use of NG/LNG as feed for the production of urea in each year *y* of the crediting period, in tCO_2
$PE_{Heat,y}$	Emissions due to fuel consumption for the puropose of production of thermal energy ~~used~~ in the furnaces (feed treatment and reforming) after deducting the CO_2 recovered by the CDR plant (if any) in each year *y* of the crediting period, in tCO_2
$PE_{CDR,y}$	Emissions due to the production of energy used by the CDR plant (if any) in each year *y* of the crediting period, in tCO_2
$PE_{Utility,y}$	Emissions due to the increased usages of steam and/or electricity in each year *y* of the crediting period, in tCO_2

Emissions due to the use of NG/LNG as feed ($PE_{Feed,y}$)

The emissions due to the use of NG/LNG as feed for the production of urea are calculated as follows:

$$\cancel{PE_{Feed,y} = PE_{PJ,y} - PS_{Urea,y}}$$

$$PE_{Feed,y} = PE_{PJ,y} - BS_{Urea,y} \quad \textbf{(10 ~~9~~)}$$

Where:

$PE_{PJ,y}$	Quantity of CO_2 produced from NG/LNG as feed in each year *y* of the crediting period, in tCO_2
~~$PS_{Uurea,y}$~~	~~Quantity of CO_2 required for the production of urea in each year y of the crediting period, in tCO_2~~

The quantity of CO_2 produced from NG/LNG as feed is calculated as follows:

$$\cancel{PE_{PJ,y} = \frac{44}{12} \cdot \left(F_{NG,PJ,y} \cdot CF_{NG} + F_{Naphtha,PJ,y} \cdot CF_{Naphtha,PJ}\right)}$$

$$PE_{PJ,y} = \frac{44}{12} \times \left(F_{NG,PJ,y} \times CF_{NG} + F_{Existing\ feedstock,PJ,y} \times CF_{Existing\ feedstock,PJ}\right) \quad \textbf{(11 ~~10~~)}$$

Where:

$F_{NG,PJ,y}$	Consumption of NG/LNG as feed during the year y of the crediting period, in tonnes. If the available data are measured in volume units use the appropriate density of NG, corrected for temperature and pressure, to calculate the equivalent mass
CF_{NG}	Carbon content, expressed as weight fraction, of NG/LNG used as feed during year y of the crediting period, in tonnes of carbon/tonnes of NG/LNG
$\cancel{F_{Naphtha,PJ,y}}$ $F_{Existing\ feedstock,PJ,y}$	Consumption of existing feedstock ~~naphtha~~ as feed during the year y of the crediting period, in tonnes
$\cancel{CF_{Naphtha,PJ}}$ $CF_{Existing\ feedstock,PJ}$	Carbon content, expressed as weight fraction, of existing feedstock ~~naphtha~~ used as feed during year y of the crediting period, in tonnes of carbon/tonnes of feedstock~~naphtha~~

~~The quantity of CO_2 required for the production of urea is calculated as follows:~~

$$\cancel{PS_{Urea,y} = \frac{44}{60} \cdot P_{Urea,PJ,y}} \tag{~~11~~}$$

Emissions from thermal energy ($PE_{Heat,y}$)

Emissions due to the fuel used in production of thermal energy ~~used~~ in the furnaces (feed treatment and reforming) is calculated according to latest version of the 'Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion' where $PE_{heat,y}$ is equal to $PE_{FC,j,y}$ of the tool. ~~as follows:~~

$$\cancel{PE_{Heat,y} = (\sum_i FC_{i,y} \times NCV_{i,y}) \times EF_{CO2,PJ,y}} \tag{~~12~~}$$

~~Where:~~

~~$FC_{i,y}$~~	~~Quantity of fuel type i consumed in the furnaces (feed treatment and reforming) in each year y of the crediting period, in mass or volume units.~~
~~$NCV_{i,y}$~~	~~Net calorific value of fuel type i in each year y of the crediting period, in TJ/mass or volume units.~~
~~$EF_{CO2,PJ,y}$~~	~~CO_2 emission factor of the fuel type with the lowest emission factor among all the i fossil fuels used in the furnaces (feed treatment and reforming) in each year y of the crediting period, in tCO_2/TJ.~~

~~For the determination of emission factors, guidance from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories should be followed where appropriate. Project participants may either conduct measurements or they may use accurate and reliable local or national data where available. Where such data is not available, IPCC default emission factors (country-specific, if available any) may be used if they are deemed to reasonably represent local circumstances. All values should be chosen in a conservative manner and the choice should be justified and documented in the CDM-PDD. Where measurements are undertaken, project participants may estimate the emission factors or net calorific values ex-ante in the~~

~~CDM-PDD and should document the measurement results after implementation of the project activity in their monitoring reports.~~

Emissions from CDR ($PE_{CDR,y}$)

If installation of CDR plant is also carried out in the project activity as a means to make up for reduced carbon feed, then the emissions due to the operation of the CDR plant need also to be accounted for in the project activity emissions. These emissions would arise from the production of energy (electricity and steam) required to the operation of the CDR plant. They are calculated as follows:

$$PE_{CDR,y} = PE_{CDR,elec,y} + PE_{CDR,steam,y} \quad \textbf{(12)}$$

Where:

$PE_{CDR,elec,y}$	Emissions due to the production of electricity used for the operation of the CDR plant in each year *y* of the crediting period, in tCO_2
$PE_{CDR,steam,y}$	Emissions due to the production of steam used for the operation of the CDR plant in each year *y* of the crediting period, in tCO_2

The emissions due to the production of electricity used for the operation of the CDR plant should be calculated as per the latest version of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". $PE_{CDR,elec,y}$ corresponds to the parameter $PE_{EC,y}$ Project emissions from electricity consumption in year *y*, in the tool referred above.

