SOME ASPECTS OF THE ANALYSIS OF ECOLOGICAL SAFETY OF THE INDUSTIRAL TECHNOLOGIES IN THE UKRAINE

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ABSTRACT

Some aspects of financial tools for countering climate change under flexible Kyoto mechanisms are studied. Within industry sectors and production processes, data of National GG Cadastre (period 1998 – 2005) on energy consumption and GG emissions are processed by means of an information-analytical system constructed on the Microstrategy platform. Analysis of the rating of the industrial sectors relative to saved emission allowances enables distributing investment financial flows toward development of innovative technologies with respect to the estimated contribution of each industrial sector to the emission allowances total for the country.

Keywords: Clean development, Energy efficiency, GG emission allowance units, Emission quota, Carbon market, Investment flows

1 INTRODUCTION

The current ecological situation requires efficient measures of environment protection, in particular, the implementation of environmental-friendly industrial technologies. The central idea is a sustainable development, which is to be realised, in particular, by means of Kyoto flexible mechanisms (United Nations, 1998). The mechanisms represent a financially reasonable approach to make the industrial processes' environment safe. Air pollution abatement can be achieved through improvement of industry's energy efficiency, as energy consumption is accompanied by greenhouse gas (GG) emissions. To make energy consumption more efficient, restructuring of industrial sectors is required. Such technological changes in production, processing, transportation, and consumption of energy resources are based on implementation of the Low Carbon Technologies (LCT), Environmental Friendly Technologies (EFT), and Energy Efficient Technologies (EET) being transferred within the Projects of Joint Implementation (JIP) covered by the Kyoto Protocol (United Nations, 1998). The flexible Kyoto mechanisms include GG emission permits trading, whereby quotas on emissions of basic GG are set for the countries party to the Protocol. With respect to the Kyoto Protocol, within the years 2008 – 2012, countries whose emissions are less than their permitted limits can trade saved emission units with countries that exceed their quotas. Because industrial countries can invest in projects that transfer low carbon technologies to developing and transition countries in order to create emission units for sale, it is becoming possible to join the efforts of potential investors with the aim of developing tools to realise the Kyoto Agreement mechanisms directed toward global sustainable development.

2 INFORMATION-ANALYTICAL SYSTEM ON ESTIMATION OF GG EMISSION ALLOWANCE UNITS' SAVING

2.1 Some special features of Ukrainian industrial technologies

From the point of view of energy consumption, the economics of the Ukraine is far from efficient (Kolesnichenko & Tsarenko, 2007), and so it is beneficial for the companies of other countries party to Annex I of the Kyoto Protocol to invest in the development of an energy efficient Ukrainian industry. These investments will reduce the level of the GG emissions and will allow saved emission units to count as a contribution toward global GG emission reduction. With respect to the Protocol classification, Ukraine belongs to the parties of the Protocol that are able to participate in the flexible Kyoto mechanisms (United Nations, 1998) on GG emission permits trading under clean development. Energy efficient technologies are also of great importance because of to rising prices of energy resources (Kolesnichenko & Tsarenko, 2007). With respect to the Kyoto Protocol, the overall emissions level in the Ukraine within the second phase of the Protocol realisation (years 2008 – 2012) has not to exceed the norm defined as a quintuple amount of the emissions of the basic year 1990. It is profitable for the Ukraine to have the year 1990 as a basic one, as at that time, Ukrainian industry was functioning at full capacity with a large amount of emissions. As a result of the economic downturn after 1990, GG emissions were reduced from 926, 2 millions t CO_2 eq. in 1990 to 413, 7 millions t CO_2 eq. in 2004. In case the Ukraine in the year 2008 does not reach the emissions' level of the year 1990, it will be able to sell saved emission units to other parties to the protocol as defined in Annex 1, under the mechanism of trading of permitted emission units. Also, it will be possible to benefit from participation in joint implementation projects.

2.2 Problem posting

Ecological efficiency of innovative industrial technologies is of great importance. This efficiency, the macroeconomic situation of the country as well as solving global warming problems are substantially characterised by GG emission level dynamics. We are interested in the analysis of some aspects of sustainable development tools: improvement of financial mechanisms of countering climate change, planning of the global financial flows as a measure of GG emission abatement, development of efficient and adequate international measures to prevent climate change, as well as adaptation of the industrial sectors to the new ecological conditions and requirements.

Ecological efficiency of the industrial technologies implemented is to be estimated based on certain indicators from ISO 14031 standards, which regulate the form of information representation concerning results of the control of the ecological aspects of innovative technology. These indicators include: overall energy consumption, GG emissions, material resources consumption costs, water resources consumption, etc. The rate of innovation activity of the industrial sectors is defined by the ecological efficiency of the technologies of these industries, and an approach to distribute corresponding financial flows initiated by saved emission units is introduced.

2.3 Basics of the approach

Indicators of ecological efficiency of the industrial technologies are constructed based on the data on energy consumption levels of industry sectors within the reporting period, by fuel types, and by GG emission levels, which in turn characterize the energy consumption level. By means of graphical representation of the data, and further tools, the dynamic of energy efficiency is analyzed annually (how emission levels and energy consumption levels correlate, what expenses enterprises and industry sectors have, etc.), and the corresponding distribution of financial flows is constructed.

Emission limits by industry sectors (enterprises, regions) are defined on the basis of the emission norms introduced. Quantitative estimates of industry sectors' participation in emission units saving are converted into monetary equivalents based on CO_2 market prices. Specific rates of ecological efficiency of innovative industrial technologies within industrial sectors are defined as the ratio of saved emission units to quotas (various GG) for the industry sector, and analogously, for the enterprise, as the ratio of GG emission units saved at the enterprise to limits on emissions (various GG).

2.4 Mathematical modelling

The averaged norm of GG emission on each fuel type is defined as

$$V_i^{norm} = \frac{1}{J}\sum_{j=1}^{J}\frac{V_{ij}}{E_{ij}k_i}, \tag{1}$$

where i = 1,2,K fuel types, j = 1,2,K industry sectors, V_{ij} is the GG emissions (CO_2 eq) at industry j while i-th is the fuel type burned, E_{ij} is the energy amount obtained while the i-th fuel type is burned, consumed by industry sector j, and k_i are the measure units matching the coefficient.

