CALCULATION OF EMISSION FACTOR

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INTRODUCTION

In the last decades much attention is drawn energy and environment problem, emissions, energy sustainability and another.

Rapid energy production growth leads to environmental impacts which can also constrain development. Energy production, whether from depreciable fossil and nuclear fuels or large – scale exploitation of hydroelectric or biomass resources, leads to many of the most severe environmental impacts faced by developing and industrialized nations alike. These include air pollution, radioactive waste, siltation of river basins, deforestation and soil erosion, etc.

In the past, environmental issues have been considered secondary to economic growth in developing and industrialized nations.

Air Pollutant consists of CO_2, CO, NO_x, SO_x, Pb Particles;

- NOx control is performed by controlling the combustion process have control after burning process.
- Control during combustion can reduce NO_x emissions by 15-50% by controlling the amount of air.
- Control by the amount of fuel accounts for 40-60% NO_x emissions reductions.
- Reduction of NO_x by ammonia solution injection.
- Total reduction of NOx can be 80-90%.

The main source of GHG is CO_2 which is as a result of burning fuel, energy companies Contribute one third of CO_2 - global emissions.

Carbon plants emit 24 kg C / GJ, fuel oil plants produce 20 kg C / GJ whiles natural gas combustible plants emit 14 kg C / GJ [7].

The most important greenhouse gas in the atmosphere is water vapors (H_2O), responsible for approximately 2/3 of the total greenhouse effect. The content of water in the atmosphere is not directly influenced by anthropogenic activities, but rather it is determined by the cycle of water in nature, expressed in a simpler way, as a difference between evaporation and precipitations.

Carbon dioxide (CO_2) has a 30 percent share in the greenhouse effect, while methane (CH_4), nitrous oxide (N_2O) and ozone (O_3) taken together account for 3 percent.

The group of artificial substances (man-made): chlorofluorocarbons (CFC) and their substitute, hydro-fluoride-carbons (HCFC, HFC) and other substances, as well as per-fluoride-carbons (PFCs) and sulphur hexafluoride (SF6) are also attributed to direct GHG.

There are other photo-chemically active gases, such as carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane volatile organic compounds (NMVOC) (include substances such as: propane, butane and ethane), which are not attributed to direct GHG, but have an indirect contribution to greenhouse effect. Such gases influence the formation and destruction of ozone in the atmosphere in the presence of solar rays (ultraviolet radiation) and are considered to be ozone precursors in the troposphere.

Though GHG are considered to be natural components of the air, their presence in atmosphere is strongly affected by anthropogenic activities. Increased concentrations of GHG in atmosphere (caused by emissions of anthropogenic origin) contribute strongly to greenhouse effect thus leading to additional warming of the atmosphere. The GHG concentration in atmosphere is determined by the difference between GHG emissions and removals. It has been stated with certainty that GHG concentration in atmosphere have increased significantly in comparison with pre-industrial period. Thus, since 1750 the concentration of CO_2 increased by 35 percent, concentration of CH4 - by 143 percent, and concentration of N_2O – by 18 percent.

To control their effect or reduce it, investigations have to be made and their causes highlighted.

1. EMISSION FACTOR

The purpose of this work is to find a method for calculating greenhouse gas emissions for renewable sources of energy. Despite, these sources are considered clean, it is obvious that biomass for example in any combustion process results in greenhouse emission.

The problem of greenhouse gas calculation is studied in most countries of the world. There are various methods and programs for calculating these emissions, such as GEMIS, MARKAL, EMPEB etc. Unfortunately all these methods do not take into consideration emissions from renewable energy sources as their results always indicates zero pollution from them, which is not always the reality.

As an example, combustion process of biomass will be analyzed, which is also considered renewable source of energy. The by-product of combustion process will be examined taken into consideration greenhouse gases.

For each of the impacts considered, environmental controls in the form of regulations can be applied to reduce environmental discharges or other effects. The type of regulation depends on the evaluated impact. Table 1 lists the regulatory options available for each impact [1].