~~are calculated as follows:~~

$$\cancel{PE_{CDR,elec,y} = EC_{CDR,elec,y} \cdot EF_{elec,y}} \quad \cancel{\textbf{(14)}}$$

~~Where:~~

~~$EC_{CDR,elec,y}$~~	~~Quantity of electricity consumed by the CDR plant in each year y of the crediting period, in MWh. Measured in the project activity.~~
~~$EF_{elec,y}$~~	~~CO_2 emission factor for electricity during each year y of the crediting period, in tCO_2/MWh. Calculated as per equation below.~~

~~The electrical energy supplied to the CDR plant might be coming from either grid or captive power generation or a mix of both. Thus the CO_2 emission factor for electrical energy would be calculated as follows:~~

~~*Option 1: Grid power*~~

~~If the electricity used is obtained from the grid:~~

$$\cancel{EF_{elec,y}=EF_{grid,y}}$$

~~Where $EF_{grid,y}$, in tCO_2/MWh, is the emission factor of the grid that must be calculated as the generation-weighted average emissions per electricity unit of all generating sources serving the system or assumed as a default value of 1.3 tCO_2/MWh.~~

~~*Option 2: Captive power*~~

~~For captive power supply the emission factor would be $EF_{elec,y}$=$EF_{captive,y}$ calculated as follows:~~

$$\cancel{EF_{captive,y} = \frac{44}{12} \cdot \frac{\sum_i FC_{CDR,captive,i,y} \cdot NCV_{i,y} \cdot EF_{i,y}}{TEP_{CDR,captive,y}}} \quad \cancel{(15)}$$

~~Where:~~

~~$EF_{captive,y}$~~	~~Emission factor for captive power generation (tCO_2/MWh).~~
~~$FC_{CDR,captive,i,y}$~~	~~Amount of fossil fuel of type i used in the captive power plant in each year y of the crediting period, in mass or volume units.~~
~~$TEP_{CDR,captive,y}$~~	~~Total electricity produced by the captive power plant in year y, in MWh.~~
~~$EF_{i,y}$~~	~~Emission factor of fuel type i used for steam generation in each year y of the crediting period, tCO_2/TJ.~~

~~*Option 3: Both grid and captive power*~~

~~For both grid and captive power supply the emission factor $EF_{elec,y}$ would be calculated as the weighted average of grid and captive power, as follows:~~

$$\cancel{EF_{elec,y} = \frac{EC_{grid,y}}{EC_{grid,y} + EC_{captive,y}} \cdot EF_{grid,y} + \frac{EC_{captive,y}}{EC_{grid,y} + EC_{captive,y}} \cdot EF_{captive,y}} \quad \cancel{(16)}$$

~~Where:~~

~~$EC_{grid,y}$~~	~~Quantity of electricity obtained from the grid by the projecty activity during each year y of the crediting period, in MWh.~~
~~$EC_{captive,y}$~~	~~Quantity of electricity obtained from a captive power plant by the projecty activity during each year y of the crediting period, in MWh.~~

The emissions due to the production of steam used for the operation of the CDR plant are calculated as follows:

$$PE_{CDR,steam,y} = EC_{CDR,steam,y} \times EF_{Boiler,y} \quad (13\ \cancel{17})$$

Where:

$EC_{CDR,steam,y}$	Quantity of thermal energy (steam) used for the operation of the CDR plant during each year *y*, in TJ. The calculation of the amount of thermal energy (steam) used for the operation of the CDR plant must take into consideration the pressure and temperature in which the steam is produced (T_{steam}, P_{steam}). The specific enthalpy is a function of pressure and temperature and can be obtained from steam tables
$EF_{Boiler,y}$	Emission factor of the steam generator during each year *y*, tCO_2/TJ

The annual equivalent energy for steam consumption is calculated as follows:

$$EC_{CDR,steam,y} = SC_{CDR,y} \times (E_{steam} - E_{feedwater}) \quad (14\ \cancel{18})$$

Where:

$SC_{CDR,y}$	Quantity ~~Demand~~ of steam required for the operation of the CDR plant in each year y of the crediting period, in tonnes
E_{steam}	Specific enthalpy of the steam at the steam generator outlet, in TJ/tonnes. Obtained from steam tables using the measured temperature (T_{steam}) and pressure (P_{steam}) of the steam in the steam generator outlet
$E_{feedwater}$	Specific enthalpy of the feed water at the steam generator inlet, in TJ/tonnes. Obtained from steam tables using the measured temperature (T_{fw}) and pressure (P_{fw}) of the feedwater in the steam generator inlet

The emission factor of the steam generator is calculated as follows:

$$EF_{Boiler,y} = \frac{\sum_i FC_{CDR,steam,i,y} \times NCV_{i,y} \times EF_{i,y}}{TSP_{CDR,steam,y} \times \left(E_{steam} - E_{feedwater}\right)} \quad (15\ \cancel{19})$$

Where:

$FC_{CDR,steam,i,y}$	Amount of fuel type i consumed in the steam generator in each year y of the crediting period, in mass or volume units
$SP_{CDR,steam,y}$	Total amount of steam produced by the steam generator in each year y of the crediting period, in tonnes
$EF_{i,y}$	Emission factor of fuel type i used for steam generation in each year y of the crediting period, tCO_2/TJ

Emissions from increased steam and/or electricity consumption ($PE_{utility,y}$)

In case the project activity results into increase in specific consumption of steam and/or electricity, the corresponding emissions should be accounted for as project emissions however in case of decrease or no change in specific consumption of steam and/or electricity the project emissions due to consumption of utility is considered as zero.

$$PE_{Utility,y} = PE_{utility,elec,y} + PE_{utility,steam,y} \quad (16)$$

Where:

$PE_{utility\ elec,y}$	Emissions due to the increase in electricity used in each year y of the crediting period, in tCO_2
$PE_{utility,steam,yy}$	Emissions due to the increase in steam used in each year y of the crediting period, in tCO_2

The emissions due to increased consumption of electricity after implementation of project activity are calculated as follows:

$$PE_{utility,elec,y} = \max[\{((\frac{EC_{utility,elec,y}}{P_{Urea,PJ,y}}) - (\sum_{k=1}^{3} \frac{EC_{utility,elec,BL,k}}{3 \times P_{Urea,BL,k}})) \times P_{Urea,PJ,y} \times EF_{utility,elec,y}\},0] \quad (17)$$

Where:

$EC_{utility,elec,y}$	Quantity of electricity consumed by the project activity plant in each year *y* of the crediting period, in MWh
$EC_{utility,Bl,k}$	Quantity of electricity consumed during the most recent three years of baseline in MWh
$EF_{utility,elec,y}$	CO_2 emission factor for electricity used for utilities during each year *y* of the crediting period, in tCO_2/MWh

For $EF_{utility,elec,y}$, refer to the latest "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".