Emissions by industry sectors are:

$$V_j = \sum_{i=1}^{I} V_{ij} \ . \tag{2}$$

GG emission quotas in the country are:

$$V = V^{Kyoto} - \sum_{j=1}^{J} V_j \ , \tag{3}$$

where V_j is the amount of emissions (CO_2 eq) within the sector *j,* and
V^{Kyoto} is the norm defined by the Kyoto Protocol (constitutes 4,604,184,663 tonnes CO_2 eq).

The emission norm of an industry sector *j* is defined as:

$$V_j^{norm} = \sum_{i=1}^{I} V_i^{norm} \cdot E_{ij} \ . \tag{4}$$

The GG emission quota consumption rate by an industrial sector *j* is:

$$V_j - V_j^{norm} \begin{cases} > 0, & overconsumption \\ = 0, & norm \\ < 0, & \epsilon \quad free \quad quotas \end{cases} \ . \tag{5}$$

The share of an individual industry *j* in saving of emission units within the whole amount of free quotas in the country (for $j = j \cdot \max\{0, -sign(V_j - V_j^{norm})\}$) is:

$$P_j^{direct} = \frac{\left|V_j - V_j^{norm}\right|}{V} \ . \tag{6}$$

The pay off for an industry *j* that has exceeded its emission allowances level is:

$$P_j^{indirect} = P_j^{direct} \cdot \sum_{j=1}^{J} \max\{0, sign(V_j - V_j^{norm})\}(V_j - V_j^{norm}). \tag{7}$$

Financial flows initiated because of saving of emission allowance units are distributed with respect to the contribution of the industry sector to emission units saved.

2.5 Software realization

2.5.1 Prerequisites

The ecological safety of an industrial technology is analyzed with the help of information-analytical systems (IAS) allowing estimation of aspects of both the innovation effect of the industrial technologies and the corresponding financial flows intended for substantial development. We have used the software tool Microstrategy (Microstrategy, version 8.1.1, 2007) to realise the information-analytical system. Microstrategy is a powerful tool for intellectual visual analysis of data. By means of flexible statistical capability and strong visualisation tools, the possibility of understanding the sense of the information contained in large volumes of data is provided. Microstrategy allows studying the dynamics of the processes described by given statistical data.

The IAS realizes the monetarisation methodology of the effect of implementation of innovative industrial technologies of clean development and energy efficiency, which correspond to the Kyoto flexible mechanisms on GG emission units trading. Within industry sectors and production processes, statistical data on energy consumption and GG emissions are processed. The efficiency of the implementation of innovative technologies is estimated on the basis of the analysis of GG emissions' level dynamics per unit of energy consumed. Further, analysis of the dynamics of consumption of various fuel types allows the study of how innovations in industrial technologies help to optimize diversification of various fuel types consumed, which is of great interest, in particular, under the current energy conditions.

Innovation activities of the industrial sectors in sustainable development are considered under the economic development of the country in a whole. On the basis of data on saving from emission units saving because of innovation implementation, the contribution of each industrial sector to the emission units' total for the country is estimated. Analysis of the industry sectors' rating by saved emission units allows distribution of financial flows with respect to the contribution of innovations in the sectors' saving of emission units.

2.5.2 Input data

Below are input data taken by the National Cadastre of GG emissions of industrial sectors, production processes, by various fuel types consumption, from a database on emission of basic GG, data warehouse on energy consumption by industry sectors and production processes, and GG emission by enterprises, sectors, regions.

Table 1. Fragment of data on energy consumption level (TJ) and GG emission (Gg CO_2 eq.) by industry sectors within the period 1998 – 2005

		Period							
Ind. sector	**Indicator**	**1998 year**	**1999 year**	**2000 year**	**2001 year**	**2002 year**	**2003 year**	**2004 year**	**2005 year**
Energetic	Energy consumed (TJ)	1 893 260,629	1 982 204,028	1 842 816,766	1 866 693,740	1 866 666,731	1 985 536,235	1 859 200,834	1 871 617,344
	Emissions (Gg CO_2 eq.)	138 247,903	142 556,928	131 779,062	137 836,645	139 947,244	147 660,208	136 354,596	140 161,234
Food industry	Energy consumed (TJ)	156 973,664	138 679,322	132 266,088	137 218,871	130 299,153	144 858,345	140 700,687	140 710,699
	Emissions (Gg CO_2 eq.)	10 292,644	8 916,994	8 219,264	8 437,274	8 002,905	8 830,282	8 552,982	8 474,661
Pipelines	Energy consumed (TJ)	262 275,529	272 560,836	257 356,847	231 621,171	247 492,626	262 732,443	273 985,367	267 418,183
	Emissions (Gg CO_2 eq.)	14 766,502	15 348,555	14 490,562	13 041,407	13 936,863	14 792,135	15 428,480	15 055,007

Data on GG inventions characterizes emissions of four GG types of direct impact, specified in the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitric oxide (N_2O), and perfluorcarbons. Data on hydrofluorcarbons and sulphur hexafluoride (SF_6) do not exist, as these gases are not produced in the Ukraine, and there is no information in the national statistics on their application. The GG cadastre that served as a data source for the current research contains also data on GG of indirect impact, such as carbon oxide (CO), nitric protoxide (NO_x), non-methane volatile compounds, and sulphur dioxide (SO_2).

Table 2. Fragment of the data on consumption of various fuel types by industrial sectors of the Ukraine

Ind. sect.	Indicator	1998 year	1999 year	2000 year	2001 year	2002 year	2003 year	2004 year	2005 year
Energetic	Energy consumed from biomass (TJ)	90,029	124,053	182,121	172,140	41,590	64,442	82,249	72,665
	Energy consumed from gaseous fuel (TJ)	1 026 069,425	1 171 830,333	1 111 169,075	1 012 657,647	955 732,486	1 087 343,000	1 045 201,950	983 650,034
	Energy consumed from other fuel (TJ)	18 203,533	16 400,515	14 332,301	12 240,641	7 607,375	5 818,663	2 458,195	3 453,264
	Energy consumed from liquid fuel (TJ)	100 534,886	52 854,812	20 214,779	21 368,185	22 732,051	10 972,429	6 952,688	6 132,434
	Energy consumed from solid fuel (TJ)	748 362,756	740 994,316	696 918,490	820 255,127	880 553,229	881 337,701	804 505,753	878 308,947
Ferrous metallurgy	Energy consumed from biomass (TJ)	3,852	6,313	5,289	4,861	64,732	1,483	2,598	0,000
	Energy consumed from gaseous fuel (TJ)	417 589,991	409 336,595	444 206,816	426 065,859	378 624,445	417 818,960	428 078,986	407 610,659
	Energy consumed from other fuel (TJ)	117,496	253,548	669,177	311,783	186,936	289,116	264,033	1 166,780
	Energy consumed from liquid fuel (TJ)	18 338,912	14 569,448	13 040,749	13 006,740	10 444,852	10 541,682	9 311,698	16 397,381
	Energy consumed from solid fuel (TJ)	73 548,225	92 296,730	98 648,106	105 481,709	101 422,456	116 810,461	118 060,346	130 666,283