Table 1. Regulatory Controls Available

IMPACT	REGULATIONS AVAILABLE
Air Pollution	Emission limits Required control device Chemical content of fuel
Water Supply and Pollution	Water intake limit Wastewater volume discharge limit Pollutant concentration Required equipment Chemical content of fuel
Land Use	Land use restriction Land restoration requirement
Solid Waste	Waste quantity limit Required control technique Chemical content of fuel
Occupational Health and Safety	Required control program
Resources	applicable

The regulations can be imposed singly or in combinations. It is possible to designate regulations that will apply only to specified facilities, specified types of facilities, in designated geographical areas, after a specified starting date, or to new, existing, or all facilities. This gives the user flexibility to apply different regulatory control programs.

The proposed basic equation, using air pollution as an example is as below [1]:

$$UEM_i \;=\; UEF_i \;*\; E_{input} \qquad (1.1)$$

where:

UEM_i - Uncontrolled emissions of Pollutant *i* (kg/year),

UEF_i - Emission Factor for Pollutant i (kg/GJ_{in}),

E_{input} - Energy Input (GJ).

In general, an emission factor is dependent on the fuel used except SO_2 [9]. For SO_2 emission factor has the form:

$$EF_{SO_2} = 2C_S\left(1-\alpha_S\right)\frac{1}{H_u}10^6\left(1-\beta\right) \qquad (1.2)$$

where:

- EF_{SO2} - specific emission factor;
- C_S - sulfur content in fuel, %;
- α_S - sulfur content in the ashes;
- H_u - heat capacity of gas;
- A century - the efficiency of secondary reduction in%;
- β - the possibility to provide secondary measures, in%

Calculation methodology of the emission [2], one determined the following values and constrains:

$$C_m = C_v \cdot \frac{22{,}4}{M_{pol}} \cdot \frac{273{,}15+t}{293{,}15} \cdot \frac{1{,}013\cdot 10^5}{p_b} \quad \left[mg/m^3\,N\right] \qquad (1.3)$$

where:

C_m - mass concentration of the pollutant, in ppm,

C_v - volumetric concentration of the pollutant, in mg/m^3N

Mpol - molar mass of the pollutant, in kg/kmol,

22,41 - molar volume under normal conditions, in m3/kmol,

t - temperature, °C

p_b - barometric pressure, in Pa.

Thus the mean value becomes:

$$\left[\left(C_m\right)_{med}\right]_i = \frac{\sum_{i=1}^{n}\left(C_m\right)_i}{n} \qquad \left[mg/m^3N\right] \qquad (1.4)$$

where:

n - is the simultaneous registered traffic values,

i – specie of the pollutant.

Emission factors and emission inventories have long been fundamental tools for air quality management. Emission estimates are important for developing emission control strategies, determining applicability of permitting and control programs, ascertaining the effects of sources and appropriate mitigation strategies, and a number of other related applications by an array of users, including federal, state, and local agencies, consultants, and industry. Data from specific source of emission tests or continuous emission monitors are usually preferred to estimating a source's emissions because those data provide the best representation of the tested source's emissions. However, test data from individual sources are not always available and/or they may not reflect the variability of actual emissions over time. Thus, emission factors are frequently the best or only method available for estimating emissions, in spite of their limitations.

Emission factors may be appropriate to use in a number of situations such as making specific source emission estimates for area wide inventories. These inventories have many purposes including ambient dispersion modeling and analysis, control strategy development, and in screening sources for compliance investigations. Use of emission factor may also be appropriate in some permitting applications, such as in applicability determinations and in establishing operating permit fees.

For the purpose of Electricity production from renewable or for the purchase of green electricity, emission factors given in table 2 can be used.

Table 2. Emission factors for local production of electricity from renewable sources:

Electrical Energy Source	**Standard factor emission (T CO_2/MWhe)**	**LCA emission factors (T CO_2-eq/MWhe)**
Solar	0	0,020 – 0,050
Wind	0	0,007
Hidroenergy	0	0,024

2. GEMIS - GLOBAL EMISSION MODEL FOR INTEGRATED SYSTEMS

Another method for calculating greenhouse gas emissions is GEMIS method [10].

