

## DETERMINATION OF EMISSION AND OXIDATION FACTORS IN MONITORING CO<sub>2</sub> EMISSIONS FOR EMISSION TRADING SCHEME

Pavel FOTT<sup>1)\*</sup>, František KOLÁŘ<sup>2)</sup> and Dušan VÁCHA<sup>1)</sup>

<sup>1)</sup> Czech Hydrometeorological Institute, 143 06 Praha 4

<sup>2)</sup> Institute of Rock Structure and Mechanics, Czech Academy of Sciences, Praha

\*Corresponding author's e-mail: fott@chmi.cz

(Received December 2005, accepted June 2006)

### ABSTRACT

EU Emission Trading Scheme, which is applied in EU Member States to decrease CO<sub>2</sub> emissions, requires accurate, reliable, comparable and transparent methodology for monitoring, reporting and verification of emissions. Existing Monitoring and Reporting Guidelines provides operators only with general and undetailed instructions. This paper should provide the plant operators with guidance for a better understanding, interpretation and mastering of the methods of monitoring and reporting CO<sub>2</sub> emissions for the purposes of emission trading. This paper is focused on experimental determination of emission and oxidation factors of solid fuels and on calculation of emission factors of gaseous fuels from their composition.

**KEYWORDS:** emission and oxidation factors, CO<sub>2</sub> monitoring, greenhouse gas, emission trading

---

### INTRODUCTION

The system of trading greenhouse-gas emissions, introduced in the EU member states, for which the abbreviation EU ETS (Emission Trading Scheme) is now commonly used, is the first tool (measure) applied in the Czech Republic, the purpose of which is decreasing greenhouse gas emissions. The ETS is an economic tool, which is to achieve the reduction of emissions in an economically effective manner, i.e. at a low cost as far as possible. A company, depending on local conditions, is able to choose its own strategy: where the conditions are favourable for reducing emissions (e.g., where fossil fuels can partly be replaced by biomass, where power effectiveness can be increased, etc.) the company will choose the strategy of introducing reduction measures with the purpose of achieving profit. On the contrary, in places where reduction of emissions would be expensive, the company will purchase the additional allowances required without having to restrict production. The ETS is being introduced within the EU based on Directive 2003/87/EC (Directive, 2003), which was implemented in the Czech Republic as Act No. 695/2004 Coll. (Act, 2004). An indispensable part of the ETS is the National Allocation Plan (NAP), a document describing the conditions and results of allocating allowances to the individual facilities (officially termed as "installations") to which the Act applies, which, after correction by the European

Commission, was adopted by the Czech Government in July 2005. Another important part of the EU ETS is the method of monitoring and reporting CO<sub>2</sub> emissions from the individual sources, which is described by the decision of the European Commission No. 2004/156/EC (Commission, 2004) and which was implemented in the Czech Republic in the form of Decree of the Ministry of Environment No. 696/2004 Coll. (Decree, 2004). The purpose of this paper is to provide a better understanding and mastering of this methodology, namely as regards determining the emission factors.

### BASIC INFORMATION ON EMISSION TRADING

The directive and act (Directive 2003, Act, 2004) define the basic terms, the principles of allocating allowances to the individual facilities, the principles of preparing the NAP, the possibilities and obligations in managing permits, the monitoring requirements, reporting and verification of greenhouse gas emissions, penalties, the duties of the Scheme Manager, and the requirements as to the register of allowances. Annex 1 of the Act lists the categories of activities to which the ETS applies. The list contains some categories of activity according to the Categorisation for the Integrated Prevention of Pollution and Control (IPPC); however, with combustion facilities the thermal input limit was reduced from 50 to 20 MW. It is necessary to draw

attention to the fact that many of the activities, to which integrated prevention applies, have not been included in the ETS although they significantly contribute to greenhouse-gas emissions: this concerns, in particular, chemical plants (the relevant company power and heat producing installations have, however, been included in the ETS). Other annexes of the directive and act provide details of the principles of preparing the NAP and of the basic principles of monitoring, reporting and verifying emissions, which are further elaborated in the decision and/or decree (Commission, 2004; Decree 2004).

