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**MATERIAL FLOW COST ACCOUNTING.
“ONLY” A TOOL OF ENVIRONMENTAL
MANAGEMENT OR A TOOL
FOR THE OPTIMIZATION OF CORPORATE
PRODUCTION PROCESSES?**

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Environmental Management Accounting (EMA) is considered to be a system providing information to support decision-making mainly within the framework of environmental management. EMA includes also Environmental Cost Accounting which uses an extensive range of methods. Of major significance for the management of corporate processes are primarily the methods based on material and energy flows. The paper focuses on Material Flow Cost Accounting (MFCA). It characterizes MFCA not only as a tool of environmental management, but mainly as a tool for the management of material flows and points out the

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significance of MFCA information for the optimization of production processes. The paper also includes selected results of research activities focusing on EMA and MFCA application in the Czech Republic.

Environmental Management Accounting as a Tool of Environmental Management

Environmental Management Accounting (hereinafter EMA) is defined according to International Federation of Accountants [14] as “environmental and economic performance management through the development and implementation of adequate, environment-related accounting systems and practices. EMA includes Life – Cycle Costing, Full Cost Accounting, assessment of benefits and strategic planning for environmental management. In some enterprises, the system may also include reporting and auditing”. From the definition it is evident that of EMA concern are both financial and environmental aspects of carrying business. EMA provides information on environmental aspects and impacts of corporate operations, products and services, and on environmentally induced financial impacts, and such information is primarily intended for internal users (i.e. management).

In special literature, EMA is always divided into two subsystems — Environmental Management Accounting (in physical units) = PEMA, and Environmental Management Accounting (in monetary units) = MEMA. This approach within EMA is used to show that especially accentuated is the measurement of non-financial aspects of performance and their management, which is of high significance mainly for long-term decision-making [16,17].

PEMA serves as information tool to support internal decision-making. Of concern are environmental aspects and impacts that are expressed in physical units. According to S. Schaltegger and R. Burrit [24], PEMA serves as

- an analytical tool enabling to specify strengths and weaknesses in the area of environmental approach,
- a tool to support decision-making processes, focusing on environmental quality assessment,
- a tool for the measurement of environmental efficiency,
- a tool of direct and indirect control of environmental implications,
- a responsibility tool providing basis for internal (and indirectly also external) environmental communication,
- a tool which may help support sustainable development.

MEMA deals with environmental aspects that are expressed in monetary units. This means that it is based on traditional management accounting which is extended and modified to monitor and evaluate environmental aspects of corporate

operations, products and services. Of concern are, for example, material, energy and water costs, waste management costs, investments in projects mitigating environmental impacts, etc. MEMA represents a very important tool to support internal decision-making processes — MEMA traces, monitors and evaluates costs and benefits (revenues, cost savings) that arise in consequence of corporate acting on the environment. The information resulting from MEMA is used within the strategic and tactical-operative planning, as information support in taking measures to achieve the desired goals and targets, and plays an important role in responsibility management.

From the text above it is evident that EMA is drawn up to provide information which would allow to assess and manage corporate environmental behaviour and its economic effects. EMA also respects differing information needs of various stakeholders, its aim is to show business carrying process from the viewpoint of information needs of management, i.e. all staff members at different levels of corporate management — provided information serve to support business carrying process management.

A very important category of EMA is formed by environmental costs. The basic definition specifies corporate environmental costs as environmental protection costs [8]. Nevertheless, to specify corporate environmental costs, also material and energy flows can be taken as a basis. Environmental costs then can be defined as a sum of all costs relating, directly or indirectly, with the use (consumption) of materials and energies and with environmental impacts resulting therefrom [8]. The difference between both concept is shown in Fig. 1.

