The enhancement of economic compensation mechanisms for environmental costs

A. Boyarinov
Department of Environmental Economics,
Ural Federal University, Russia

Abstract

In the countries with a transitional economy, environmental problems stand very sharply. Power engineering is the branch which makes a great contribution to environmental pollution. CHP plants pollute the atmosphere; greenhouse gases emissions; nuclear power plants produce nuclear fuel wastes; hydropower plants flood huge territories. The polluter-pays principle is active in Russia as well as in other countries. But emission charges take less than 0.1% in product value. It is not enough to repair environmental damage and to stimulate the enterprises to invest in environmental projects. The reasons for low payments are put into a theory of value. A process cost forming mechanism is caused in that the producer compensates consumption of all factors (means of labor, objects of labor and work) at the expense of the price. The environment is involved in the process of production and is used very intensively due to the fact that it loses natural and consumer properties. The environment has all the signs of manufacture factors that allow us to consider it as a parity manufacture factor.

The purpose of the paper is to develop a methodology to justify enterprises' emission charges. The approach considering the enterprises' abatement costs as the basis for calculating the emission charges is herein suggested. In the paper, the principles of an assessment and compensation the "amortization" of the active part of a manufacture factor – "environment" are formulated. The need for calculating environment "amortization" based on costs to prevent negative consequences of production activity is proved. The order of formation and use the "amortization" of the active part of a manufacture factor – "environment" is developed. As a result of application of the author's approach, the motivation from the enterprises to reduce negative impact on the environment increases.
Keywords: "environment" production factor, emission charges, production expenses, labor theory of value.

WIT Transactions on Ecology and The Environment, Vol 190, © 2014 WIT Press
www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/EQ141042

1 Introduction

By the 80s of XX century, the USSR significantly lagged behind the developed countries in terms of power effectiveness and efficiency of nature use. As the main reasons the following factors can be mentioned: the prevailing ideology of "inexhaustible natural reserves" and branch structure of the economy management where ministries and departments were analog to natural monopolies. In the industrial regions (and so-called "monocities") the critical problem was not only low effectiveness of resources use but also protection of environment. During the Soviet period environmental and ecological problems remained inside ministries and departments. The power industry multiply accumulated all negative aspects of the plan-oriented Soviet economy. Improvement of ecological situation demanded tremendous expenses and reforms in power industry, economy, and nature use. Soviet leadership could not dare to launch any radical reforms [1].

After the disintegration of the USSR and with the appearance of business structures the environmental situation became even more aggravated. In the effort to maximize income in the shortest possible time enterprises pay insufficient attention to protection of environment. A technocratic approach to the human being – nature interaction problem is predominant in public mind. At present the critical ecological situation has not yet reached the level of irreversible changes. However, the lack of funding for environment protection and depreciation of basic production assets can cause disastrous environmental consequences. Currently existing administrative and economic instruments of environment protection regulation do not produce the desired output. The environment quality deteriorates. And this is typical not only for this country but for the whole global commonwealth. It is necessary to alter the economic foundation of the environmental protection management in order to prevent really an ecological disaster. All this stipulates for the relevance of development of economic mechanism for production environmental costs recovery.

2 Methodological principles of accounting of deterioration of an active part of the "environment" production factor in calculating production cost

The foundations of the mechanism currently in force for formation and recovery of production expenses were laid about two hundred years ago. Destination of the mechanism is an exact determination of the expenses structure and full recovery of the resources consumed in the process of the resources production by their owner. The action of the expenses formation mechanism is determined by the fact that the producer recovers all costs (means of labor, subjects of labor, and labor itself) at the expense of selling price. However, the mechanism currently in force for expenses formation does not take into account that at the present stage of the economy development environment is engaged in the production process, and it is used very intensively. Due to this fact environment is losing its natural and consumer properties while these properties are not fully taken into account in formation of the price of a commodity. A number of scholars [2] have already considered environment a parity factor of production. It comprises renewable resources (forest, land resources, fauna and flora), relatively renewable resources (atmospheric air and water resources), and nonrenewable resources (mineral resources). The use of environment as a parity factor is only partially recovered in the process of production. Nonrenewable and renewable natural resources are taken into account in the expenses structure according to the price of their acquisition which comprises so-called "ecological" taxes (mining tax, excises, water and land taxes, forest charges, cost of quotas for the right to use fauna and flora objects, etc.). Relatively renewable resources and individual elements of renewable resources (soils) are taken into account within expenses structure not completely. Nowadays in the production expenses structure accounting of this environment part consumption is represented by the pollution charges; their share in the product's cost is less than 0.1%, and this does not enable to recover this production factor consumption [3]. Figure 1 shows current directions of expenses recovery in terms of environment individual elements during (dark hatching (left): consumption, light hatching (right): accounting and recovery) [4].