The emissions due to increased consumption of steam after implementation of project activity are calculated as follows:

The emissions due to the production of additional steam used for the plant utilities are calculated as follows:

$$PE_{utility,steam,y} = EC_{utility,steam,y} \times EF_{utility,Boiler,y} \quad (18)$$

Where:

$EC_{utility,steam,y}$	Additional quantity of thermal energy (steam) used for the operation of the utilities in plant, in TJ. The calculation of the amount of thermal energy (steam) used for the operation of the utilities must take into consideration the pressure and temperature in which the steam is produced ($T_{utility,steam}$, $P_{utility,steam}$). The specific enthalpy is a function of pressure and temperature and can be obtained from steam tables
$EF_{utility,Boiler,y}$	Emission factor of the steam generator, tCO_2/TJ

The annual equivalent energy for additional steam consumption for plant utilities is calculated as follows:

$$EC_{utility,steam,y} = \max[\{((\frac{SC_{utility,steam,y}}{P_{Urea,PJ,y}}) - (\sum_{k=1}^{3} \frac{SC_{utility,steam,BL,k}}{3 \times P_{Urea,BL,k}})) \times (E_{utility,steam,} - E_{utility,feedwater}) \times P_{Urea,PJ,y}\},0] \quad (19)$$

Where:

$SC_{utility,steam,y}$	Quantity of steam consumed by the project activity plant in each year *y* of the crediting period, in tonnes of steam
$SC_{utility,steam,BL,k}$	Quantity of steam consumed during the most recent three years of baseline in tonnes of steam
$E_{utility,steam}$	Specific enthalpy of the steam at the steam generator outlet used for utility steam, in TJ/tonnes. Obtained from steam tables using the measured temperature ($T_{utility,steam}$) and pressure ($P_{utility,steam}$) of the steam in the steam generator outlet
$E_{utility,feedwater}$	Specific enthalpy of the feed water at the steam generator inlet used for utility steam, in TJ/tonnes. Obtained from steam tables using the measured temperature ($T_{utility,fw}$) and pressure ($P_{utility,fw}$) of the feedwater in the steam generator inlet

The emission factor of the steam generator is calculated as follows:

$$EF_{utility,Boiler,y} = \frac{\sum_i FC_{utility,steam,i,y} \times NCV_{i,y} \times EF_{i,y}}{TSP_{utility,steam,y} \times \left(E_{utility,steam} - E_{utility,feedwater}\right)} \quad \text{(20 ~~31~~)}$$

Where:

$FC_{utility,steam,i,y}$	Amount of fuel type i consumed in the steam generator used for utility steam in each year *y* of the crediting period, in mass or volume units
$TSP_{CDR,steam,y}$	Total amount of steam produced by the steam generator used for utility steam in each year *y* of the crediting period, in tonnes
$FC_{i,y}$	Quantity of fuel type i consumed in the furnaces (feed treatment and reforming) in each year *y* of the crediting period, in mass or volume units
$NCV_{i,y}$	Net calorific value of fuel type i in each year *y* of the crediting period, in TJ/mass or volume units
$EF_{i,y}$	Emission factor of fuel type i used for steam generation in each year *y* of the crediting period, tCO_2/TJ

Leakage

The leakage (LE_y) in the project activity would be due to feed extraction, processing, liquefaction, transportation, re-gasification and distribution of feed outside of the project boundary. This includes mainly: (i) fugitive CH_4 emissions; (ii) CO_2 emissions from the process of CO_2 removal from the raw natural gas stream in order to upgrade the natural gas to the required market conditions; and (iii) CO_2 emissions from associated fuel combustion and flaring. In this methodology, the following leakage emission sources shall be considered:[3]

[3] The Meth Panel is undertaking further work on the estimation of leakage emission sources in case of fuel switch project activities. This approach may be revised based on outcome of this work.

- Fugitive CH_4 emissions associated with feed extraction, processing, liquefaction, transportation, re-gasification and distribution of natural gas used in the project plant and fossil fuels used in the grid in the absence of the project activity;
- CO_2 emissions from the process of CO_2 removal from the raw natural gas stream in order to upgrade the natural gas to the required market conditions; and
- In the case LNG is used in the project plant: CO_2 emissions from fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression into a natural gas transmission or distribution system.

Thus, leakage emissions are calculated as follows:

$$\cancel{LE_y = LE_{CH4,y} + LE_{LNG,CO2,y}}$$

$$\mathrm{LE_y = LE_{CH4,y} + LE_{CO2,y} + LE_{LNG,CO2,y}} \quad \textbf{(21)}$$

Where:

$\mathrm{LE_y}$	Leakage emissions in the year *y* (tCO_2e)
$LE_{CH4,y}$	Leakage emissions due to fugitive upstream CH_4 emissions in the year *y*, in tCO_2
$\mathrm{LE_{CO2,y}}$	Leakage emissions due to the removal of CO_2 from the raw natural gas stream in year *y* (tCO_2)
$LE_{LNG,CO2,y}$	Leakage emissions due to fossil fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system during the year *y*, in tCO_2

Fugitive methane emissions

For the purpose of determining fugitive methane emissions associated with the production – and in case of natural gas, the transportation and distribution of the fuels – project participants should multiply the quantity of natural gas consumed as feed with a methane emission factor for these upstream emissions ($EF_{NG,upstream,CH4}$) as follows:

$$LE_{CH4,y} = F_{NG,PJ,y} \times NCV_{NG,y} \times EF_{NG,upstream,CH4} \times GWP_{CH4} \quad \textbf{(22)}$$

Where:

$F_{NG,PJ,y}$	Consumption of NG/LNG as feed during the year *y* of the crediting period, in m^3. If the available data are measured in mass units, use the appropriate density of NG/LNG, corrected for temperature and pressure, to calculate the equivalent volume
$NCV_{NG,y}$	Average net calorific value of the natural gas combusted during the year *y*, in TJ/m^3
$EF_{NG,upstream,CH4}$	CH_4 emission factor for upstream fugitive methane emissions from production, transportation and distribution of natural gas feed supplied to final consumers, in tCH_4/TJ
GWP_{CH4}	Is the global warming potential of methane = 21

Where reliable and accurate national data on fugitive CH_4 emissions associated with the production, and in case of natural gas, the transportation and distribution of the fuels is available, project participants should use this data to determine average emission factors by dividing the total quantity of CH_4 emissions by the quantity of fuel produced or supplied respectively.[4] Where such data is not available, project participants may use the default values provided in the table below. Note that the emission factor for fugitive upstream emissions for natural gas ($EF_{NG,upstream,CH4}$) should include fugitive emissions from production, processing, transport and distribution of natural gas, as indicated in the table below.