So far two periods have been set for trading permits: in the first three-year period (2005 – 2007) called the “running-in (warming-up) period”, the penalties for failing to meet obligations are lower. The second period covers the commitment period of the Kyoto Protocol (2008 – 2012) which was ratified at the beginning of 2005, thereby coming into legal force. The NAP contains a list of more than 460 facilities (i.e. plants) and altogether the number of allowances issued corresponds to 97.6 mil. t CO<sub>2</sub>. The relevant “historical” CO<sub>2</sub> emissions in the year 2000 amounted to 90.4 t CO<sub>2</sub>, so that the allocation plan assumes an increase of 8% for the running-in (warming-up) period as compared to the year 2000. From this point of view Czech companies are at an advantage compared to companies from traditional EU member countries, which have, moreover, been restricted by the requirements of gradual fulfilment of the Kyoto reduction target, which is a problem for a number of countries. Most Czech companies will, therefore, be able to sell part of their allowances, which should motivate them to additional reductions of emissions under the present market conditions.

The basic data for drawing up the NAP were the data on historical emissions in the years 1999-2001

and forecasts for the separate sectors (refer to Table 1). The facilities included in the ETS account for approximately 70% of the total nationwide CO<sub>2</sub> emissions. The resultant allocation of allowances by sector as per Government resolution of July 20, 2005 is shown in Table 1. A premium on the basic allocation are bonuses in respect of implementation of measures to reduce CO<sub>2</sub> emissions in the past: specifically, in respect of “timely measures” (early action), in which case a total of 2 892 796 allowances were distributed, and in respect of “combined power and heat production” – 1 446 398 allowances. Another 713 247 allowances were distributed among rapidly expanding companies. Since the allocation was based on data of “exceptionally (above average) warm winters”, another 673 468 allowances were distributed among heating plants. 500 000 permits were retained as a reserve for new sources. A total of 97.1 mil. allowances were distributed among approximately 460 companies and 500 000 allowances remained as a reserve for new sources.

Each and every operator of a facility to which the ETS applies had to apply to the Ministry of Environment (also the Ministry of Industry and Trade participated) at the beginning of 2005 for greenhouse gas emission permit, an obligation required by law (Act, 2004).

The application had to include information relating to the facility, monitoring, reporting and checking of the reported emission, inclusive of the authority of the individual interested persons or organisations, as the case may be. This document is referred to as the Monitoring Plan. The produced monitoring plans for the individual facilities were reviewed by the Ministry of Environment (and ratified by the Ministry of Industry and Trade) to determine whether they contain all the particulars required to

**Table 1** Distribution of greenhouse-gas emission allowances by sector

Sector	Emissions in 2000 [t CO <sub>2</sub> ]	Anticipated annual increase [%]	Allowance allocation (allowance = 1 t CO <sub>2</sub> )
Public energy production	62 169 389	0.26	63 458 493
Energy production in plants (auto-producers)	3 625 715	-0.19	3 766 771
Energy production in chemical industry	4 588 752	7.11	5 574 288
Refineries	950 963	2.71	1 370 498
Coke production	231 746	2.05	249 527
Metal production and processing	12 124 187	3.61	15 455 479
Cement production	3 048 171	-0.50	3 047 260
Lime production	1 202 714	2.42	1 341 085
Glass production	762 902	1.99	827 848
Ceramics production	740 847	1.19	808 166
Cellulose production	153 147	2.02	251 899
Paper and cardboard production	790 776	-1.13	948 384
<b>Total:</b>	<b>90 389 308</b>		<b>97 100 000</b>

issue the permit: to wit, whether the monitoring plan describes sufficiently clearly and comprehensively the method of determining the overall value of CO<sub>2</sub> emissions for the given facility. It was found that the preparation of the monitoring plan was very demanding with regard to the operator, because a relatively large part of the applications were returned to the operators for revising.

#### DECREE NO. 696/2004 ON MONITORING AND REPORTING EMISSIONS

The methodical instructions, contained in Decree No. 696/2004 (Decree, 2004), for monitoring and reporting emissions of greenhouse gases (only CO<sub>2</sub> is being considered for the time being) describe in detail the procedures of monitoring, reporting and verifying emissions. The document can be divided into two parts: the first part is devoted to general issues and the second describes the ways in which emission can be determined for the separate technological activities, contained in Annex 1 to the said act (Act, 2004).