Thus, to obtain complete accounting and recovery of environment factor expenses during the production process the current mechanism of the expenses formation should be supplemented with the cost estimation of this production factor's elements (insufficiently taken into account now). The "environment" factor deterioration the author interprets as a loss by environment of its initial and consumer properties, such as ability to self-restoration; sustainability of ecosystems; ability to serve a habitat, to satisfy aesthetic, recreational, and other human demands. As a result, human living conditions and production process conditions deteriorate.

The environment is losing its natural properties as a result of its pollution in the course of anthropogenic activities. Within the framework of this work an attempt has been made to assess, in terms of money, the cost of consumption of relatively renewable resources and individual elements of renewable resources (soils) that can be conditionally determined as an active part of the "environment" production factor. Nonrenewable resources and the remaining elements can be related to the passive part of the "environment" production factor.

Conceptual frameworks of improvement of the economic mechanism of environmental costs of production recovery are the following:

- production process occurs inside environment and is not possible without environment's direct involvement;
- actual damage caused by environmental pollution considerably exceeds the expenses that are taken into account during the production process and recovered to the society by a producer;
- rights of property for environmental benefits are not determined;
- the environment possesses all the principal characteristics of production factors.

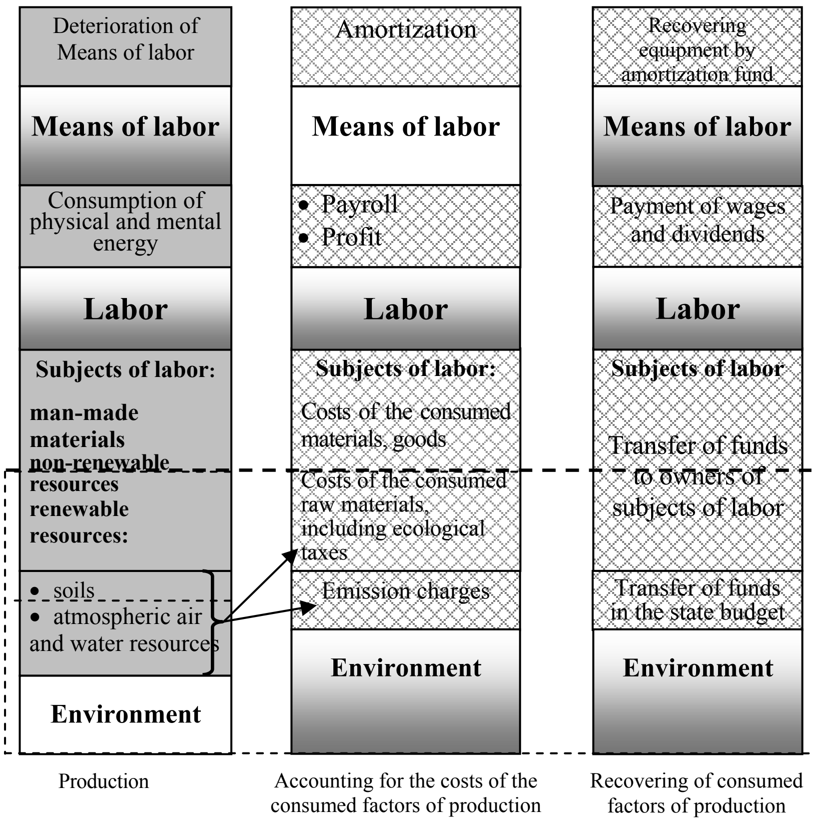

Figure 1: Mechanism of the production expenses formation and recovery.

The main objective of development of the mechanism of production expenses formation through accounting and recovery of deterioration of the active part of the “environment” production factor is decreasing the negative load upon environment due to enhancement of management bodies’ economic motivation. The main principles of accounting of the active part of the “environment” production factor are the following:

1. Principle of pre(liminary)-expenses use. Cost estimation of deterioration of the “environment” production factor active part is to be based on preliminary expenses; that is, the expenses associated with prevention (averting) of environmental damage. This is much cheaper for a producer, state, and society in comparison with the expenses for the environment post-damage restoration.

2. Principle of stimulation. Amount of charges to be paid by a producer in order to recover the “environment” production factor active part deterioration should stimulate a producer to invest into adoption of environmentally-friendly techniques.