Table 2: Default emission factors for fugitive CH_4 upstream emissions

Activity		**Unit**	**Default emission factor**	**Reference for the underlying emission factor range in Volume 2 of the 2006 Revised IPCC Guidelines**
Natural gas				
Developed countries				
Gas production		Gg per 10^6 m^3 gas production	3.8E-04 to 2.3E-03	Table 4.2.4, p. 4.48
Gas processing	Sweet gas plants	Gg per 10^6 m^3 raw gas feed	4.8E-04 to 10.3E-03	Table 4.2.4, p. 4.48
	Sour gas plant	Gg per 10^6 m^3 raw gas feed	9.7E-05	Table 4.2.4, p. 4.48
Gas transmission & Storage	Transmission	Gg per 10^6 m^3 of marketable gas	6.6E-05 to 4.8E-04	Table 4.2.4, p. 4.49
	Storage	Gg per 10^6 m^3 of marketable gas	2.5E-05	Table 4.2.4, p. 4.49
Gas distribution		Gg per 10^6 m^3 of utility sales	1.1E-03	Table 4.2.4, p. 4.50
Developing countries and countries with economies in transition				
Gas production		Gg per 10^6 m^3 gas production	3.8E-04 to 2.4E-02	Table 4.2.5, p. 4.55
Gas processing	Sweet gas plants	Gg per 10^6 m^3 raw gas feed	4.8E-04 to 1.1E-03	Table 4.2.5, p. 4.55
	Sour gas plant	Gg per 10^6 m^3 raw gas feed	9.7E-05 to 2.2E-04	Table 4.2.5, p. 4.55

4 GHG inventory data reported to the UNFCCC as part of national communications can be used where country specific approaches (and not IPCC Tier 1 default values) have been used to estimate emissions.

Activity		**Unit**	**Default emission factor**	**Reference for the underlying emission factor range in Volume 2 of the 2006 Revised IPCC Guidelines**
Natural gas				
Gas transmission and storage	Transmission	Gg per 10^6 m^3 of marketable gas	16.6E-05 to 1.1E-03	Table 4.2.5, p. 4.57
	Storage	Gg per 10^6 m^3 of marketable gas	2.5E-05 to 5.8E-05	Table 4.2.5, p. 4.57
Gas distribution		Gg per 10^6 m^3 of utility sales	1.1E-03 to 2.5E-03	Table 4.2.5, p. 4.57

<u>Note</u>: The emission factor should be selected in order to ensure conservativeness in estimation of emission reduction.

Upstream emissions due to CO_2 removal from raw natural gas stream ($LE_{CO2,y}$)

In processing natural gas, CO_2 contained in the raw gas is removed and usually vented to the atmosphere. The CO_2 is removed to upgrade the gas to specifications required for commercial application. Emissions from venting of the CO_2 only need to be estimated if the average CO_2 content of the raw gas, which is processed in the gas processing plants supplying the applicable gas transmission and distribution system, is higher than 5% on a volume basis. In this case, the leakage emissions $LE_{CO2,y}$ are to be estimated as follows:

$$LE_{CO2,y} = F_{NG,PJ,y} \times \frac{r_{CO2}}{1 - r_{CO2}} \times \rho_{CO2} \tag{23}$$

Where:

$LE_{CO2,y}$	Leakage emissions due to the removal of CO_2 from the raw natural gas stream in year y (tCO_2)
$F_{NG,PJ,y}$	Quantity of natural gas combusted in the project plant in year y (m^3)
r_{CO2}	Average CO_2 content in the raw natural gas stream on volume basis (ratio)
ρ_{CO2}	Density of CO_2 under standard conditions ($tonnes/m^3$)

CO_2 emissions from LNG

If LNG is used as feed at the project activity, CO_2 emissions from fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system ($LE\cancel{2}_{LNG,\ CO2,y}$) should be estimated by multiplying the quantity of natural gas combusted in the project with an appropriate emission factor, as follows:

$$LE_{LNG,CO_2,y} = F_{NG,PJ,y} \times NCV_{NG,y} \times EF_{CO_2,upstream,LNG,y} \tag{24}$$

Where:

$EF_{CO2,upstream,LNG,y}$	Emission factor for upstream CO_2 emissions due to fossil fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system in year *y*, in tCO_2/TJ

Where reliable and accurate data on upstream CO_2 emissions due to fossil fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system is available, project participants should use this data to determine an average emission factor. Where such data is not available, project participants may assume a default value of 6 tCO_2/TJ as a rough approximation.[5]

Emissions reductions

The emissions reductions are calculated as:

$$ER_y = BE_y - PE_y - LE_y \quad (25)$$

Changes required for methodology implementation in 2nd and 3rd crediting periods

At the renewal of the crediting period, project participants should follow the latest version of the tool "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of a crediting period".

~~evaluate whether the project activity continues not to be the baseline scenario, i.e. whether it would have been implemented in the absence of the project activity. The crediting period may only be renewed if the application of the procedure results in that the baseline as determined in the draft CDM-PDD, still apply.~~

~~Furthermore,~~ All relevant data contained under "Data and parameters not monitored" should be updated.

Project activity under a programme of activities

This methodology is not applicable to project activities under a programme of activities.

Data and parameters not monitored

Parameter:	$P_{urea,Blky}$
Data unit:	Tonnes
Description:	Production of urea in each of the three most recent years *k* previous to the implementation of the project activity
Source of data:	Obtained from data logs and urea stock verification records at the project site
Measurement procedures (if any):	Daily urea production calculated based on the ammonia input to the urea plant and periodic (Quarterly) urea stock verification records
Any comment:	-

[5] This value has been derived on data published for North American LNG systems. "Barclay, M. and N. Denton, 2005. Selecting offshore LNG process. <http://www.fwc.com/publications/tech_papers/files/LNJ091105p34-36.pdf> (10th April 2006)".

Parameter:	$CF_{\cancel{N}Existing\ feedstock\cancel{aphtha},BL}$
Data unit:	tonnes of carbon/tonnes of existing feedstock~~naphtha~~
Description:	Carbon fraction of existing feedstock ~~naphta~~ used in the baseline as feed
Source of data:	On-site measurements and plant laboratory records
Measurement procedures (if any):	Laboratory analysis of the composition of the feed. In case of more than one feedstock used, the lowest carbon fraction of the feedstock should be used
Any comment:	-

Parameter:	$F_{Existing\ feedstock,BL,k}$
Data unit:	Tonnes
Description:	Quantity of existing feedstock used as feed in each of the three most recent years *k* previous to the implementation of the project activity
Source of data:	Obtained from data logs, measurements and plant records at the project site
Measurement procedures (if any):	Feed consumption flow meter. Cross check with feed purchase receipts
Any comment:	-