#### DELIMITATION

Monitoring and reporting at the plant level includes emissions from all sources related to the activities to which the said act applies, carried out in a given facility (i.e. plant). In determining whether the threshold value has been exceeded (e.g., 20 MW of input with combustion sources) the separate capacities or inputs of the activity in question add up. However, if the capacities or inputs have exceeded the threshold value for a single activity, to which the said act applies, all emissions, even from other activities, to which this act applies for the given plant, are monitored and reported. The emissions from the engines of mobile sources are not included. Only direct emissions produced within a given plant, are considered.

#### CALCULATION OF EMISSIONS

Emissions of greenhouse gases (only CO<sub>2</sub> will be monitored in the first stage) can be determined on the basis of continual emission measurements, or by calculation. Continual measurements are to be considered only in places where standard pollutants are already being measured continually, however, even there it is necessary to verify the measurements by calculation. In this paper, we shall only deal with calculation, which is to be used with most sources.

There are two methods of calculation: the basic calculation using a formula, which is applied to the separate sources (or to a group thereof, provided they have the same parameters) on the one hand, and, on the other, a more complicated calculation based on the carbon balances for the whole facility, or even for several facilities together, provided the operator is the same. This method allows balance calculations only for mineral oil refineries and iron and steel production, where coking and agglomeration can be

included. Other activities require calculation based on formulae, two basic formulae being given: one for calculating combustion emissions, the other for calculating emissions from processes (CO<sub>2</sub> emissions are expressed in tonnes). CO<sub>2</sub> combustion emissions are calculated using the formula:

$$\text{CO}_2 \text{ Emissions} = \text{Fuel consumption [TJ]} \cdot \text{Emission factor [t CO}_2\text{/TJ]} \cdot \text{Oxidation factor} \quad (1)$$

where the fuel consumption is expressed in TJ (i.e. in weight or volume amount times net calorific value). During combustion, most of the fuel oxidises to CO<sub>2</sub>, a small part may, however, stay in the ash or create soot. The oxidation factor (approaching unity) is expressed in terms of the ratio of oxidized carbon. Biomass is understood to be neutral and its emissions are, therefore, not included in the emission report for the given facility. The combustion emissions represent most of the CO<sub>2</sub> emissions not only in energy production, but also in other activities (technologies) to which the said act applies.

CO<sub>2</sub> emissions from processes are calculated using the formula:

$$\text{CO}_2 \text{ Emissions} = \text{Activity data [t, thou m}^3\text{]} \cdot \text{Emission factor [t CO}_2\text{/t, thou m}^3\text{]} \cdot \text{Conv. factor} \quad (2)$$

where the weight and volume amounts of the raw material or product represent the activity data. The carbon contained in the raw material, which is not changed into CO<sub>2</sub>, is considered in the conversion factor. If all carbon is converted into CO<sub>2</sub>, the conversion factor is equal to unity. A typical example of a process emission is the baking of clinker in manufacturing cement. This formula is also used to calculate emissions from desulphurising exhaust (stack) gas using limestone.

If data for determining the emissions from the individual partial sources using the above formulae are lacking, in the case of refineries and iron and steel production the CO<sub>2</sub> emissions can be calculated from the carbon balance, using the following general formula:

$$\text{CO}_2 \text{ Emissions} = (C_i - C_p - C_w - C_{ch}) \cdot S.\text{factor} \quad (3)$$

where S.factor is stoichiometric factor CO<sub>2</sub>/C, suffixes i - input, p - products, w - wastes and ch - change in reserves. The change in reserves is positive in growth. Waste does not include CO<sub>2</sub> emissions (nor CO) into the atmosphere.

#### TIER APPROACH

The Tier Approach is applied to all calculated parameters, i.e. to activity data, net calorific values, emission factors, oxidation factors and conversion factors. An increasing number of the tier (the tiers are

usually numbered from 1 to 3, with activity data even from 1 to 4 ) indicates higher required accuracy, if the same tier is involved, but different approaches, designated by letters, e.g., tier 2a, 2b.