3. Principle of impossibility of full cost estimation of environmental damage. Cost of the environment restoration, as a rule, is difficult to forecast; besides, not all of them can be estimated in terms of their cost.

4. Principle of fairness. At the present stage of economic development the mankind has not yet produced non-waste technologies therefore a producer is not liable to be responsible for negative impact upon environment. A share of this load is to be taken by society through buying goods. However, any damage due to the use of "dirty" techniques in case of availability of "clean" techniques should be paid for by the producer. When estimating negative consequences of economic activities it is necessary to take into account an ecological situation and ecological significance of the territory where an enterprise is located.

5. Principle of delegation of right of property in terms of ecological benefits. Top-priority environmental benefits (atmospheric air, drinking and domestic purposes water, land resources for recreational purposes, etc.) property should belong to society and this is to be fixed in the Constitution. According to this principle society delegates its rights to use environment to the state authorities that are to take charges from producers for the "environment" production factor active part deterioration.

3 Methodological approach to the cost estimation of the "environment" production factor active part deterioration

Within the framework of improvement of the approach to the production and products (labor, services) sale cost formation it has been proposed to include in their structure cost estimation of the "environment" production factor active part deterioration. It should be based, in our opinion, on current cost connected with prevention of environmental damage. As a result of the expenses recovery mechanism modification charges for environment pollution will cease to be practical. This paper has proposed an approach to estimation of the "environment" production factor active part deterioration (Det_{env}) which reflects the damage caused by environment pollution as a result of economic activities. A well-known method of generalized indirect assessments was used as a basis for calculation. We propose to carry out the deterioration cost estimation according to the first principle formulated by the author, namely, to make it on the basis of expenses occurring as a result of implementation of measures and investment projects aimed at prevention of negative consequences instead of expenses connected with removal of consequences of negative impact upon environment. In estimation of the "environment" production factor active part deterioration an indicator of specific deterioration (p_{ij}) is the key element. With this approach, this indicator will be determined through specific expenses connected with prevention of environmental damage. Specific expenses are cost price of decrease by 1 ton of adverse matters emissions (discharges). Calculation of cost price can include items presented in Table 1.

In estimation of the "environment" production factor active part deterioration amount it is necessary to consider all possible combinations and versions that can enable to reach such a level of negative impact at which adverse matter background concentration will not exceed maximal permissible concentration (Q_{MPC}) within the framework of a given enterprise (Fig. 2). A specific running costs curve has a form of hyperbola as for attaining of pollution volumes close to

Table 1: Items of environment protection expenses.

Items of cost estimation	Expenses structure
Raw materials and other materials	Cost of agents, filters, etc. for treatment of discharges and emissions in terms of adverse matters
Power consumption for technological needs	Cost of power and steam to be bought or produced to provide functioning of environment protection foundations
Maintenance and operation expenses for environment protection equipment	Cost of repair, maintenance, depreciation, and operation of environment protection equipment
Shop costs	Salary of management staff, specialists and shop employees with assignments, cost of repair and maintenance of shop buildings and facilities, and other shop overhead expenses
Depreciation of non-material assets	Depreciation allocations from nits of intellectual property of nature protective character (patents, licenses, exclusive rights, trademarks, etc.)
Interest for the use of borrowed capital	Interest charged for the use of capital which is the source of funding of nature protective measures

zero considerable funds expenses are necessary. Considerable investments depending on variable costs per unit (C_{var}) will be needed to cope with a great amount of pollution ($q>>Q_{MPC}$). Fixed costs per unit (C_{fixed}) will decrease with the pollution volume increase due to the scale effect. An enterprises' costs will be minimal (C_{min}) when the pollution volume decreases to the q_o value.

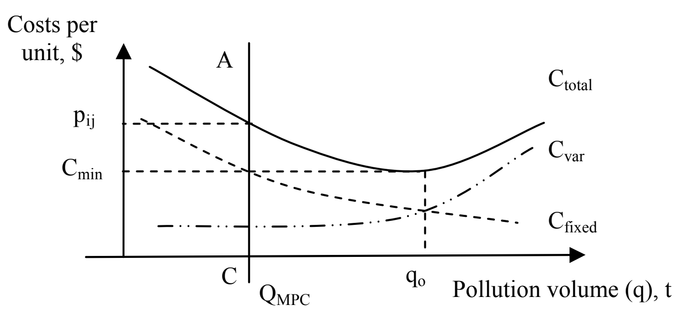

Figure 2: Dependence between specific nature protective costs and pollution volume.