2.5.3 Calculations and visual intellectual analysis

Calculations are done by means of Metrics, constructed in the Microstrategy environment. The averaged norm of GG emissions is defined for every fuel type: solid, liquid, gaseous, biomass, etc. A typical screen is shown in Figure 1.

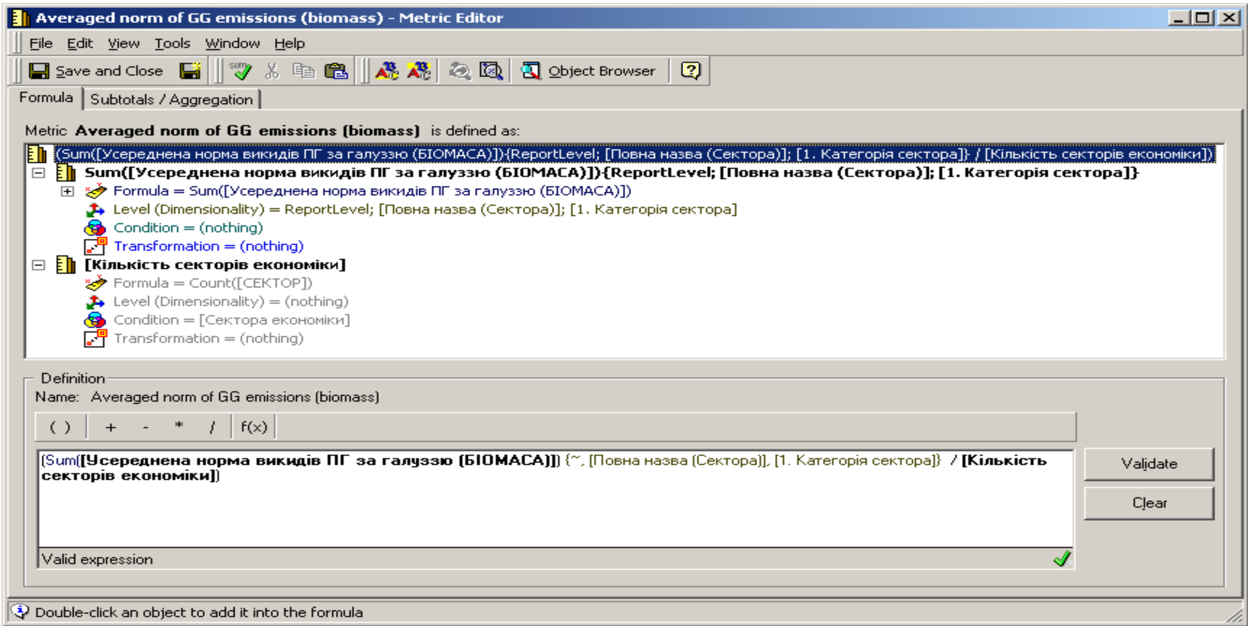

Figure 1. Averaged norm of GG emissions (biomass)

GG emissions per unit of the energy consumed for every fuel type are calculated as shown in Figure 2.

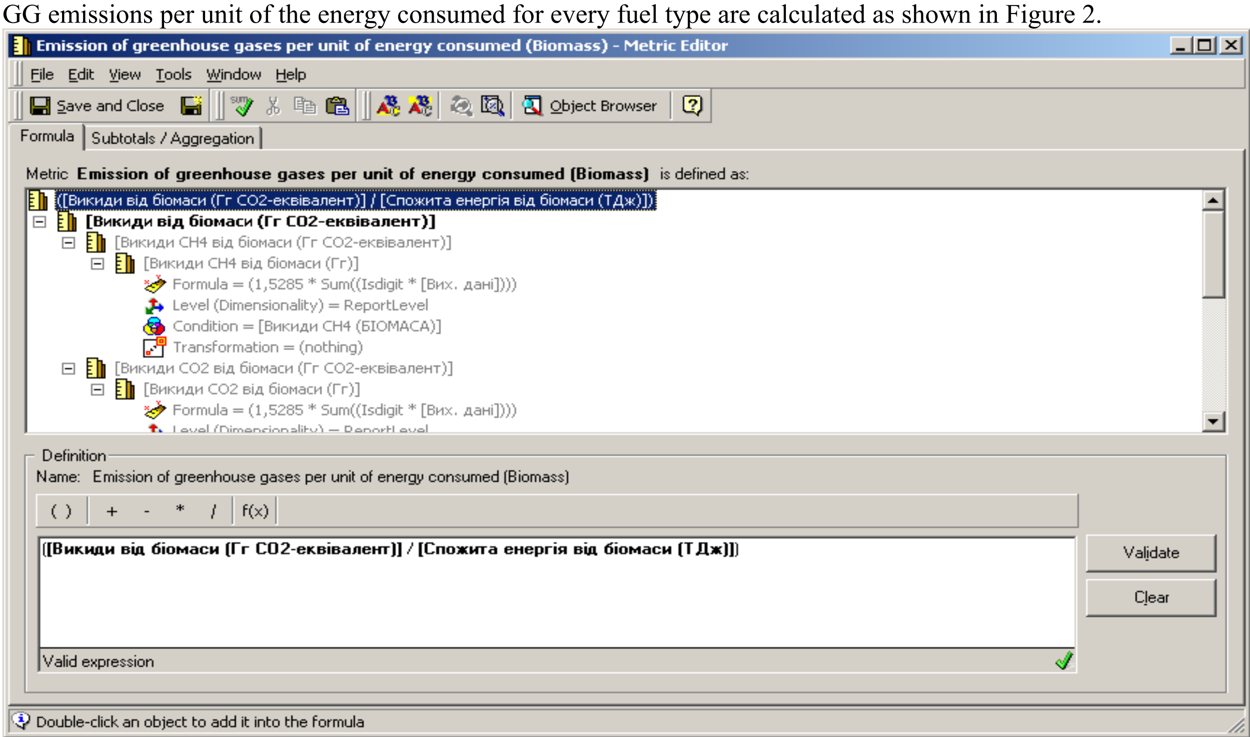

Figure 2. Emission of greenhouse gases per unit of energy consumed (Biomass, similarly for other fuel types)

Calculation of the norm of GG emissions for every industry sector is done as shown in Figure 3.