Parameter:	$EF_{BL,CO2}$
Data unit:	tCO_2/TJ
Description:	CO_2 emission factor for the baseline fuel that would be used in the furnaces (feed treatment and reforming) in each year *y* of the crediting period. Chosen as the emission factor of the fuel type with the lowest emission factor among all the *i* fossil fuels used in the furnaces (feed treatment and reforming) in each year *y* of the crediting period
Source of data:	For the determination of emission factors, guidance from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories should be followed where appropriate. Project participants may either conduct measurements or they may use accurate and reliable local or national data where available. Where such data is not available, IPCC default emission factors (country-specific, if available any) may be used if they are deemed to reasonably represent local circumstances. All values should be chosen in a conservative manner and the choice should be justified and documented in the CDM-PDD. Laboratory analysis/Online Analysis - If carbon emission factor of fuel used is estimated by laboratory analysis, then the yearly average of fuel composition of respective fuel is to be used to calculate carbon emission factor
Measurement procedures (if any):	
Any comment:	-

Parameter:	$FC_{BL,i,k}$
Data unit:	Tonnes
Description:	Quantity of fuel type i consumed in the furnaces (feed treatment and reforming) in each of the most recent three years k previous to the implementation of the project activity

Source of data:	Obtained from data logs, measurements and plant records at the project site
Measurement procedures (if any):	Fuel flow meter. Cross check with fuel purchase receipts
Any comment:	-

Parameter:	$NCV_{i,k}$
Data unit:	TJ/tonnes
Description:	Net calorific value of fuel type *i* consumed in the furnaces (feed treatment and reforming) in each of the most recent three years *k* previous to the implementation of the project activity
Source of data:	Project specific data obtained from fuel purchase receipts and/or laboratory tests, is preferred. In the absence of project specific data, local or national data may be used. In the absence of previous options, use data obtained from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories
Measurement procedures (if any):	-
Any comment:	-

Parameter:	$EC_{utility,elec,BL,k}$
Data unit:	MWh
Description:	Quantity of electricity consumed during the most recent three years of baseline
Source of data:	Obtained from data logs books and plant records at the project site
Measurement procedures (if any):	Plant energy meters
Any comment:	-

Parameter:	r_{CO2}
Data unit:	Ratio
Description:	CO_2 content in the raw natural gas stream on volume basis
Source of data:	Official, governmental or public studies; public databases; or written statements from the applicable natural gas processing facility(ies), including the average chemical composition of the raw gas in the reservoirs where the project activity natural gas is extracted from
Measurement procedures (if any):	-
Any comment:	-

Parameter:	ρ_{CO2}
Data unit:	tonnes/m^3
Description:	Density of the CO_2 gas under standard conditions
Source of data:	A default value of 0.001978 t CO_2 / m_3 CO_2 under standard conditions
Measurement procedures (if any):	ρ_{CO2}
Any comment:	-

~~Parameter:~~	~~$NCV_{i,k}$~~
~~Data unit:~~	~~TJ/tonnes~~
~~Description:~~	~~Net calorific value of fuel type i consumed in the furnaces (feed treatment and reforming) in each one of the most recent three years k previous to the implementation of the project activity.~~
~~Source of data:~~	~~Project specific data obtained from fuel purchase receipts and/or laboratory tests, is preferred. In the absence of project specific data, local or national data may be used. In the absence of previous options, use data obtained from in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.~~
~~Measurement procedures (if any):~~	~~-~~
~~Any comment:~~	~~-~~

Parameter:	$SC_{utility,steam\cancel{elec},BL,k}$
Data unit:	Tonnes
Description:	Quantity of steam consumed during the most recent three years of baseline
Source of data:	Obtained from data logs books and plant records
Measurement procedures (if any):	Plant steam flow meters
Any comment:	-

III. MONITORING METHODOLOGY

Monitoring procedures

The data and parameters monitored are essentially related to the main activity of production of urea in the manufacturing facility.

Data and parameters monitored

Data / Parameter:	$P_{urea,PJ,y}$
Data unit:	Tonnes
Description:	Production of urea in each year *y* of the crediting period
Source of data:	Urea stock verification records
Measurement procedures (if any):	Daily urea production calculated based on the ammonia input to the urea plant and periodic (Quarterly) urea stock verification records
Monitoring frequency:	Quarterly
QA/QC procedures:	Flow meter(s) (Ammonia to urea plant) should be calibrated regularly according to manufacturer's guidelines. Measurement results should be cross-checked with the periodic urea stock verification carried out by external agencies
Any comment:	-

Data / Parameter:	$F_{NG,PJ,y}$
Data unit:	Mass or volume units
Description:	Consumption of NG/LNG as feed during the year y of the crediting period. If the available data are measured in volume units use the appriopriate density of NG/LNG, corrected for temperature and pressure, to calculate the equivalent

	mass
Source of data:	On-site measurements
Measurement procedures (if any):	Flow-rate meters
Monitoring frequency:	Continuously
QA/QC procedures:	Meters should be calibrated regularly according to standard procedure or manufacturer's guidelines. Cross-check with fuel purchase receipts
Any comment:	Volumetric units should be at normal pressure and temperature (NTP)

Data / Parameter:	$F_{Existing\ feedstock,PJ,y}$
Data unit:	tonnes
Description:	Consumption of existing feedstock as feed during the year *y* of the crediting period
Source of data:	On-site measurements
Measurement procedures (if any):	Flow-rate meters
Monitoring frequency:	Continuously
QA/QC procedures:	Meters should be calibrated regularly according to standard procedure or manufacturer's guidelines. Cross-check with fuel purchase receipts
Any comment:	-

Data / Parameter:	CF_{NG}
Data unit:	Tonnes of carbon/tonnes of NG/LNG
Description:	Carbon content, expressed as weight fraction, of NG/LNG used as feed during year y of the crediting period~~, in tonnes of carbon/tonnes of NG/LNG. Obtained at the project activity~~
Source of data:	Derived from the feed composition report provided by the feed supplier
Measurement procedures (if any):	-
Monitoring frequency:	Daily
QA/QC procedures:	The feed composition report provided by the feed supplier should be from a certified laboratory
Any comment:	-

Data / Parameter:	$CF_{\cancel{Naphtha}Existing\ feedstock,PJ}$
Data unit:	tonnes of carbon/tonnes of ~~naphtha~~existing feedstock
Description:	Carbon content, expressed as weight fraction, of existing feedstock~~naphtha~~ used as feed during year *y* of the crediting period
Source of data:	Onsite measurement and ~~Measured at the project activity through~~ plant laboratory records
Measurement procedures (if any):	Laboratory analysis of composition of feed
Monitoring frequency:	Daily
QA/QC procedures:	The plant laboratory should be certified by third party~~analysis should be carried out in a certified laboratory.~~
Any comment:	-