The Tier Approach (level of accuracy – tier) consists in more emphasis on the accuracy for the facilities (plants) emitting CO<sub>2</sub> in larger amounts, which is reflected also in increased costs of the monitoring process. The said methodical instructions (Decree, 2004) give a table of required tiers for the separate kinds of parameters with a view to the emission output of a given plant (designated by the letters A, B, C) the requirements as to the tier of the separate parameters increasing with the output:

- A- smallest emission output, emissions smaller than or equal to 50 kt CO<sub>2</sub>;
- B- medium emission output, emissions in excess of 50 kt but smaller than or equal to 500 kt CO<sub>2</sub>;
- C- largest emissions, emissions in excess of 500 kt CO<sub>2</sub>.

If the prescribed tier for a given plant can hardly be achieved technically, or should it require unreasonably high expenses, application may be filed with the “competent authority” (in this particular case the Ministry of Environment) to decrease the tier within the monitoring plan. Nor is it necessary to observe the requirement of accuracy for the minor partial sources of the given facility (plant).

#### EMISSION FACTORS

The emission factors for monitoring at the basic tier are tabulated in the Decree (Decree, 2004). In the case of fuel combustion, standardly recommended (default) values were adopted from the IPCC methods (Revised, 1996; Good Practice, 2000) used for national inventories of greenhouse gases. At higher tiers the emission factors are determined by chemical analysis of carbon, and with fuels also from measuring the net calorific value (lower heating value). Some of the values tabulated for the basic types of fuels are given in Table 2.

Values of 0.99 and 0.995 are considered for solid, and for liquid and gaseous fuels, respectively, as standard values of oxidation factors. These values for solid and liquid fuels differ slightly from those of the existing IPCC, which gives 0.98 for solid and 0.99 for liquid fuels as default values.

#### DETERMINATION OF EMISSION FACTORS OF SOLID FUELS

The highest tier, 3, is used for combustion of solid fuels, which means determination by chemical analysis and net calorific value required for facilities of Classes B and C, i.e. for facilities emitting more than 50 kt CO<sub>2</sub> per year. The procedure itself, however, is only outlined in the decree (Commission, 2004). Therefore the CHMI prepared more detailed instructions (Determination, 2006) of how to proceed

in the determination on the website of the Ministry of Environment. We shall mention at least the main principles below:

In accord with Decree No. 696/2004 Coll., the emission factor for solid fuels can be expressed by the following formula:

$$EF(\text{CO}_2) = (44/12)(C^r/Q) \quad (4)$$

where  $C^r$  is the content of carbon in a raw sample of the fuel (i.e. in the fuel supplied),  $Q$  is the net calorific value of the fuel supplied, and the ratio 44/12 represents the stoichiometric coefficient. If  $Q$  is expressed in TJ/t and  $C^r$  as a weight fraction,  $EF(\text{CO}_2)$  comes out in t CO<sub>2</sub>/TJ. For example, for coal containing 60% carbon ( $C^r = 0.6$ ) with a net calorific value of 23.3 MJ/kg the emission factor is equal to 94.42 t CO<sub>2</sub>/TJ. It is necessary to point out that care must be taken in selecting the samples for determining the representative annual average of a given type of solid fuel. Experience indicates, however, that the EF value is substantially less sensitive to the fluctuation of the quality of a fuel of a given type in the course of the year (e.g., for coarse-grained brown coal dust from the Most area) than, e.g., the net calorific value of this fuel. The quality features of the given fuel, i.e. the carbon content and net calorific value, have to be taken from a single sampling batch for determining the EF.