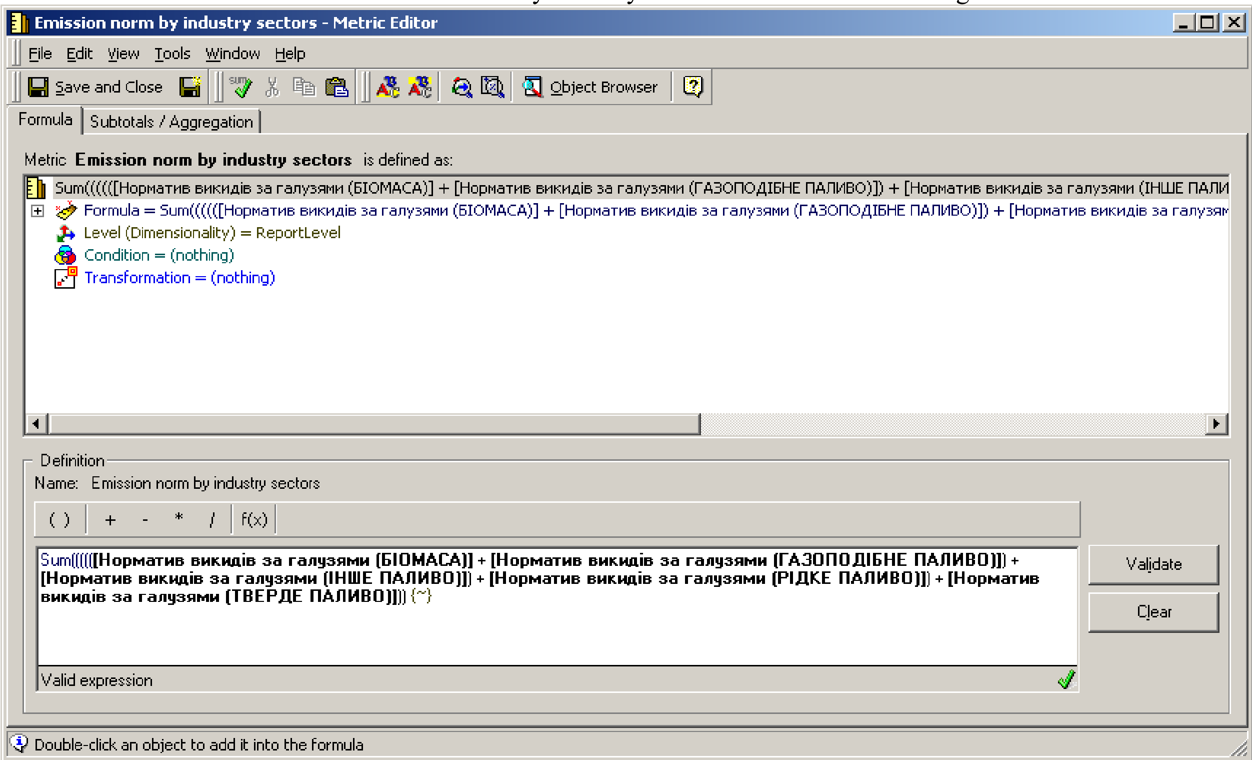

Figure 3. Emission norm is defined for every industry sector.

The norm of GG emissions by industry sectors for every fuel type is calculated as shown in Figure 4.

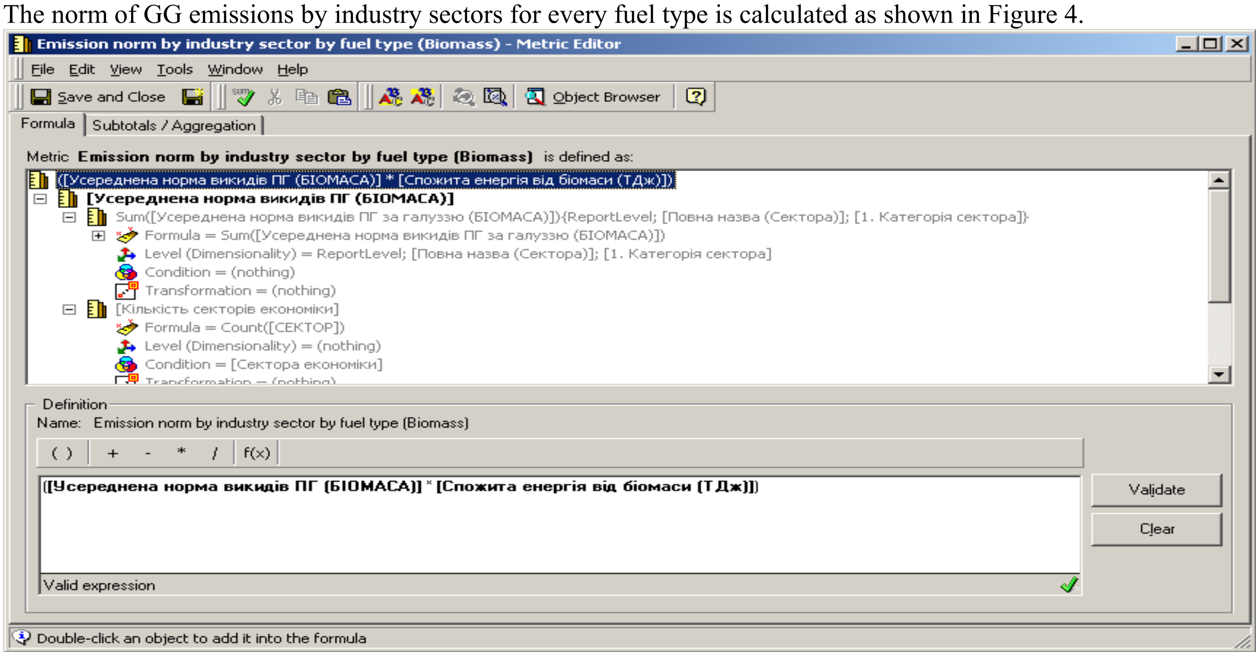

Figure 4. Emission norm by industry sector and fuel type (as example, Biomass)

2.6 System functionality

Application of data mining and visualization techniques regarding energy consumption rate and GG emission level (within the period 1998 – 2005) enables the study of the innovative activity in development of energy efficient technologies as well as technologies of clean development. By means of the information-analytical system, the dynamics of both the improvement of energy efficiency and GG emission rate are analyzed in comparison with energy consumption level by industry sectors. Typical results are shown in Figure 5.