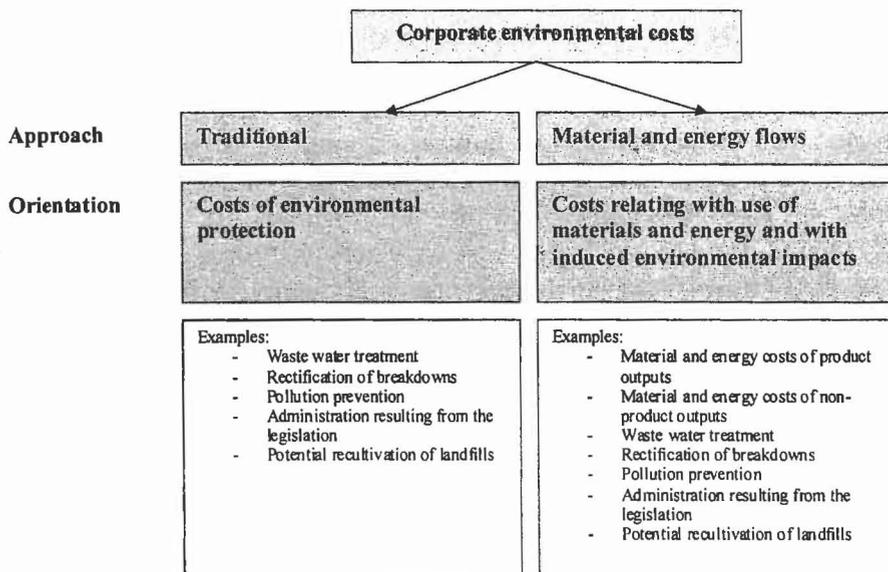


Fig. 1 Corporate environmental costs (Source: Prepared by the author)

The conception of environmental costs based on material and energy flows may give management a new view of corporate processes. EMA will cease to be perceived by business practice as a “mere” tool of environmental management, but it may provide information which will bring a new (different) view of corporate (primarily production) processes. Waste flows will cease to be perceived only in connection with costs of their disposal, but, management will acquire also information on the value leaving the company together with them (expended costs thus have no equivalent in revenues).

Methods used within Environmental Management Accounting

From the text above it is evident that the basic category of EMA can be considered environmental costs. This means that inseparable part of EMA (or more precisely MEMA) is formed by Environmental Cost Accounting [12,14]. IFAC [14] defines Environmental Cost Accounting as the “identification and assessment of environmental costs and their allocation to the processes, operations, products or centres”. Methods used within Environmental Cost Accounting can be divided into groups which stem from the definition of environmental costs and from the methods used in Cost Accounting (see Table I). The cost analysis applied always depends on the problem which is to be addressed; for different purposes it is necessary to start from different approaches to classification of costs. Within the approach which is based on the concept of environmental costs as environmental protection costs, it is necessary to differentiate between past costs, present costs and future costs. The approach focusing on costs of material and energy flows is based primarily on past results (see, for example, Ref. [24]).

Of high significance for corporate processes management is primarily the application of material and energy flow-based methods. Material Flow Cost Accounting (hereinafter MFCA) so belongs to very important methods of Environmental Cost Accounting (and thus also of EMA). It is a basic tool of management approach referred to as flow management, whose aim is to manage mainly production processes with regard to material, energy and information flows so that production process runs efficiently and in conformity with the set targets. Energy flows within this approach can be viewed as material flows, because energy input in a company is frequently first in the form of material (coal, gas, oil).

MFCA – a Tool of Material Flow Management

In flow management, enterprise is understood as a system of material flows. On the one hand, this system contains material flow relating with value added generation (from purchase of input materials through particular processing stages

Table I An overview of current methods used in Environmental Cost Accounting

	ENVIRONMENTAL PROTECTION COSTS		MATERIAL AND ENERGY FLOW-RELATED COSTS	
	Past and present costs	Future costs	Past and present costs	Future costs
STAND ALONE CALCULATIONS	Waste reduction costs, waste water reduction costs and emissions to the air reduction costs [28]	Environmental budgeting [31]		
FULL COST ACCOUNTING	Full environmental protection-related costs [3,5,6,32]	Environmental risk-related costs [11,12]	Costs of remaining material [1,10]	
DIRECT COSTING	Environmentally-oriented direct costing [18,23]	Costing of future environmental costs [18,23]		
PROCESS COSTING	Activity-based costing [4]	Activity-based budgeting [2]	material and energy flow-oriented costing [8,20]	Material and energy flow-oriented activity-based budgeting [24]