GEMIS (Global Emission Model for Integrated Systems) is a computerized life-cycle analysis model, LCA database, and cost-emission analysis system. GEMIS evaluates environmental impacts of energy, material and transport systems, i. e. air emissions (SO_2, NO_x, particulates, CO, NMVOC etc.), greenhouse gases (CO_2, CH_4, N_2O etc.), solid/liquid wastes, and land use. It can be used to analyze local, regional, national and global energy/material/transport systems, or any scope of sectoral or cross-spectral sub-system (e.g., a plant, facility, or special life-cycle). Furthermore, GEMIS can determine the economic costs of scenario options.

Program GEMIS is linear, it is worth looking quantities x_1 counts type equations

$$x_I = f_k(y_j) = y_{kj} y_j + k_{ko} \qquad (1.5)$$

where: $f_k(y_j)$ is a linear function, and input variables y_j, k_{kj}, k_{ko} constants.

For example the emissions of a substance during combustion of fuel Ej compute GEMIS of relation:

$$E_J = k_j * Q \qquad (1.6)$$

where:

kj so-called emission factor,

Q is the heat in the process of bringing fuel.

The emission factor kj are either stored in a data file or are computed. The size issue can be further adjusted for specific conditions such as the concentration of solid particles in the exhaust gas can be adjusted by the effectiveness of dust separators. The advantage of linear algorithms of the program is to simplify and speed up the computation, as each individual process chain can easily superimpose. This solution represents a certain compromise between calculation accuracy and the benefits to the user.

Program GEMIS defines the products as inputs and outputs of processes. Products contain the necessary information for calculating the energy and environmental characteristics of processes. Standard database GEMIS version 4 includes features over 750 basic types of products.

Types of products are defined as:

- Carriers of Energy - products entering or leaving a process, other than fuel, it can be electricity, steam, hot water,

- Solid and Liquid Fuels (Solid / liquid fuels) - the type of energy carrier

- Materials - products entering or leaving a process than carriers of energy (chemical compounds, building materials, industrial and agricultural products, semi-finished products, food, drinks, etc.)

- Resources - products that can be converted into energy or materials (fuel, water, wind, ore bearing materials), also contain information about the quality of environmental influences,

- Gases - Sub-Categories fuels (natural gas, LNG, LPG),

- Gaseous emissions (Emissions into air) - Theoretical GEMIS calculated pollutant emission from fuel element analysis,

- Waste (Residuals) - solid or liquid waste products of processes, data on the major waste are listed in the database, the user can also freely enter your own data on five types of waste.

GEMIS defines a process as a specific activity, which aims to transform the input product for the product output. However, it may be used other auxiliary input products (such as auxiliary power), and may occur in the secondary outputs (eg emissions of harmful substances). Like processes, products can be detected by filters, which greatly facilitates the work as the standard version 4.3 includes over 9500 processes.

GEMIS includes the following basic types of processes:

• transformation of energy (Energy conversion), combustion, heat exchangers, turbines, etc.

• conversion of material (conversion), production of steel, chemical products, etc.,

• incineration (Combustion)

• mining and acquisition of materials (Extraction), such as oil, ores, fuels,

• transport of goods, persons (Freight transport service, transport Person)

• handling of waste (Waste treatment facility

• cash (Monetary services)

• dispatcher (Mixer) - not a real process, but the sum of several processes, the contribution of the main process is quantified (in%), such mix of electricity produced in power plants of various types and used as the entry product in the primary process.

GEMIS analyze the above processes all sub-processes that chain, auxiliary energy consumption and consumption of materials. For these processes are in the data base characteristics and constants, like the products:

Each process has its own code name, which must briefly comment on the nature and process by which the compiled script. Two different processes may not have the same name. Process list contains the names of processes in different colors to distinguish the data source.

CONCLUSION

The proposed calculation method is good because it introduces a new approach, namely: it calculates not only emissions but also take into account efficiency of equipment for the reduction of the effects of emission, and the second factor is that one can evaluate the effects of emission not only during production but also through the entire period of development of the source. For example, if we have a bio-fuel plant - the emissions occur, but it takes into consideration the emissions from industrial production equipment (LCA-Life Assessment cycle). The actual emission = emission due to material + production process emission - emission captured.

Equations used in GEMIS and that of the proposed method had been discussed in this paper. Comparison of results from the proposed method and GEMIS will be carried out in the next paper to show its effectiveness.

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