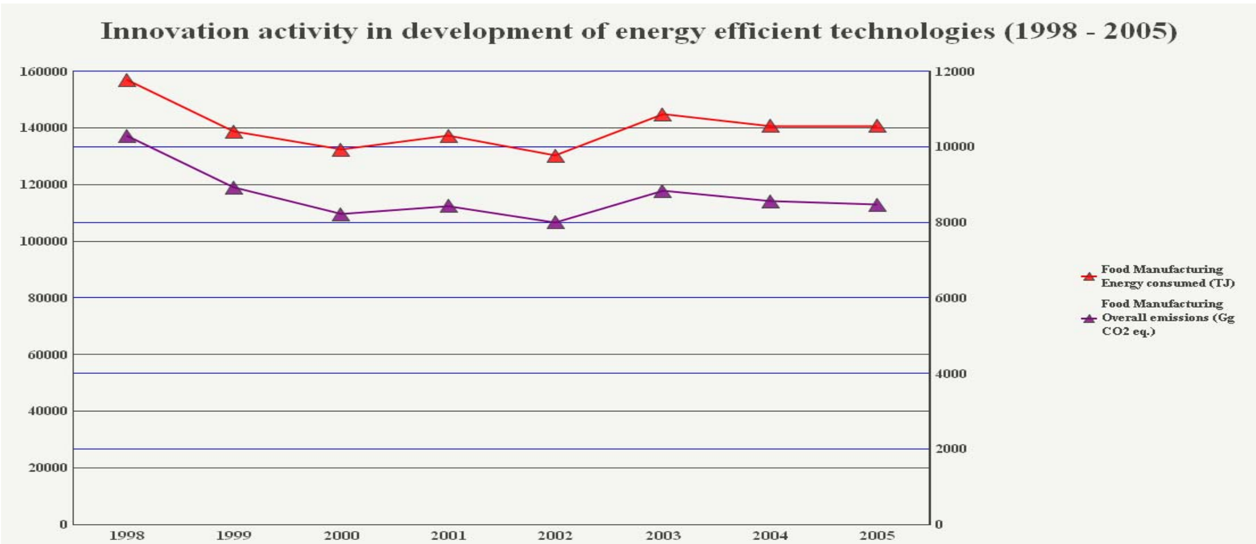

Figure 5. Innovation activity of industry sectors (for instance, the food industry) in improvement of energy efficiency

Further, on the basis of data mining concerning consumption of various fuel types by industry sectors of the Ukraine, the process of diversification of the fuel consumption is investigated. Visualisation tools of the system help to estimate the deviation of the actual diversified fuel consumption from the optimal one, as shown in Figure 6.

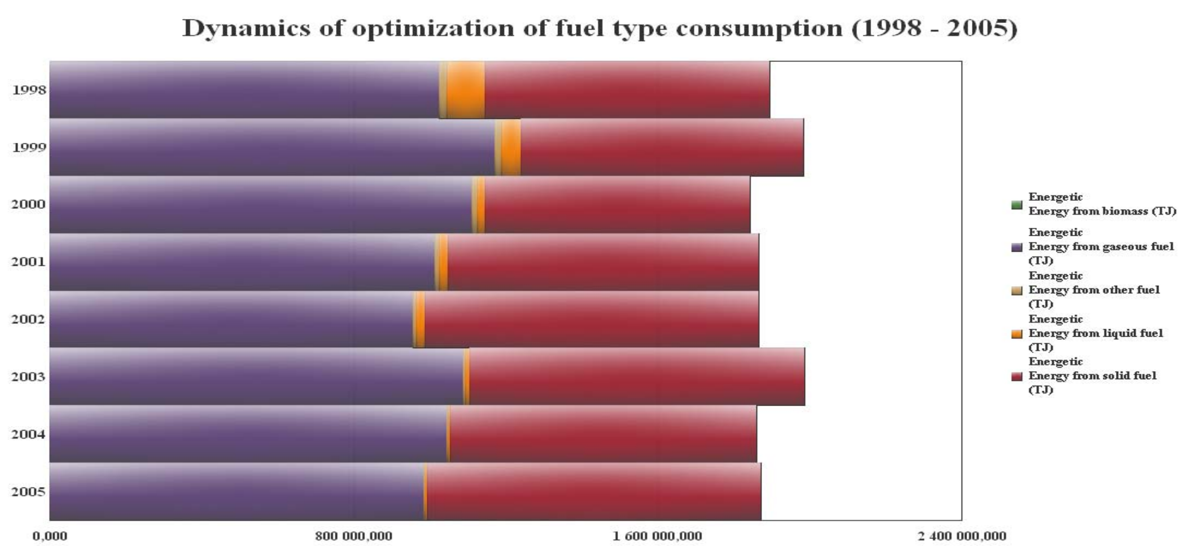

Figure 6. Dynamics of optimization of fuel type consumption

Mining of the data on GG emission by industry sectors within the period 1998 – 2005 gives estimates of the share of industry sectors of the Ukraine in national air pollution, as given in Figure 7.