~~**Data / Parameter:**~~	~~$EC_{captive,y}$~~
~~Data unit:~~	~~MWh~~
~~Description:~~	~~Quantity of electricity obtained from a captive power plant by the projecty activity during each year y of the crediting period.~~
~~Source of data:~~	~~Measured in the project activity by digital control systems and/or data logs.~~
~~Measurement procedures (if any):~~	~~Electrical Energy Meter~~
~~Monitoring frequency:~~	~~Continuously~~
~~QA/QC procedures:~~	~~Electrical Energy Meter used for measurement should be calibrated regularly as per ISO procedures or according to manufacturer's guidelines~~
~~Any comment:~~	~~Applicable only if CDR plant is also being installed.~~

Data / Parameter:	$EF_{i,y}$
Data unit:	tCO_2/TJ
Description:	Emission factor of fuel type i used for steam generation in the year *y*
Source of data:	For the determination of emission factors, guidance from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories should be followed where appropriate. Project participants may either conduct measurements or they may use accurate and reliable local or national data where available. Where such data is not available, IPCC default emission factors (country-specific, if available any) may be used if they are deemed to reasonably represent local circumstances. All values should be chosen in a conservative manner and the choice should be justified and documented in the CDM-PDD
Measurement procedures (if any):	~~For the determination of emission factors, guidance from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories should be followed where appropriate. Project participants may either conduct measurements or they may use accurate and reliable local or national data where available. Where such data is not available, IPCC default emission factors (country-specific, if available any) may be used if they are deemed to reasonably represent local circumstances. All values should be chosen in a conservative manner and the choice should be justified and documented in the CDM-PDD.~~ Laboratory analysis/Online Analysis - If carbon emission factor of fuel used is estimated by laboratory analysis, then the yearly average of fuel composition of respective fuel is to be used to calculate carbon emission factor
Monitoring frequency:	Yearly
QA/QC procedures:	Equipments and instruments used in the lab should be calibrated regularly as per ISO procedures or according to manufacturer's guidelines. If the analysis is carried out by outside agency ,it should be a certified/reputed lab
Any comment:	This parameter only needs to be monitored if CDR plant is also being installed

~~**Data / Parameter:**~~	~~$EF_{CO2,PJ,y}$~~
~~Data unit:~~	~~tCO_2/TJ~~
~~Description:~~	~~CO_2 emission factor of fuel type i used in the furnaces (feed treatment and reforming) in each year y of the crediting period. Chosen as the emission factor of the fuel type with the highest lowest emission factor among all the i fossil fuels used in the furnaces (feed treatment and reforming) in each year y of the crediting period.~~
~~Source of data:~~	~~For the determination of emission factors, guidance from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories should be followed where appropriate. Project participants may either conduct measurements or they may use accurate and reliable local or national data where available. Where such data is not available, IPCC default emission factors (country-specific, if available any) may be used if they are deemed to reasonably represent local circumstances. All values should be chosen in a conservative manner and the choice should be justified and documented in the CDM-PDD~~
~~Measurement procedures (if any):~~	~~For the determination of emission factors, guidance from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories should be followed where appropriate. Project participants may either conduct measurements or they may use accurate and reliable local or national data where available. Where such data is not available, IPCC default emission factors (country-specific, if available any) may be used if they are deemed to reasonably represent local circumstances. All values should be chosen in a conservative manner and the choice should be justified and documented in the CDM-PDD.~~ ~~Laboratory analysis/Online Analysis - If carbon emission factor of fuel used is estimated by laboratory analysis, then the yearly average of fuel composition of respective fuel is to be used to calculate carbon emission factor.~~
~~Monitoring frequency:~~	~~Yearly~~
~~QA/QC procedures:~~	~~Equipments and instruments used in the lab should be calibrated regularly as per ISO procedures or according to manufacturer's guidelines. If the analysis is carried out by outside agency ,it should be a certified /reputed lab~~
~~Any comment:~~	~~This parameter only needs to be monitored if CDR plant is also being installed~~

Data / Parameter:	$EF_{CO2,upstream,LNG,y}$
Data unit:	tCO_2/TJ
Description:	Emission factor for upstream CO_2 emissions due to fossil fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system in year *y*

Source of data:	Where reliable and accurate data on upstream CO_2 emissions due to fossil fuel combustion/electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system is available, project participants should use this data to determine an average emission factor. Where such data is not available, project participants may assume a default value of 6 tCO_2/TJ as a rough approximation[6]
Measurement procedures (if any):	~~Where reliable and accurate data on upstream CO_2 emissions due to fossil fuel combustion / electricity consumption associated with the liquefaction, transportation, re-gasification and compression of LNG into a natural gas transmission or distribution system is available, project participants should use this data to determine an average emission factor. Where such data is not available, project participants may assume a default value of 6 tCO_2/TJ as a rough approximation[7]~~
Monitoring frequency:	Yearly
QA/QC procedures:	-
Any comment:	-

Data / Parameter:	$EF_{NG,upstream,CH4}$
Data unit:	tCH_4/TJ
Description:	CH_4 emission factor for upstream fugitive methane emissions from production, transportation and distribution of natural gas feed supplied to final consumers
Source of data:	Where reliable and accurate national data on fugitive CH_4 emissions associated with the production, and in case of natural gas, the transportation and distribution of the fuels is available, project participants should use this data to determine average emission factors by dividing the total quantity of CH_4 emissions by the quantity of fuel produced or supplied respectively.[8] Where such data is not available, project participants may use the default values provided in table below. Note that the emission factor for fugitive upstream emissions for natural gas ($EF_{NG,upstream,CH4}$) should include fugitive emissions from production, processing, transport and distribution of natural gas, as indicated in the table provided in the baseline section

[6] This value has been derived on data published for North American LNG systems. "Barclay, M. and N. Denton, 2005. Selecting offshore LNG process. <http://www.fwc.com/publications/tech_papers/files/LNJ091105p34-36.pdf> (10th April 2006)".

[7] ~~This value has been derived on data published for North American LNG systems. "Barclay, M. and N. Denton, 2005. Selecting offshore LNG process. http://www.fwc.com/publications/tech_papers/files/LNJ091105p34-36.pdf (10th April 2006)"~~

[8] GHG inventory data reported to the UNFCCC as part of national communications can be used where country specific approaches (and not IPCC Tier 1 default values) have been used to estimate emissions.