In determining the emission factors of Czech hard coals and brown coals (lignite) a significant correlation was observed between the emission factor and the calorific capacity of the fuel. The studies of several separate sets of hard coals and brown coals (lignite) were published in several specialist publications. The results of many analyses were condensed (Fott et al., 1996; Fott, 1999; Fott, 2002) into the following formula, which is satisfactory for Czech brown coals (lignite) and hard coals:

$$EF(\text{CO}_2) [t/TJ] = 10 \cdot (44/12) \cdot (2.333 + 5.511/Q [\text{MJ/kg}]) \quad (5)$$

For example, if the calorific capacity of the supplied brown coal (lignite) is 12 MJ/kg, the emission factor calculated from this correlation is 102.38 t CO<sub>2</sub>/TJ. This correlation, with slightly modified parameters, can also be applied to European hard coals and brown coals (lignite) used for power engineering purposes (Fott, 1999; Fott, 2002)

#### DETERMINATION OF OXIDATION FACTORS OF SOLID FUELS

Under perfect fuel combustion, all the carbon is emitted into the atmosphere in the form of CO<sub>2</sub>. Practically, however, most combustion is imperfect, part of the carbon contained in the fuel is not burnt and remains in the ash, or settles in the form of soot. The part of the carbon, which remains unburned in the ash, is referred to as unburned carbon, and has not part

**Table 2** Default emission factors for fuel combustion (Decree, 2004).

Type of fuel	Emission factor [t CO <sub>2</sub> /TJ]	Type of fuel	Emission factor [t CO <sub>2</sub> /TJ]
Stone coal	94.5	Heating oil (TTO)	77.3
Lignite	101.1	Heating oil (LTO), fuel oil	74.0
Coke	108.1	Petrol	69.2
Briquettes	94.5	Kerosene	71.8
Natural gas	56.1	LPG (propane-butane)	63.0

in the CO<sub>2</sub> emission. To reflect this effect, Decree No. 696/2004 Coll. introduces the oxidation factor which will be designated in this paper by  $f_{ox}$ , and which expresses the proportion of combusted carbon. Whereas the emission factor characterises the fuel as such, the oxidation factor depends significantly on the type of combustion facility, as well as on combustion conditions. The following text describes the method of determining the oxidation factor at tier 2 (only two tiers are defined with the oxidation factor).

In computing the oxidation factor we draw on the analytically determined content of carbon in the initial fuel and in the ash, which is created after the fuel is burned in the given facility (ash, fly ash, clinker). The content of carbon in ash  $C_{noncomb}^A$  (the so-called unburned carbon) has to be reduced to the total weight of the raw fuel  $C_{noncomb}^r$

$$C_{noncomb}^r = A^r [C_{noncomb}^A / (1 - C_{noncomb}^A)] \quad (6)$$

where  $A^r$  is the ash content in the raw fuel. As in the previous cases, we shall express the quality characteristics of the fuel in the equations by weight fractions.

The oxidation factor is calculated as the ratio of the weight fractions of the burned and total carbon contained in the raw fuel:

$$f_{ox} = (C_{comb}^r / C^r) = 1 - (C_{noncomb}^r / C^r) \quad (7)$$

Practically, the value of the oxidation factor is slightly smaller than 1, the value  $f_{ox} = 1$  corresponding to complete combustion of the fuel into CO<sub>2</sub>. The procedure can be explained by the following example:

In burning lignite coarse-grained dust, the unburned carbon in the fly ash was determined at 7% (i.e. 7% of the carbon remained in the ash unburned). The following quality characteristics were determined for this fuel: carbon content in dry matter 50.25%, ash content in dry matter 33.0%, water content 27.5%. We shall first determine the weight fractions of carbon in the fuel:

$C^r = 0.525 \cdot (1 - 0.275) = 0.3643$ , and the ash content in raw fuel:  $A^r = 0.33(1 - 0.275) = 0.2393$ . The value of  $C_{noncomb}^r$  is 0.0181, so that the Oxidation factor equals  $1 - 0.01801/0.3643 = 0.951$ .

## DETERMINATION OF EMISSION FACTORS OF GASEOUS FUELS

The use of the emission factor at tier 3 is required by the (Decree, 2004) only for the largest sources over 500 kt CO<sub>2</sub> per year (i.e. Class C). However, with gaseous mixes of fluctuating composition, for which the Decree gives no tabulated value of the emission factor (e.g., firedamp from degassing wells) a similar procedure has to be adopted, although emissions do not reach the value of 500 kt CO<sub>2</sub> per year. Our experience indicates that the best is to determine the emission factor from the current analysis of composition (in terms of volume fractions), gases containing carbon being mainly analysed.