This level, however, will not secure the environment favorable quality. The AC line corresponding to the Q_{MPC} pollution level is an absolutely inelastic statement that fixes maximal permissible level of negative impact upon environment; any value less than this will provide the normal statue of environment (adverse matter background concentration will not exceed MPC). Q_{MPC} is to be set by appropriate state authorities.

Deterioration per unit (p_{ij}) of the "environment" production factor active part as a result of negative impact upon it will be determined on the basis of the preset maximal permissible negative impact (Q_{MPC}) and total costs (C_{total}) for prevention emissions of 1 ton. Fig. 2 shows this as a point of intersection of the AC line and the curve of total costs (C_{total}).

A part of the "environment" production factor active part deterioration amount (Det'_{env}) connected with pollution within the limits of Q_{MPC} can be assessed with the following expression:

$$Det'_{env} = \sum_{i=1}^{n} \sum_{j=1}^{k} p_{ij} \cdot m_{ij} \cdot Ke \qquad (1)$$

where p_{ij} is a deterioration per unit, caused by pollution with the i-th adverse matter of the j-th component of environment, ruble/ton; m_{ij} is mass of the i-th adverse matter discharged into the j-th component of environment, within limits of Q_{MPC}, tons; n is a number of adverse matters types; k is a number of components (types) of environment to be affected by environmental impact; K_e is a coefficient that reflects ecological situation and ecological significance of the territory where the enterprise locates.

In the case of negative impact exceeding the Q_{MPC} level a producer is to pay to the society for the damage made in addition to the cost estimated for the "environment" production factor active part deterioration within the Q_{MPC} limits. Expenses of the enterprise associated with the negative impact upon environment above the Q_{MPC} level should have the form of fines (Det''_{env}) for the producer's failure to reach the necessary pollution level (Q_{MPC}) in case of availability of the appropriate techniques. Calculation of the fines' value should not be linked with the amount of expenses for the damage prevention but should be completely dependent on the pollutant's level of hazard and total exceeding of maximal permissible negative impact (Q_{MPC}) (Fig. 3).

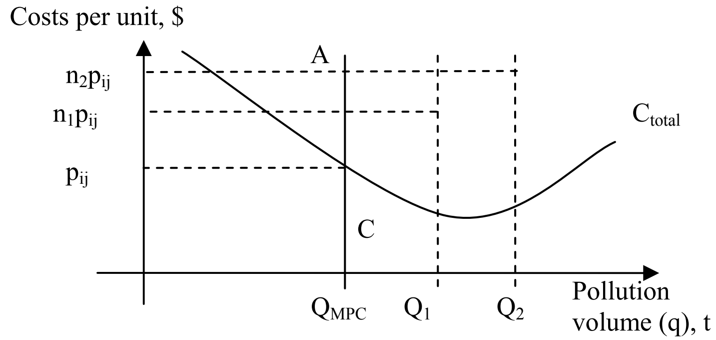

Figure 3: Dependence between specific expenses for nature protection and pollution volume

If an enterprise pollutes environment above the Q_2 level it is necessary to activate some administrative regulatory instruments to protect environment: to terminate or cease the enterprise's activities till the remedy of the revealed infringement. Negative impact exceeding Q_{MPC} but without exceeding of Q_2 should be fined in multiply:

$$Det''_{env} = \sum_{i=1}^{n}\sum_{j=1}^{k} n_1 \cdot p_{ij} \cdot \Delta m_{1_{ij}} \cdot K_e + \sum_{i=1}^{n}\sum_{j=1}^{k} n_2 \cdot p_{ij} \cdot \Delta m_{2_{ij}} \cdot K_e \qquad (2)$$

where n_1, n_2 are multiplication coefficients applied in case of environment pollution above Q_{MPC} within the limits of Q_1 and Q_2, respectively; Δm_{1ij} is a difference between the actual mass of emission (discharge) of the i-th harmful matter to the j-th environment component and the Q_{MPC} level if the actual mass equals Q_1 or is less than that; Δm_{2ij} is a difference between the actual mass of emission (discharge) of the i-th harmful matter to the j-th environment component and the Q_1 level if the actual mass is equal to Q_2 or is led than that but exceeds Q_1.