Measurement procedures (if any):	~~Where reliable and accurate national data on fugitive CH_4 emissions associated with the production, and in case of natural gas, the transportation and distribution of the fuels is available, project participants should use this data to determine average emission factors by dividing the total quantity of CH_4 emissions by the quantity of fuel produced or supplied respectively[9]. Where such data is not available, project participants may use the default values provided in table below. Note that the emission factor for fugitive upstream emissions for natural gas ($EF_{NG,upstream,CH4}$) should include fugitive emissions from production, processing, transport and distribution of natural gas, as indicated in the table provided in the baseline section.~~
Monitoring frequency:	Yearly
QA/QC procedures:	-
Any comment:	-

Data / Parameter:	P_{steam}
Data unit:	Mpa
Description:	Pressure of the steam produced in the steam generator
Source of data:	DCS/log sheet of steam generation plant or power plant
Measurement procedures (if any):	-
Monitoring frequency:	Daily
QA/QC procedures:	The device used for pressure measurement should be calibrated regularly as per ISO procedures or according to manufacturer's guidelines
Any comment:	Used to calculate E_{steam}, the specific enthalpy of the steam at the steam generator outlet, in TJ/tonnes. Calculated as per guidance below

Data / Parameter:	T_{steam}
Data unit:	^{o}C
Description:	Temperature of the steam produced in the steam generator
Source of data:	DCS/log sheet of steam generation plant or power plant
Measurement procedures (if any):	-
Monitoring frequency:	Daily
QA/QC procedures:	The device used for temperature measurement should be calibrated as per ISO procedures or according to manufacturer's guidelines
Any comment:	Used to calculate E_{steam}, the specific enthalpy of the steam at the steam generator outlet, in TJ/tonnes. Calculated as per guidance below

Data / Parameter:	P_{fw}
Data unit:	Mpa
Description:	Pressure of the feedwater used in the steam generator
Source of data:	DCS/log sheet of steam generation plant or power plant
Measurement procedures (if any):	-

9 ~~GHG inventory data reported to the UNFCCC as part of national communications can be used where country specific approaches (and not IPCC Tier 1 default values) have been used to estimate emissions.~~

Monitoring frequency:	Daily
QA/QC procedures:	The device used for pressure measurement should be calibrated regularly as per ISO procedures or according to manufacturer's guidelines
Any comment:	Used to calculate $E_{feedwater}$, the specific enthalpy of the feed water at the steam generator inlet, in TJ/tonnes

Data / Parameter:	T_{fw}
Data unit:	°C
Description:	Temperature of the feedwater used in the steam generator
Source of data:	DCS/log sheet of steam generation plant or power plant
Measurement procedures (if any):	-
Monitoring frequency:	Daily
QA/QC procedures:	The device used for temperature measurement should be calibrated as per standard ~~ISO~~ procedures or according to manufacturer's guidelines
Any comment:	Used to calculate $E_{feedwater}$, the specific enthalpy of the feed water at the steam generator inlet, in TJ/tonnes

Data / Parameter:	$PE_{CDR,elec,y}$$\cancel{FC_{CDR,captive,i,y}}$
Data unit:	~~Mass or volume units~~ tCO_2
Description:	Emissions due to the production of electricity used for the operation of the CDR plant in each year *y* of the crediting period ~~Amount of fossil fuel of type i used in the captive power plant in each year y of the crediting period.~~
Source of data:	As per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"~~Measured at the captive power plant.~~
Measurement procedures (if any):	As per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"~~Flow-rate meters, mass meters, cross-check with fuel purchase receipts.~~
Monitoring frequency:	As per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"~~Continuously~~
QA/QC procedures:	~~Meters should be calibrated regularly according to manufacturer's guidelines.~~
Any comment:	-

Data / Parameter:	$FC_{CDR,steam,i,y}$
Data unit:	Mass or volume units
Description:	Amount of fuel type *i* consumed in the steam generator in each year *y* of the crediting period
Source of data:	Measured at the steam generator site
Measurement procedures (if any):	Flow-rate meters/mass meters ~~cross-check with fuel purchase receipts.~~
Monitoring frequency:	Continuously
QA/QC procedures:	Meters should be calibrated regularly according to standard procedure or manufacturer's guidelines. Cross-check with fuel purchase receipts
Any comment:	-

Data / Parameter:	$PE_{Heat,y}$ ~~$FC_{i,y}$~~
Data unit:	tCO_2/year ~~Mass or volume units~~
Description:	Emissions due to fuel consumption for the puropose of production of thermal energy in the furnaces (feed treatment and reforming) after deducting the CO_2 recovered by the CDR plant (if any) in each year *y* of the crediting period, in tCO_2~~Quantity of fuel type i consumed in the furnaces (feed treatment and reforming) in each year y of the crediting period.~~
Source of data:	As per the the 'Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion' ~~On-site measurements~~
Measurement procedures (if any):	As per the 'Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion'~~Flow-rate meters~~
Monitoring frequency:	As per the 'Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion'~~Continuously~~
QA/QC procedures:	~~Meters should be calibrated regularly according tostandard procedure or manufacturer's guidelines.~~
Any comment:	~~Volumetric units should be at normal pressure and temperature~~

Data / Parameter:	$NCV_{i,y}$
Data unit:	TJ/mass or volume units
Description:	Average net calorific value of fuel type i ~~and NG/LNG respectively~~, in year *y* of the crediting period
Source of data:	Project specific data obtained from fuel purchase receipts and/or laboratory tests, is preferred. In the absence of project specific data, local or national data may be used. In the absence of previous options, use data obtained from ~~in the~~ 2006 IPCC Guidelines for National Greenhouse Gas Inventories
Measurement procedures (if any):	-
Monitoring frequency	The calorific value of the respective fuel is measured daily and monthly average of calorific value is calculated by averaging daily value. Yearly average of calorific value is calculated by averaging monthly value
QA/QC procedures	-
Any comment:	-

Data / Parameter:	$SC_{CDR,y}$
Data unit:	tonnes
Description:	Quantity ~~Demand~~ of steam required for the operation of the CDR plant in each year y of the crediting period
Source of data:	DCS/log sheet of ammonia plant
Measurement procedures (if any):	Use steam flow meters
Monitoring frequency:	Continuously
QA/QC procedures:	Steam Flow Meter used for measurement should be calibrated regularly as per standard ~~ISO~~ procedures or according to manufacturer's guidelines
Any comment:	-

~~**Data / Parameter:**~~	~~$TEP_{CDR,captive,y}$~~
~~Data unit:~~	~~MWh~~
~~Description:~~	~~Total electricity produced by the captive power plant in year y.~~
~~Source of data:~~	~~Measured at the captive power plant through electricity meters. Cross check with electricity purchase receipts, if any.~~
~~Measurement procedures (if any):~~	~~-~~
~~Monitoring frequency:~~	~~Continuously~~
~~QA/QC procedures:~~	~~Electricity flow meter used for measurement should be calibrated regularly as per ISO procedures or according to manufacturer's guidelines.~~
~~Any comment:~~	-