Source: Modified according to Ref. [24]

to distribution of products to the customers). On the other hand, inseparable part of material flows is formed by material losses that occurred in the course of corporate processes (for example, defective products of poor quality, scrap, waste, damaged products, products with expired term of consumption, etc.). This means that materials leave enterprise in the form of undesirable residues – undesirable from both economic and environmental viewpoints. As a matter of fact, these are waste flows of all states (solid waste, waste water and emissions to the air).

Within MFCA, emphasis is primarily laid on transparency of material flows and on the relating costs. Thus, there are created basic conditions for proposing measures that are connected with significant material and cost savings. Measures aiming to reduce consumption of materials are associated also with cost savings in the area of handling the materials as well as in the area of waste disposal.

To achieve transparency in the area of material flows, it has to be built on the knowledge of the following categories [27,30]:

- material,
- system,

- product delivery and waste disposal.

To assess the value of materials and of the relating costs, it has to be started from the knowledge of their quantities (volumes), in link with the particular flows and also in the area of inventories. The existing material record systems and production planning systems provide a number of pieces of information which can be started from, and systems can be modified in line with new requirements. Based on the quantitative information (on quantities and volumes) and based on material prices input analyses can be performed to acquire the information on the value of the particular materials and on the relating costs.

System costs are defined as all costs arising in the course of corporate material flow handling (for example, personnel costs, depreciation). Movement of material is regarded as cost driver. This means that system costs in enterprise are expended in order to ensure that movement of material is realized in a desirable way. Every material flow in enterprise can be considered a carrier of system costs, irrespective of whether raw materials, unfinished production, semiproducts, products or material losses are concerned. System costs should be allocated to cost carriers on the basis of causal relationship. It is necessary to allocate all costs being incurred by enterprise in connection with ensuring the course of material flows. System costs are always allocated to output flows (for example, to outputs from production centres) and are further passed to subsequent flows and inventories.

The flows leaving enterprise need to be further allocated to by costs relating with their delivery to the customers or with the disposal of such flows. These costs include payments effected to external third parties. They include all costs expended in connection with the “material” to leave enterprise. This means that they include not only costs of products transportation, but also costs of produced waste disposal (for example, air pollution charges, waste disposal charges, waste water treatment charges, etc.).

MFCA represents accounting approach providing entirely new information — information on the material flow in monetary units. The system provides information not only on the material costs, but, it is also a source of information on costs of such material processing from particular production phases to final products delivery to the customers. This allows monitoring of gradual increase in the value of material which through unfinished production and semiproduct becomes a completed product intended for customers. In the course of production process material losses (wastage) and devaluation occur, poor quality products and wastes (solid, liquid and gaseous) may be produced. The system informs users not only about costs expended on production of products intended for customers, but also about the “value” of poor quality products and wastes (i.e. non-product outputs) and about costs of their disposal (costs of their management).

Figure 2 and Table II show an example of information which can be gained from MFCA system; it is only a sample example.