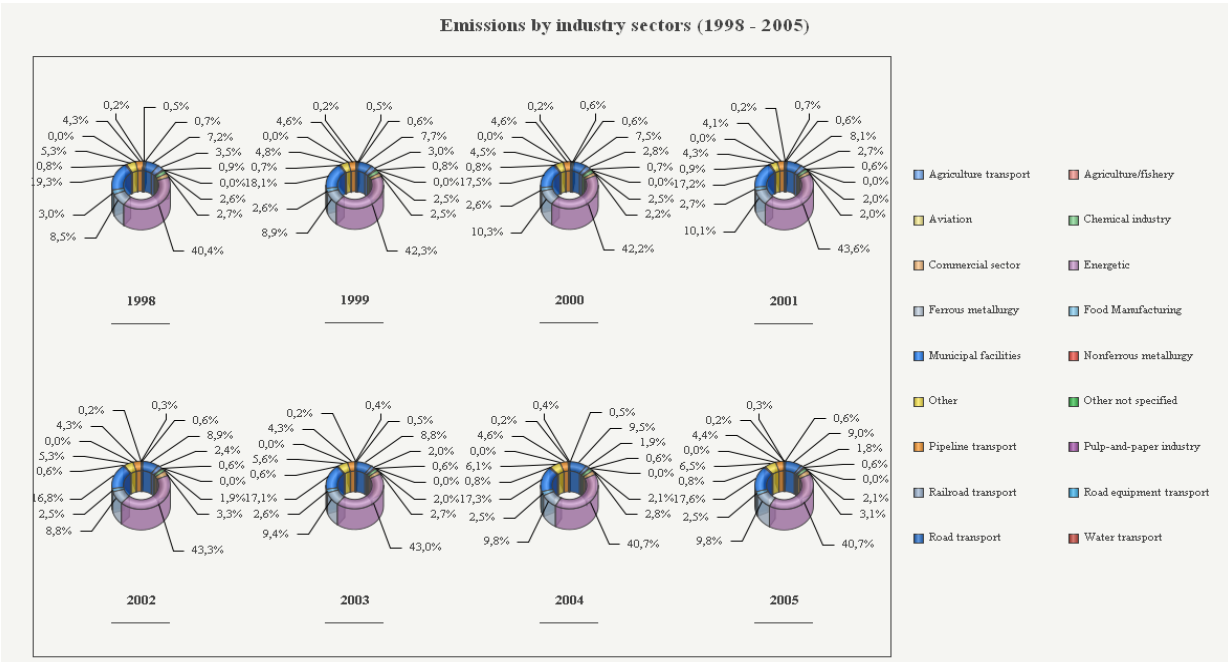

Figure 7. Distribution of GG emissions by industry sectors

Applying an analytical approach in data mining on GG emissions together with visual representation of data, we get the idea of the dynamics on emission allowance units' saving by each industry sector, as displayed in Figure 8.

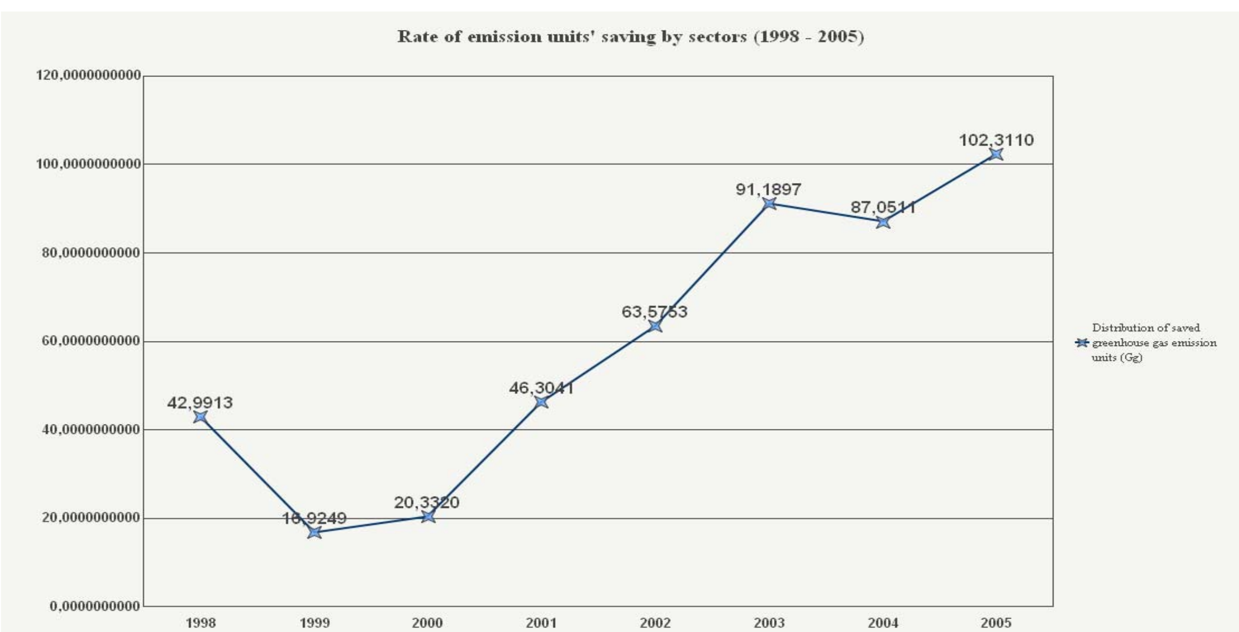

Figure 8. Microstrategy Report representing the dynamics on emission allowance units' saving for every industry sector (for example, the chemical industry), in Gg of CO_2 eq within the period 1998 - 2005

Figure 9, which illustrates the rate of emission allowance units accumulated within the period 1998 – 2005, describes the progress in contribution of industry sectors in the national emission allowance basket.

