The Improvement of Greenhouse Gas Inventory as a Tool for Reduction of Emission Uncertainties for Oil Activities in Russia

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- *As a Party to the UNFCCC Russian Federation has been obliged to prepare, publish and regularly update national emission inventories of greenhouse gases*

- *Reliable national inventory is one of the steps to efficient greenhouse gas emission mitigation*

- *National inventory reliability is defined by uncertainty level that becomes more important in the case of the key categories of the national greenhouse gas inventory*

- *At the Fifteenth Conference of the Parties to the UN Framework Convention on Climate Change (UNFCCC, Copenhagen, December 2009) the Russian Federation indicated of its intention to reduce greenhouse gas emissions by 15 to 25% below the 1990 year by year 2020*

- *The improvement of the reliability of the national greenhouse gas inventory particularly for Key categories such as oil activities promotes for identification of the sources with the higher mitigation potential*

Uncertainty as provided by National inventory of the Russian Federation

- **According to the National Inventory Report of the Russian Federation the quantitative greenhouse gas emission uncertainty corresponds to Tier 1 (IPCC, 2000)**

- **To make assessment of greenhouse gas emission uncertainty following equations were used (IPCC, 2000):**

$$STANDARD\_DEVIATION = \left(\sigma_1^2 + \sigma_2^2\right)^{1/2} \qquad U_{TOTAL} = \frac{\sqrt{(U_1 \bullet x_1)^2 + (U_2 + x_2)^2 + \ldots + (U_n \bullet x_n)^2}}{x_1 + x_2 + \ldots + x_n}$$

Where:

σ_i *- the standard deviations of the probability density functions of the emissions in year* t_i*. The 95% confidence limits (this time of the mean or the difference in the means) will be given by plus or minus approximately two standard deviations;*

U_{TOTAL} *- the percentage uncertainty in the sum of the quantities (half the 95% confidence interval divided by the total (i.e. mean) and expressed as a percentage);*

x_i *and* U_i *- the uncertain quantities and the percentage uncertainties associated with them, respectively.*

- **Uncertainty was assessed by expert judgment (IPCC, 2000):**

Parameter	Uncertainty estimate
Activity data	± 5%
Emission factors	± 25%

•The overall uncertainty for oil operations was estimated as 21% (NIR 2009)

Improving the level of uncertainty of greenhouse gas emission estimations

- **An attempt to improve the level of uncertainty of greenhouse gas emission estimates was made by a shift from production-based approach (IPCC Tier 1) to mass balance approach (IPCC Tier 2) for oil activities excluding storage and transportation operations of the oil, which have the lower contribution to the entire emission profile**

- **According to Tier 2 IPCC for the greenhouse gas emission estimation the following equations were used (IPCC, 2006):**

$$E_{venting} = GOR \cdot Q_{oil} \cdot (1 - CE) \cdot (1 - X_{flared}) \cdot M_{gas} \cdot y_{gas} \cdot 42.3 \cdot 10^{-6}$$

$$E_{N_2O\ flaring} = GOR \cdot Q_{oil} \cdot (1 - CE) \cdot X_{flared} \cdot EF_{N_2O}$$

$$E_{CH_4\ flaring} = GOR \cdot Q_{oil} \cdot (1 - CE) \cdot X_{flared} \cdot (1 - FE) \cdot M_{CH_4} \cdot y_{CH_4} \cdot 42.3 \cdot 10^{-6}$$

$$E_{CO_2\ flaring} = GOR \cdot Q_{oil} \cdot (1 - CE) \cdot X_{flared} \cdot (1 - FE) \cdot M_{CO_2} \cdot \left[y_{CO_2} + (Nc_{NMVOC} \cdot y_{CH_4} + Nc_{NMVOC} \cdot y_{NMVOC} \cdot (1 - X_{soot}) \right] 42.3 \cdot 10^{-6}$$

Where:

$E_{venting}$ *- direct amount (Gg/y) of greenhouse gas emitted due to venting at the oil production facilities;*

$E_{CO2, CH4, N2Oflaring}$ *- direct amount (Gg/y) of greenhouse gas emitted due to flaring at the oil production facilities;*

X_{soot} *– fraction of the non-CO_2 carbon in the input waste gas stream that is converted to soot or particulate matter during flaring;*

$42{,}3 \times 10^{-6}$ *– the number of kmol per m^3 referenced at 101.325 kPa and 15°C times a unit conversion factor of 10^{-3} Gg/Mg (the inverse value of the Molar volume, i.e. $1/V_m$).*

GOR *is the average gas-oil ratio (m^3/m^3) referenced at 15°C and 101.325 kPa;*

CE *– gas conservation efficiency factor;*

Q_{oil} *- total annual oil production ($10^3 m^3/y$);*

M_{gas} *– molecular weight of the gas of interest;*

EF_{N2O} *– emission factor for N_2O from flaring;*

X_{flared} *– fraction of the waste gas that is flared rather than vented;*

y_i *– mol or volume fraction of the associated gas that is composed of substance I;*

N_{Ci} *– number of moles of carbon per mole of compound i.*

FE *– flaring destruction efficiency;*

Adaptation Tier 2 IPCC to the national conditions of the Russian Federation

Parameters of the Tier 2 IPCC equation		Recalculation to the national conditions	Background
The number of kmol per m^3 referenced at 101.325 kPa and 15°C	**42.3×10^{-6}**	**41.6×10^{-6}**	Volume of gas is referenced at 20°C and 101.325 kPa
Total annual oil production by the the average gas-oil ratio	$GOR \bullet Q_{OIL}$	$\frac{Q_{USED\_OIL\_GAS}}{CE}$	Due to peculiarities of the activity data on the operations with oil provided by the national statistics
Fraction of the waste gas that is flared rather than vented	$\mathbf{x_{flared}}$	$\frac{Q_{FLARED}}{\frac{Q_{USED\_OIL\_GAS}}{CE} \bullet (1 - CE)}$	Due to peculiarities of the activity data on the operations with oil provided by the national statistics
The chemical composition of the associated oil gas	-	Based on the data for the Western Siberia	The oils produced in Western Siberia dominate in total oil production in the country.

- Thus mass balance approach allows not only to obtain highly accurate assessments, but it also allows to cross-check and verify calculations at each estimation stage

- Finally it is also possible to compare value of greenhouse gas emission from oil activity obtained by mass-balance approach with initial activity data

Comparing the estimated uncertainty with one for Tier 1 approach

- ✓ The uncertainty of the greenhouse gas emissions calculated with the using of mass-balance approach was estimated as recommended by the IPCC

- ✓ The values of the uncertainties obtained for the different approaches of the greenhouse gas emissions estimations:

GHG emissions estimated by production-based approach (Tier 1)	**GHG emissions estimated by mass-balance approach (Tier 2)**
21%	**18 %**

- ✓ The further reduction of the uncertainty can be achieved by improvement of accuracy of the parameters such as chemical composition of the associated oil gas and parameters of flaring

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