Data / Parameter:	$TSP_{CDR,steam,y}$
Data unit:	Tonnes
Description:	Total amount of steam produced by the steam generator in each year *y* of the crediting period
Source of data:	Measured at the steam generator site through steam flow meters
Measurement procedures (if any):	Steam flow meters
Monitoring frequency:	Continuously
QA/QC procedures:	Steam flow meter used for measurement should be calibrated regularly as per standard ~~ISO~~ procedures or according to manufacturer's guidelines
Any comment:	-

Data / Parameter:	$EC_{,utility,elec,y}$
Data unit:	MWh
Description:	Quantity of electricity consumed by the project activity in each year *y* of the crediting period.
Source of data:	Plant records and log books
Measurement procedures (if any):	Energy meters
Monitoring frequency:	Continuously
QA/QC procedures:	Energy meters used for measurement should be calibrated regularly as per standard procedures or according to manufacturer's guidelines
Any comment:	-

Data / Parameter:	$SC_{,utility,steam,y}$
Data unit:	Tonnes
Description:	Quantity of steam consumed in each year *y* of the crediting period
Source of data:	Plant records and log books
Measurement procedures (if any):	- Steam flow meters
Monitoring frequency:	Continuously
QA/QC procedures:	Steam flow meters used for measurement should be calibrated regularly as per standard procedures or according to manufacturer's guidelines
Any comment:	-

Data / Parameter:	$TSP_{utility,steam,y}$
Data unit:	Tonnes
Description:	Quantity of steam produced by the steam generator used for utility steam in each year *y* of the crediting period
Source of data:	Measured at the steam generator site through steam flow meters
Measurement procedures (if any):	-
Monitoring frequency:	Continuously
QA/QC procedures:	Steam flow meter used for measurement should be calibrated regularly as per standard procedures or according to manufacturer's guidelines
Any comment:	-

Data / Parameter:	$FC_{utility,steam,i,y}$
Data unit:	Mass or volume units
Description:	Quantity of fuel type *i* consumed in the steam generator used for utility steam in each year y of the crediting period
Source of data:	Measured at the steam generator site
Measurement procedures (if any):	Flow-rate meters, mass meters
Monitoring frequency:	Continuously
QA/QC procedures:	Meters should be calibrated regularly according to standard procedure or manufacturer's guidelines. Cross-check with fuel purchase receipts
Any comment:	-

Data / Parameter:	$P_{utility,steam}$
Data unit:	Mpa
Description:	Pressure of the steam produced in the steam generator used for utility steam
Source of data:	DCS/log sheet of steam generation plant or power plant
Measurement procedures (if any):	-
Monitoring frequency:	Daily
QA/QC procedures:	The device used for pressure measurement should be calibrated regularly as per standard procedures or according to manufacturer's guidelines
Any comment:	Used to calculate $E_{utility,steam}$, the specific enthalpy of the steam at the steam generator outlet used for utility steam, in TJ/tonnes

Data / Parameter:	$T_{utility,steam}$
Data unit:	^{o}C
Description:	Temperature of the steam produced in the steam generator used for utility steam
Source of data:	DCS/log sheet of steam generation plant or power plant
Measurement procedures (if any):	-
Monitoring frequency:	Daily
QA/QC procedures:	The device used for temperature measurement should be calibrated as per standard procedures or according to manufacturer's guidelines
Any comment:	Used to calculate $E_{utility,steam}$, the specific enthalpy of the steam at the steam generator outlet used for utility steam, in TJ/tonnes

Data / Parameter:	$P_{utility,fw}$
Data unit:	Mpa
Description:	Pressure of the feedwater used in the steam generator used for utility steam
Source of data:	DCS/log sheet of steam generation plant or power plant
Measurement procedures (if any):	-
Monitoring frequency:	Daily
QA/QC procedures:	The device used for pressure measurement should be calibrated regularly as per standard procedures or according to manufacturer's guidelines
Any comment:	Used to calculate $E_{utility,feedwater}$, the specific enthalpy of the feed water at the steam generator inlet used for utility steam, in TJ/tonnes

Data / Parameter:	$T_{utility,fw}$
Data unit:	^{o}C
Description:	Temperature of the feedwater used in the steam generator used for utility steam
Source of data:	DCS/log sheet of steam generation plant or power plant
Measurement procedures (if any):	-
Monitoring frequency:	Daily
QA/QC procedures:	The device used for temperature measurement should be calibrated as per standard procedures or according to manufacturer's guidelines
Any comment:	Used to calculate $E_{utility,feedwater}$, the specific enthalpy of the feed water at the steam generator inlet used for utility steam, in TJ/tonnes

Data / Parameter:	$EF_{utility,elec,y}$
Data unit:	tCO_2/MWh
Description:	Emission factor for electricity consumption in utilities
Source of data:	Measured at electricity consumption sites
Measurement procedures (if any):	Tool to calculate baseline, project and/or leakage emissions from electricity consumption
Monitoring frequency:	Daily
QA/QC procedures:	-
Any comment:	-

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History of the document

Version	Date	Nature of revision(s)
3.0.0	20 July 2012	EB 68, Annex # 1. Revision to include other feedstocks other than naphtha; 2. Revision in the applicability conditions for the production, steam and electricity consumption and subsequent revision to the emission reduction calculation; 3 Introduces provisions for the use of this methodology in a project activity under a PoA; 4. Editorial corrections.
2.1	EB 39, Para 15 14 May 2008	1. In variable description section of equation 2 change $BE_{Urea,y}$ to $BS_{Urea,y}$. 2. Delete text “after deducting the CO_2 recovered by the CDR plant (if any)”while describing emissions from thermal energy (above equation 12). 3. Note added below table-2 “The emission factor should be selected in order to ensure conservativeness in estimation of emission reduction.” 4. In section III monitoring methodology first para, the sentence mentioning that the parameters should be monitored on daily basis, is deleted. 5. In table “data and parameters monitored” the data unit of CF_{NG} is changed from “tonnes of carbon/tonnes of hydrogen” to “tonnes of carbon/tonnes of NG”.
02	EB 35, Para 24 19 October 2007	Revision to incorporate the use of the “Tool to calculate emission factor for an electricity system”
01	EB 31, Annex 4 4 May 2007	Initial adoption