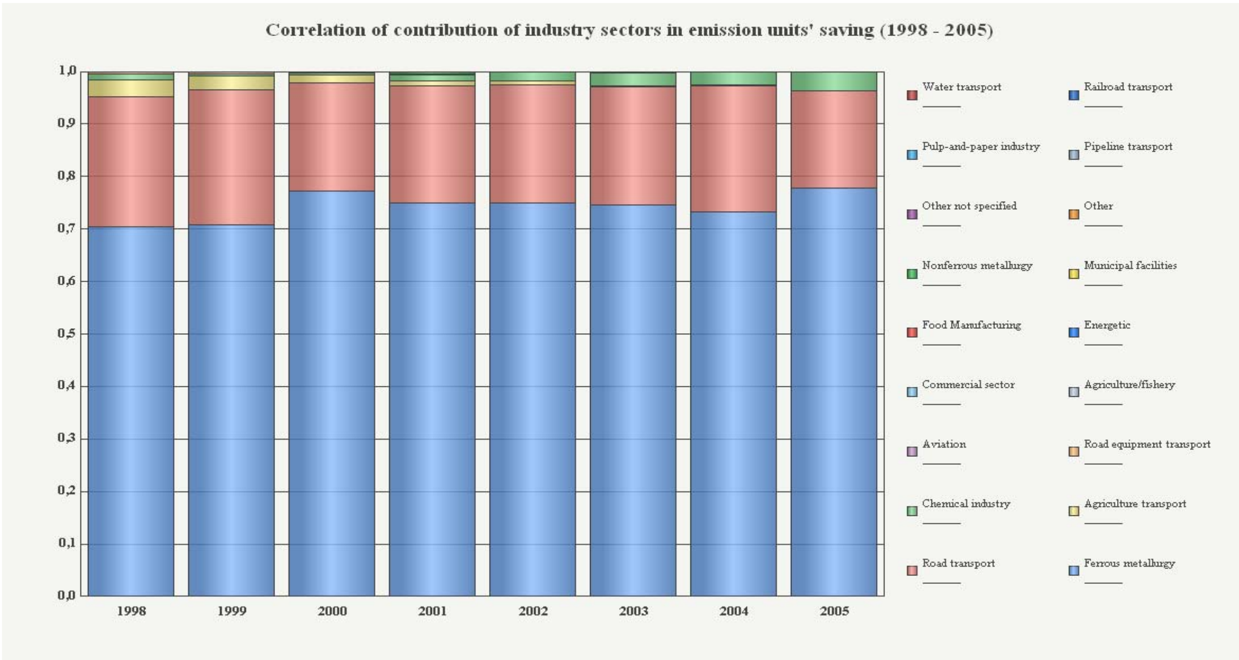

Figure 9. Share of industry sectors in national emission allowance units' basket

By means of visual analysis (Figure 10), the norms of emissions of industry sectors can be defined, and the dynamics of innovations' implementation are studied in every sector within the period 1998 – 2005 in comparison with the base year (GG emission rate per unit of energy consumed, Gg/TJ).

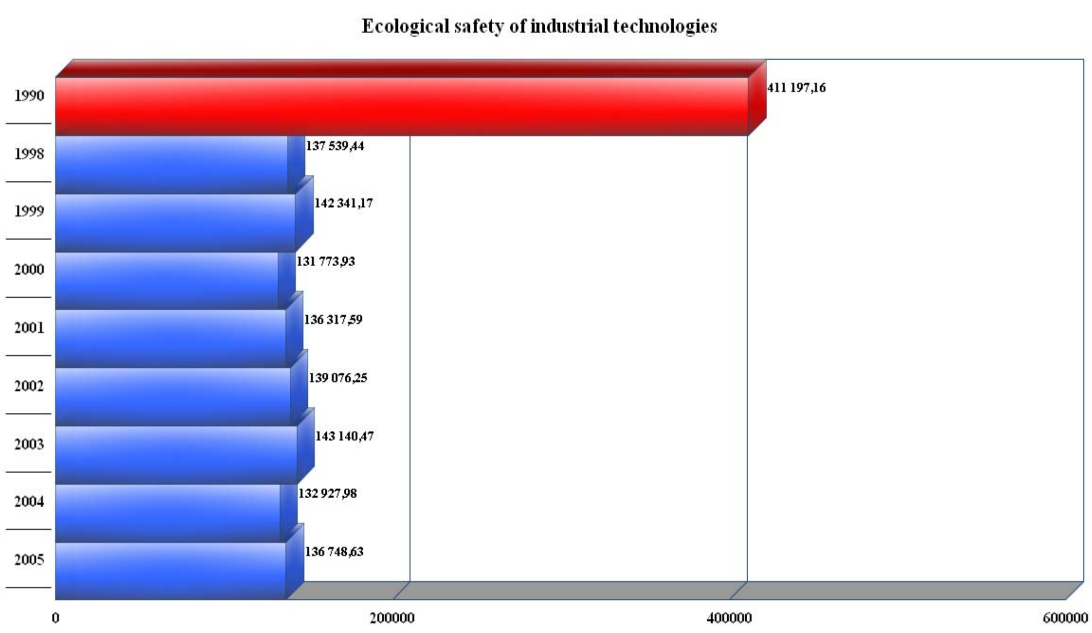

Figure 10. Development of ecologically safe industrial technologies (example, energy) annually (1998 – 2005, blue lines) in comparison with the base year (1990, red line)

The range of savings of emission allowances by industrial sectors is studied with respect to the Kyoto emission quota and the data on emissions in the first (2005) year of realization of the flexible Kyoto mechanisms, which, in particular, determine emission units' trade on the base of national emission allowance basket. (Figure 11)