Coefficients of multiplicity are recommended to be determined on the basis of the harmful matter ecological hazard and the pollution volume (at that $n_2 >> n_1$). Ranges between the Q_{MPC}, Q_1, and Q_2 pollution levels are to be formed for each individual harmful matter or for a group of pollutants depending on degree of their negative influence upon human organism and ecosystems. The more is the value of negative impact above Q_{MPC}, the more is the cost estimation of the "environment" production factor active part deterioration. Beside the main criteria (degree of pollutant ecological hazard and pollution volume) in the process of determining the coefficients of multiplicity it is necessary to take into account the current status of economy and availability of funds for the enterprises to replace their basic environment protective assets for new, more sophisticated means, as well as the harmful matter actual amount and the level of its exceeding the Q_{MPC} value. Thus, the total value of a producer's (enterprise's) costs due to environment pollution in the course of economic activities will be the sum of two components:

$$Det_{env} = Det'_{env} + Det''_{env} \qquad (3)$$

where Det'_{env} is the cost estimation of the "environment" production factor active part deterioration as a result of environment pollution within the Q_{MPC} level limits; Det''_{env} is the fines for negative impact upon environment above the Q_{MPC} level.

The author has carried out cost estimation of the "environment" production factor active part deterioration with OAO "Uralelektromed" copper-smelting shop economic activity as an example (study-case). "Uralelectromed" has a copper anode production plant located in Verkhnyaya Pyshma of Sverdlovsk region. The production of copper anode is generated following types of pollutants (Table 2).

Air cleaning department operates on "Uralelectromed" to reduce pollutants. Current annual environmental costs of the department are presented in Table 3.

Table 2: Air pollutants, maximum permissible emissions (MPE) and emissions after the passage of the cleaning system.

Pollutant	MPE, t.	Annual emission volume, t.	Reduced emission volume, t.	Emission volume after the passage of the cleaning system, t.
Suspended solids	4.166	375.161	372.862	2.299
Copper	1.752	192.173	192.029	0.144
Plumbum	0.519	74.611	74.507	0.104
Zinc	0.331	41.349	41.311	0.038
Nickel	0.057	2.682	2.669	0.013
Arsenic	0.262	0.166	0.024	0.142
Total	**7.087**	**686.143**	**683.402**	**2.740**

Table 3: Calculation of cost price of the air cleaning department.

№	**Items of cost estimation**	**Cost,** rub.
1	Salary of management staff, specialists and shop employees	1 684 879
2	Assignments of salary of management staff, specialists and shop employees	456 602
3	Depreciation of environment protection equipment	1 213 478
4	Power consumption for technological needs	4 337 103
5	Maintenance expenses for environment protection equipment	144 555
6	Cost of repair environment protection equipment	1 076 486
7	Labor protection expenses	234 140
8	Other shop overhead expenses	220 251
	Total:	**9 367 492**

Thus, the annual costs associated with reducing emissions amounted to 9,367,492 rubles. The next step is to determine the specific deterioration (per unit (p_{ij})) of the “environment” production factor active part for each pollutant. For this amount of current environmental costs must be shared between all types of pollutants. Distribution is based on procedure of total emission volume converting, subject to the toxicity of each pollutant [3]. A carbon monoxide is taken as standard. Average daily MPC of carbon monoxide is 3 mg/m^3. Distribution can be assessed with the following expression:

$$E_{CO} = 3 \cdot \sum \frac{Q_i}{MPC_i} \tag{4}$$

when E_{CO} is equivalent of carbon monoxide; Q_i is mass of the i-th air pollutant . According to procedure of distribution the follows figures are received (Table 4).

Table 4: Reduced pollutant volume subject to the toxicity of each pollutant.

Pollutants	**Reduced pollutant volume,** t.	**Average daily MPC,** mg/m^3	**Reduced pollutant volume,** in tones of carbon monoxide equivalent	**Unit weight,** %
1	2	3	4	5
Suspended solids	372.862	0.15	7 457.23	0.55%
Copper	192.029	0.001	576 087.99	42.60%
Plumbum	74.507	0.0003	745 071.76	55.09%
Zinc	41.311	0.008	15 491.77	1.15%
Nickel	2.669	0.001	8 007.03	0.59%
Arsenic	0.024	0.0003	240.00	0.02%
Total	**683.402**		**1 352 355.78**	**100%**

Costs shall be prorated by the unit weight of each pollutant in the total volume of emissions (Column 5, Table 4). Measure of the specific deterioration (per unit (p_{ij})) is calculated by dividing annual costs on reduced pollutant volume for each pollutant (Column 2, Table 4). The results of the calculation are presented in Table 5.

Table 5: Calculation of specific deterioration (per unit (p_{ij})) of the "environment" production factor active part.