Determining the emission factor relative to the calorific content of the fuel [t CO<sub>2</sub>/TJ] can be divided into two parts: we first calculate the emission factor relative to unit volume [t CO<sub>2</sub>/thou m<sup>3</sup>], the volume (of consumed gaseous fuel) being expressed under defined conditions (temperature, pressure) – usually under normal conditions [Nm<sup>3</sup>], i.e. at 0 °C and atmospheric pressure of 101.325 kPa. (Sometimes in technical practice so-called: trading: conditions are used, i.e. at atmospheric pressure and 15 °C).

The CO<sub>2</sub> emission factor relative to unit volume can be calculated from the following formula:

$$EF [t CO_2 / \text{thou m}^3] = d_{CO_2} \cdot (N_{C_1} \cdot Y_1 + N_{C_2} \cdot Y_2 + \dots + N_{C_m} \cdot Y_m) \quad (8)$$

where  $d_{CO_2}$  [kg/m<sup>3</sup>] is the density of CO<sub>2</sub> under the defined conditions, e.g., under normal conditions  $d_{CO_2} = 1.963 \text{ kg/m}^3$ ,  $N_{C_x}$  ( $x = 1, \dots, m$ ) is the number of carbon atoms for gas  $x$  containing carbon in a mix of  $m$  gases containing carbon, and  $Y_x$  is the volume fraction for gas  $x$  containing carbon.

For example, the emission factor, relative to unit volume under normal conditions for a gas, consisting of 40% hydrogen, 27.5% methane, 20% ethane, 5% propane and 7.5% nitrogen, burned in a refinery, is equal to 1.62 t CO<sub>2</sub>/thou Nm<sup>3</sup>. For a converter gas containing 1% hydrogen, 17% carbon dioxide, 63% carbon monoxide, 1% oxygen and 18% nitrogen, the emission factor comes out at 1.571 t CO<sub>2</sub>/thou Nm<sup>3</sup>.

Since the composition of gaseous fuel mixes fluctuates during the year, the weighted annual average has to be considered as the representative annual value of the volume fraction, the weights being determined from the ratio of the volume of fuel consumed per some interval of time (e.g., January) to the total annual consumption of this fuel.

It is now possible to calculate the annual emission from a partial source burning gaseous fuel of a given type as

$$\text{CO}_2 \text{ Emissions [t CO}_2\text{/year]} = \\ =V [\text{thou m}^3] \cdot \text{EF}[\text{t CO}_2\text{/thou m}^3] \cdot \text{Oxidation factor,}$$

where V is the annual consumption of fuel expressed in thousands of m<sup>3</sup> under defined (usually normal) conditions, the value of EF [t CO<sub>2</sub>/thou m<sup>3</sup>] being related to the same conditions.

Since the Decree of the Environment Ministry No. 696/2004 Coll. (Decree, 2004) also requires the use of emission factors related to the calorific content of the fuel, defined on the basis of its net calorific value, in reporting results, it is also necessary to calculate the calorific content of the fuel per year. Since the total net calorific value of the fuel is equal to the sum of the calorific values of the separate fuels, we can use the formula:

$$Q = \sum_i Y_i \cdot Q_i \quad (9)$$

where Q<sub>i</sub> are the net calorific values of the separate components per unit volume under the given conditions (e.g., normal) and Y<sub>i</sub> are the volume fractions of the components. The summation is carried out over all the components of the gaseous mix (i= 1, ..., n).

For example, for the above converter gas the combustible components are hydrogen and carbon monoxide. The net calorific values under normal conditions are as follows: H<sub>2</sub> 10.71, CO 12.605 MJ/Nm<sup>3</sup>. The resultant net calorific value of the converter gas comes out at 8.048 MJ/Nm<sup>3</sup> and the emission factor 195.13 t CO<sub>2</sub>/TJ (without including the oxidation factor).

