The methodology for assessment greenhouse gas emissions from coal mining taking into account of uncertainty

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Abstract. The determination of the level of greenhouse gases (GHG) emissions from coal mining with take account of uncertainty of assessment methodology is actual purpose. The analysis of applied methods for estimating GHG emissions and uncertainty of data was conducted. The originality of the proposed method is adequate assessment of the uncertainty of the used methodology. Comparison of methods for estimating GHG emissions on the level of uncertainty contributes to the adequate choice of methodology, obtaining more precise results of assessment to take the necessary decisions to reduce GHG emissions from coal mining.

1. Introduction
Climate change (CC) is mainly caused by the increase in the amount of greenhouse gases (GHG) in the atmosphere. Coal mining goes through different stages, where environmental pollution occurs, including GHG emissions. According to the International Energy Agency (IEA), in 2014 about 46% of the world’s carbon dioxide (CO₂) emissions were emissions from coal combustion [1, 2].

To prevent “dangerous” human intervention in the climate system the United Nations’ Framework Convention on Climate Change (UNFCCC) was adopted [3]. The Intergovernmental Panel on Climate Change (IPCC) has organized the development of internationally recognized guidelines for the preparation of National GHG Inventory Report (NIR) – IPCC 2006 [4]. Countries must provide an annual NIR about GHG emissions (Tables of NIR and CRF) prepared in accordance with IPCC 2006 [4] and IPCC Good Practice Guidance and Uncertainty Management in NIR (GPG 2000) [5].

International practices encourage countries to improve the quality of inventory data on a long-term basis through uncertainty analysis. In this context, optimal adaptation to national conditions of international guidelines for estimating GHG emissions is optimal.

2. The general methodology for estimating GHG emissions from coal mining and processing
The methodological approach to using IPCC 2006 is to combine information about the extent to which a person’s activity occurs, so-called activity data (AD), with coefficients that quantify emissions or removals per unit of activity – emission factors (EF). The IPCC tiers represent different levels of methodological complexity: Tier 1 (T1) is the main method; Tier 2 (T2); Tier 3 (T3) is the most difficult level in terms of data requirements. The T1 level for all categories is intended for the use of readily available national or international statistics in combination with the provided default EFs (D). The T2 and T3 levels are sometimes referred to as higher-level methods and are usually considered to be more accurate (using country-specific methods (CS) and/or EF) [4].
A generalized algorithm (Figure 1) and a methodology for estimating GHG emissions from coal mining (from underground coal mines, emissions from open coal mining and emissions from coal processing), which are based on IPCC 2006 requirements have been developed.

![Image of a flowchart for estimating GHG emissions from coal mining](image)

**Figure 1.** A generalized algorithm for estimating GHG emissions from coal mining

The assessment of GHG emissions from coal mining begins with the definition of the type of production – underground or open. For underground mining, the most accurate estimate is obtained when measuring data are available for each individual mine using T3. In the absence of such data, it is estimated whether the category of GHG emissions from underground coal mining is the key for the country. If the category is not a key, an emission estimate for T1 is carried out. If the category is a key, need to check the availability of available measurement data for individual mines and carry out a T3 emission estimate if measured data are available. In the absence of such measurements, it is checked whether there are any data on EF for a particular basin. If such data are available, an emission estimate for T2 is carried out; otherwise AD and EF are collected.
The assessment of total GHG emissions from underground coal mines for T1 and T2 levels without correction taking into account methane utilization or flaring:

\[ E_{MC} = \sum_{i=1}^{n} A_{D_{MC}} \cdot E_{G_{GHG}} \cdot C_{F_{GHG}}, \]

where \( A_{D_{MC}} \) is total amount of coal mined \([t]\); \( E_{G_{GHG}} \) is EF for a specific type of mine and specific GHG \([m^3/t]\); \( C_{F_{GHG}} \) is the unit conversion factor for a specific GHG; \( n = 2 \) is total number of GHGs that were taken into account in the assessment (1 – CO\(_2\), 2 – CH\(_4\)).

For open coal mining, the most accurate estimate of GHG emissions is obtained by having specific EF data for the country or basin using T2. If there is no such data, it is estimated whether the category of GHG emissions from open coal mining is key for the country. If the category is not the key one, the emissions are estimated at T1. If the category is a key then the necessary data and EF for the T2 calculations are collected.

3. A generalized methodology for estimating the uncertainty of GHG emissions from coal mining

The estimation of uncertainty is an essential element of the completeness of the NIR on GHG emissions and removals. Therefore, IPCC 2006 developed a structured approach to assessing the uncertainty of inventories. Estimates of emissions and/or removals are based on: conceptualization; models; input data and assumptions (EF, AD). Each of them can be a source of uncertainty [4, 5-10].

In IPCC 2006, the general uncertainty of \( U_{tot} \), arising from the combination of uncertainty of EF and AD, is calculated using equation:

\[ U_{tot} = \pm \sqrt{U_{EF}^2 + U_{AD}^2}, \%
\]

where \( U_{EF} \) is uncertainty associated with EF; \( U_{AD} \) is uncertainty associated with AD, provided that \( |U_{EF}| \cdot U_{AD}\% < 60 \% \) [4, 5, 6, 8].

A generalized algorithm (Figure 2) and a methodology for estimating the uncertainty of AD and EF of GHG in coal mining are developed. They are based on the general requirements of GPG 2000.

The use of appropriate levels to estimate emissions from coal mining in accordance with good practice depends on the quality of the available AD. The T1 requires countries to select from the global average EF range and use specific AD – CS to calculate total emissions. The T1 is associated with the highest level of uncertainty. The T2 uses CS or basins EF that represent the average values for the coal produced. The T3 uses direct measurements from specific mines, properly applied EF and has the lowest level of uncertainty.

For countries with underground mining operations and where measurements are available for specific mines, it is recommended to use T3. The data for a particular mine, based on measurements of ventilation and degassing of the ventilation system, reflect the actual emissions for each mine and therefore give a more accurate estimate than when using EF. The combination of T3 and T2 is suitable in situations where the measurement data of a particular mine is only available for a subgroup of underground mines [4, 5, 10].

4. Conclusion

International guidelines for estimating GHG emissions facilitate the comparability of the national data obtained and encourage countries to improve the quality of inventory data by improving the uncertainty analysis of data used at the national level. A generalized algorithm and a methodology for estimating the uncertainty of AD and EF of GHG in coal mining are developed. They are based on the general requirements of GPG 2000 and increases the reliability of the estimates obtained. An improved generalized methodology for estimating GHG emissions at the national level for coal mining and a generalized methodology for estimating the uncertainty of the data used are presented.
Figure 2. A generalized algorithm for estimating the uncertainty of AD and EF from coal mining

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