Pollutants	**Unit weight,** %	**Cost distribution,** rub.	**Reduced pollutant volume,** t.	**Specific deterioration (per unit (p_{ij}))** ruble/ton
Suspended solids	0.55%	51 654.71	372.862	138.54
Copper	42.60%	3 990 443.71	192.029	20 780.39
Plumbum	55.09%	5 160 959.71	74.507	69 267.96
Zinc	1.15%	107 308.29	41.311	2 597.55
Nickel	0.59%	55 463.08	2.669	20 780.39
Arsenic	0.02%	1 662.43	0.024	69 267.96
Total	**100%**	**9 367 491.93**	**683.402**	

The total deterioration of the "environment" production factor active part is 49 744 rubles (Table 6).

In case of the use of the proposed approach the enterprise will pay to the state as a principle owner of the said production factor nearly 17 times the sum it pays according the current system of pollution charges.

Table 6: Calculation of total deterioration of the "environment" production factor active part.

Pollutants	**Actual emissions volume after the passage of the cleaning system,** t.	**Specific deterioration (per unit (p_{ij}))** ruble/ton	**Total deterioration of the "environment" production factor active part,** rub.
Suspended solids	2.299	138.54	764
Copper	0.144	20 780.39	7 172
Plumbum	0.104	69 267.96	17 289
Zinc	0.038	2 597.55	237
Nickel	0.013	20 780.39	672
Arsenic	0.142	69 267.96	23 610
Total	**2.740**		**49 744**

4 Problems of application of the proposed approach to cost estimation of the "environment" production factor deterioration at enterprises of the power industry

Power sector enterprises will face a number of complications associated with the proposed approach application.

The main damage done by thermal power stations is caused by the use of coal for production of electric and heat power as coal in burning forms so-called "greenhouse gases". The value of the "environment" production factor deterioration for thermal power stations will be very high because of great investments into nature protective facilities and current cost. Transition to the natural gas use instead of coal could contribute to mitigation of negative impact upon environment. However, such a transition will affect not only economic interests but also both the sphere of politics and social sphere. Economy of several Russian regions (for example, Kemerovo region) survives only owing to coal mining industry. Reduction of coal delivery would cause the decline of living standard in these regions. Another problem of the thermal power stations' transition to natural gas is associated with re-orientation of gas streams: decrease of the gas export and increase of the internal consumption. This process would decrease returns to the Russian budget due to the prices imbalance at the internal and external markets. This price disparity will be gradually reduced according to the WTO regulations; this, however, will lower competitive ability of Russian enterprises.

In nuclear power industry the principal problem is the spent fuel utilization. At present there are no techniques able to lower to "zero" the spent fuel harmful radiation. All currently existing depositories and containers with processed and utilized spent fuel are temporary solutions. The value of the "environment" production factor deterioration for nuclear power stations also will be high as the processing and utilization costs are considerable.

A special feature of the hydropower stations operation is the absence of significant damage to environment during the period of their exploitation. The main damage is caused during the period of the station commissioning. It is exactly the time when flooding of a vast territory occurs. The value of the "environment" production factor deterioration should be found out at the stage of designing to be compensated at the investment stage of the station construction.

Special conditions should be established for the use of alternative energy sources: solar energy, wind power, high and low tide power, etc. Such production is to have governmental incentives like taxation preferences, system of compensations and subsidies, preferential terms of crediting, etc.

4 Conclusion

The proposed approach will significantly stimulate investments into environment protection projects. In the conditions of competition, implementation of the author's method will promote enterprises' pursuit to decrease the value of payments for the "environment" production factor active part deterioration. It will enable to reduce the load on environment as an excessive negative impact would cause considerable increase of expenses and decrease of return for an enterprise.

References

[1] Larin, V., Mnatsakanyan R., Chestin, I. *Protection of nature in Russia: from Gorbachov to Putin.* M.: KMK, 2003.

[2] Vyvarets A.D., Maiburov I.A. *Transition to a new concept of the commodity cost formation with ecological component.* Obshchestvo i ekonomika, № 9, pp. 156-165, 2005.

[3] Boyarinov A.Y., Magaril E.R. *Perfecting of methodological/scientific foundations of formation of economic mechanism of production ecological expenses recovery.* Vestnik UGTU-UPI: Seriya ekonomika i upravleniye, № 5, pp. 96-106, 2010.

[4] Vyvarets, A. D., Karelov, S. V., Fedorenko, O. V. *Environmental economy.* M.: TsNIItsvetmet ekonomiki i informatsii, 1994.