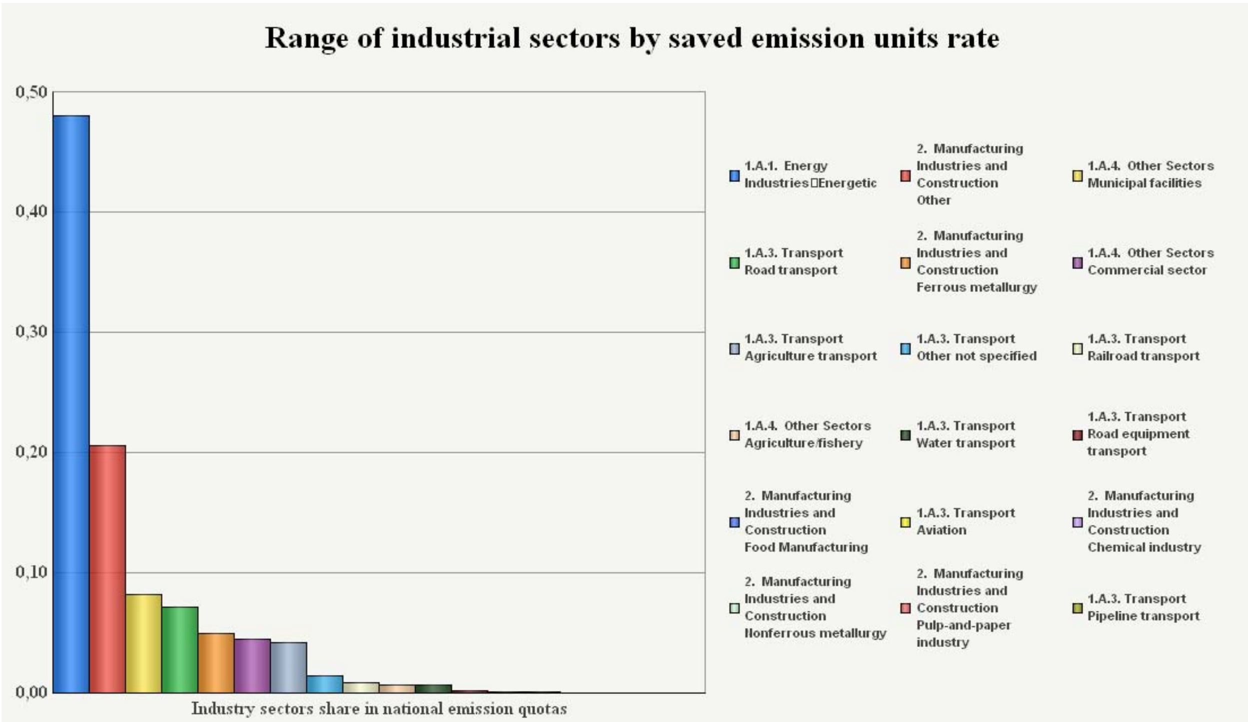

Figure 11. Range of industrials sectors with respect to their share in GG emission allowance units' saving

Visualization of investments' distribution represents the estimation of financial flows initiated by carbon trade by the current (15.03.2008) market price for Features as of December, 2008. (Figure 12)

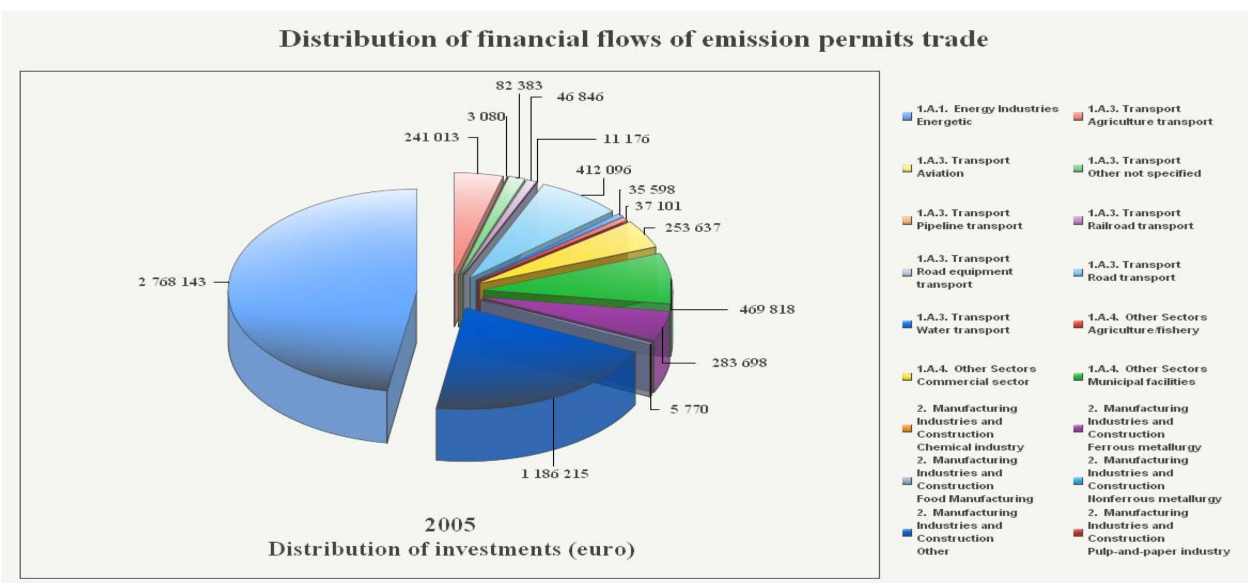

Figure 12. Estimation of the investment flows' distribution under emission allowance units' trade

2.7 Further fields of application

The information-analytical system enables the calculation of GG emission quotas by regions, sectors, enterprises as well as monitoring and controlling plans on emission abatement, determination of investment financial flows, analysis of the influence of innovation technological processes on energy efficiency improvement, estimation of the results of implementation of innovative technologies based on the dynamics of statistical parameters of emission rate change (greenhouse gases, other pollutants), estimation of the progress of the process of investment mobilization due to emission allowance trade, and estimation of the dynamics of financial parameters' change that characterizes the process of economic capitalization.

3 CONCLUSION

Discussion of the problems of ecological safety of the industrial technologies and study of the experience of the developed central and Western Europe countries allows us to investigate the most efficient approach in abating GG emissions based on implementation of sustainable development mechanisms. In the Ukraine, legislation and programs on clean development and energy saving are rather ambiguous and uncoordinated, and their realization is very passive. Well-worked out and organized measures need to be well financed, and the State is not ready to provide such measures. The main sources of financing of energy saving and emission reduction are self-investments by the enterprises. Also, international organizations deliver the large part of the financing by means of projects for energy efficiency improvement and greenhouse gas emissions' abatement.

One more potentially essential source for financing the development of ecologically safe industry is represented by the Kyoto mechanisms. First, because of a favorable scheme of setting emission quotas, the Ukraine has remaining emission allowance units, which can be traded. Second, the very low energy efficiency of the Ukrainian economy makes it easier for developed countries to purchase emission allowance units saved due to the realization of joint innovative projects of clean development in the Ukraine, which means additional financing for the Ukrainian enterprises, industrial sectors, and economy in a whole.

In general, there is a great potential for sustainable development in the Ukraine. Inefficient energy consumption means that even slight innovative improvements would guarantee essential benefits. The corresponding financial flows can be estimated with the help of the information-analytical system described in this paper. The effect of implementation of innovative ecology safety technologies is studied not only at the level of industry sectors, but also at the enterprise level. The IAS does not have any limitations with respect to its application to the international carbon market, as those for a country and its trading partners. Moreover, the system is applicable for innovation technologies intended to mitigate and to abate complex air, water, and land pollution. Based on the IAS, the distribution of financial flows, both from abroad and at home, initiated by the trade of emission allowance units saved due to implementation of innovative industrial technologies is estimated.

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