In determining the representative mean net calorific values per year for the relevant volume in the foregoing formula, the procedure would be similar to that in the previous case, i.e. the weighted annual averages, in which the ratio of the volume of the fuel consumed per some interval of time (e.g., January) to the total annual consumption of this fuel, are taken as the representative annual values of the volume fractions. More detailed information on determining CO<sub>2</sub> emissions from burning gaseous fuels are given in reference (Kolář et al., 2004) and in the Operators Instructions on the website of the Ministry of Environment (Determination, 2006).

## CONCLUSION

The accurate and correct determination of CO<sub>2</sub> emissions is highly demanding for the operators of the individual facilities. Producing a monitoring plan, which contains the selection of the method of computing the emissions and their tiers in harmony with the Decree (Decree, 2004) represents a new approach for most company ecologists. The drawing up and subsequent approval of monitoring plans, as well as the monitoring itself and reporting emissions in accord with these plans represent (together with the preparation of the NAP) important and necessary steps, without which the ETS could not be successfully implemented.

This study should provide the plant operators with a guide to a better understanding, interpretation and mastering of the methods of monitoring and reporting CO<sub>2</sub> emissions for the purposes of emission trading, prescribed by Decree No. 696/2004 Coll. The procedures of determining the emission factors of higher tiers described will also be gradually introduced in the national inventory of greenhouse gases (Fott et al., 2005) according to the requirements of the United Nations Framework Convention on Climate Change and its Kyoto Protocol.

## REFERENCES

- Act No. 695/2004 Coll. on Conditions of Trading Greenhouse-gas Emission Permits and on the Amendments of Some Acts.
- Commission Decision No 2004/156/EC (29/01/04) establishing guidelines for the monitoring and reporting of GHG emissions pursuant to Direct. 2003/87/EC. ([http://europa.eu.int/comm/environment/climat/home\\_en.htm](http://europa.eu.int/comm/environment/climat/home_en.htm)).
- Decree of the Environment Ministry No. 696/2004 Coll., which provides the procedure of determining, reporting and verifying the amount of greenhouse-gas emissions.
- Determination of Emission and Oxidation Factors of Solid Fuels (FAQ – Monitoring emission on the Environment Ministry website). ([www.env.cz/www/klima.nsf](http://www.env.cz/www/klima.nsf)). ([www.env.cz/www/klima.nsf](http://www.env.cz/www/klima.nsf)).
- Directive 2003/87/EC of the European Parliament and of the Council establishing a scheme for GHG emission trading within the Community. ([http://europa.eu.int/comm/environment/climat/home\\_en.htm](http://europa.eu.int/comm/environment/climat/home_en.htm)).
- Fott, P., Přetel, J., Vácha, D., Neužil, V., Bláha, J. and Havránek, M.: 2005, National GHG Emission Inventory Report of the Czech Republic. CHMI Report for UNFCCC, Prague, May 2005. ([www.chmi.cz/cc/start.html](http://www.chmi.cz/cc/start.html)).
- Fott, P., Svítlová, J. and Kolář, F.: 1996, Establishing of Carbon Emission Factors for Czech Coals, Acta Montana IRSM, Ser. B, No 6 (101), 79-94

- Fott, P.: 2002, CO<sub>2</sub> Emission Monitoring – Combustion of Coal and Lignite, *Acta Montana IRSM*, Ser. B, No 12 (126), 85-92  
(<http://www.irsm.cas.cz/Newweb/staff/kolar/Papers/Fott2002.pdf>).
- Fott, P: 1999, Carbon Emission Factors of Coal and Lignite: Analysis of Czech Coal Data and Comparison to European Values, *Environmental Science and Policy* (Elsevier), 2, 347-354.
- Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (ed. Penman J. et al.), IPCC, 2000  
([www.ipcc-nggip.iges.or.jp](http://www.ipcc-nggip.iges.or.jp)).
- Kolář, F., Fott, P. and Svítlová, J.: 2004, Emissions of Carbon Dioxide of Gaseous Fuels Calculated from their Composition, *Acta Geodynamica et Geomaterialia*, Vol. 1, No.,2 (134), 279-287.  
<http://www.irsm.cas.cz/Newweb/staff/kolar/Papers/K2.pdf>).
- Revised 1996 IPCC Guidelines for National GHG Inventories (vol. 1-3), IPCC/OECD/IEA 1997.