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## Proposals of effective ways for uncertainty reduction in the Polish greenhouse gas inventory system

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# GESAPU

## Geoinformation technologies, spatio-temporal approaches, and full carbon account for improving accuracy of GHG inventories

### Deliverable 1.4. Proposals of effective ways for uncertainty reduction in the Polish greenhouse gas inventory system


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**Work package 1.** Spatially resolved greenhouse gas inventory for Poland

**Deliverable 1.4. Proposals of effective ways for uncertainty reduction in the Polish greenhouse gas inventory system**

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# 1. Principles of uncertainty analysis in spatial modeling of greenhouse gas emission. Uncertainty of the main parameters of inventories.

An important element in the inventory of greenhouse gas emission is to evaluate the uncertainty of input data and the results of calculations (GHG, 2007). In terms of practical implementation of the Kyoto Protocol or any other agreement, an essential problem is the assessment of uncertainty, and not only the estimation of annual emissions. It is important to estimate the uncertainty of the results, which allows to determine the actual state of implementation by a country (a region, a company, etc.) its commitment to reduce the emission of greenhouse gases. If the assessment of the emission, taking into account the uncertainty, complies with the level of emission, specified in the agreement, it can be concluded that, the emission has been reduced.

The analysis of uncertainty of the statistical data on economic activity in the energy sector in Poland was carried out in preparation of the National Inventory Report. According to the report, in 2010 the total uncertainty of the statistical data on the use of fuel for electricity and heat generation (1.A.1.a category "Production of electricity and heat" following the IPCC procedure) was on the level of 2%. The uncertainty was relatively smaller, due to the presence of fairly detailed statistics on economic activity in the energy sector as a whole, accounting for about 90% of national emissions of greenhouse gases.

**Uncertainty of calorific values of fuels.** In the mathematical models implemented, an assessment of greenhouse gas emissions is carried out using the net calorific value of fuel for its conversion from natural units to the energy received. The uncertainty of this parameter is heavily influenced by the physical and chemical properties of the fuel used, which are different for individual countries and regions. Therefore, for this study the so-called "national" values of emission factors are used, that largely reflect the specifics of fossil fuels in Poland.

In *Table 1.1* the "national" net calorific values of the fuel used for production of electricity and heat in Poland are presented, together with the lower and upper bounds of the 95% confidence interval for the lognormal distribution. This distribution is defined by the following density function:

$$f(x;\mu,\sigma)=\frac{1}{x\sigma\sqrt{2\pi}}\exp\left(-\frac{(\ln(x)-\mu)^2}{2\sigma^2}\right),\ x>0,$$

where parameters $\mu$ and $\sigma$, ($\sigma > 0$) are, respectively,the expected value and the standard deviation of a normally distributed random variable. By definition, if the random variable X has a lognormal distribution, then its natural logarithm is normally distributed.

**Table 1.1.** The lower calorific values and uncertainty bounds (of the 95% confidence interval for the lognormal distribution) of fuels used in Poland

| Fuel | Unit | Net calorific values | Uncertainties,% | |
|---|---|---|---|---|
| | | | Lower bound | Upper bound |
| Coal | TJ/thousands t | 21,49 | 17,41 | 25,89 |
| Brown coal | TJ/thousands t | 8,88 | 7,6 | 11,9 |
| Natural gas | TJ/millions $m^3$ | 34,08 | 33,02 | 35,77 |
| Fuel oil | TJ/thousands t | 40,19 | 33,61 | 42,46 |

The expected value of the lognormally distributed random variable X is given as follows:

$$E(X) = e^{\mu + \sigma^2/2},$$

and its variance is expressed as:

$$Var(X) = \left(e^{\sigma^2} - 1\right)e^{2\mu+\sigma^2}.$$

The standard deviation of the variable X has the following form:

$$StdDev(X) = \sqrt{Var(X)} = \sqrt{\left(e^{\sigma^2} - 1\right)}e^{\mu+\sigma^2/2}.$$

The bounds of the 95% confidence interval can be presented as:

$$\left[\mu_{geo} / \sigma_{geo}^2, \mu_{geo} \cdot \sigma_{geo}^2\right],$$

where $\mu_{geo} = e^{\mu}$ is the geometric average, and $\sigma_{geo} = e^{\sigma}$ – the geometric standard deviation.

**Uncertainty of greenhouse gases emission factors.** In most cases, getting the ranges of uncertainties for emission factors is associated with serious difficulties. It is believed that, the uncertainty of emission factors for carbon dioxide is insignificant when compared to other greenhouse gases (Marland, 2009) and strongly depends on the carbon content of the fuel. Moreover, it is characterized by the normal distribution.

An important impact on the overall uncertainty of estimates of greenhouse gas emissions in the energy sector in Poland is exerted by the uncertainty of estimates of carbon dioxide emissions in the category "Electricity and heat plants for general use." In particular, this applies to the uncertainty factors and emission data on economic activity for solid fuel.

In the IPCC methodologies it is assumed that, all the fuels used for heat or power generating plants are combusted completely. However, in most cases, a small portion is not burned. In this case it is necessary to know the exact rates of combustion for each source of emission. Unfortunatelysuch data are not always available and known.

Evaluation of coefficients of greenhouse gases emissions other than carbon dioxide, is carried out separately for categories of economic activities or for separate enterprises. The reason for this is that the emissions of these gases depend on proper fuel combustion technology as well as on the equipment used in the analyzed heat or power generating plants.

In the National Inventory Report (NIR, 2011) on greenhouse gas emissions in Poland it is assumed that, the main emission coefficients of greenhouse gases are normally distributed. In the energy sector in Poland uncertainty of emission factors for carbon dioxide ($CO_2$) is 3,4%, for methane ($CH_4$) – 15,5%, and nitrous oxide ($N_2O$) – 11,3%.

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