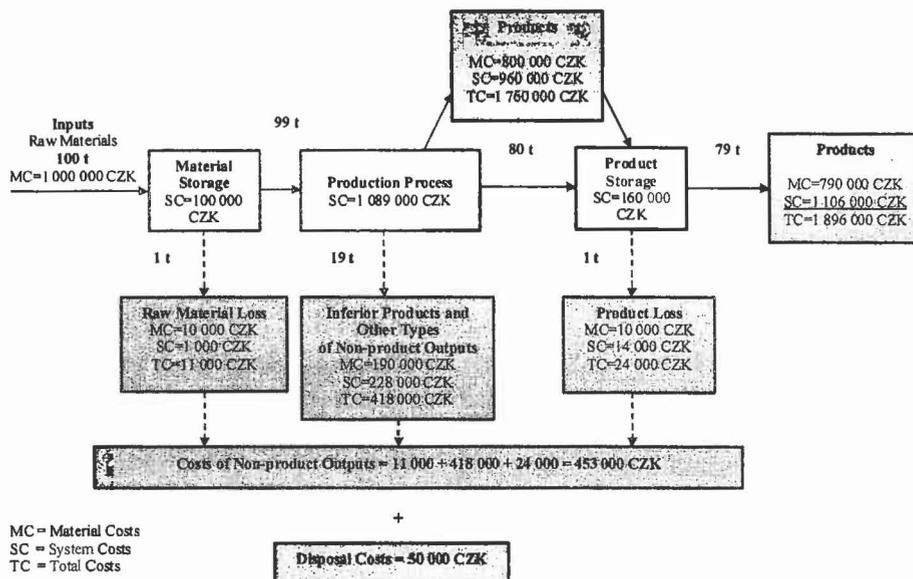


Fig. 2 Calculation of MFCA. Source: The author's own calculation

Table II Flow cost structure

Costs (1000 CZK) Items	Material costs	System costs	Disposal costs	In total
Products	790	1 106	-	1 896
Material losses (non-product outputs)	210	243	50	503
In total	1 000	1 349	50	2 399

Source: The author's own calculation

In Fig. 2, material flow through enterprise with material values (in CZK) is shown. Material costs and system costs are allocated to material flow. At the moment of material flow leaving enterprise, waste disposal costs (50 000 CZK) are added to material flow. Table II shows the flows leaving the enterprise (i.e. products and non-product outputs – these are considered material losses). Costs in classification of material costs, system costs and waste disposal costs are allocated to each of the leaving flows.

From Table II it is evident that material costs represent a very significant cost item (in our example they account for 42 % of the total costs). Costs relating to non-product outputs account for 21 % of the total costs. On the other hand,

costs of their disposal represent only 10 % of the total value of lost materials. Non-product output is not expensive for enterprise due to the costs relating with its disposal, but mainly due to the fact that it contains materials that were purchased (material costs) and further processed (system costs) to leave enterprise in the form of waste.

Examples of MFCA application in practice can be found. MFCA was applied in certain German enterprises [15]. The enterprises mention the following benefits resulting from the system application [9]:

- reduction of costs and environmental benefits (as a result of improved efficiency of production process; waste quantities and volumes as well as material consumption per product unit are reduced),
- new interesting suggestions for the development of new products, technologies and operation techniques,
- higher quality of information systems,
- improved corporate organizational structure and operation procedures,
- process of coordination and communication between the particular corporate bodies is improving,
- higher motivation of personnel and management,
- higher emphasis is laid on better use of materials and energies.

The implementation of MFCA has resulted in a reduction of corporate costs by 1-5 %.

EMA and MFCA in the Czech Republic

Since the end of the 1990s, Ministry of the Environment of the Czech Republic has been paying attention to EMA as a tool of environmental management. Since 2003, Environmental Management Accounting Implementation Guideline — hereinafter Guideline [21] has been available to enterprises, providing them with recommendations to implement EMA. In the Guideline, EMA is specified as integral part of management; EMA deals with identifying, gathering, analyzing and reporting

- information on material and energy flows,
- information on environmental costs and
- other monetary-expressed information serving as a base for decision-making within a given enterprise.

From the EMA concept it is evident that emphasis is primarily laid on information on material and energy flows and on environmental costs. Material and energy flows are the basic starting point for calculation of environmental costs. The methodology recommends to allocate environmental costs to the

particular environmental media. Such allocation facilitates a new view of environmental costs. It is significant for assessment of impacts of corporate operations on particular environmental media and shows their economic consequences. Information on environmental costs is arranged in statement of environmental costs and revenues (a simplified form of statement is shown in Table III).

Table III Statement of environmental costs and revenues

Environmental media	Air, climate	Waste waters	Wastes	Soil, ground and surface water	Noise vibrations	Biodiversity landscape	Radiation	Other	Total
Categories of environmental costs and revenues									
1. Waste management, waste water management and management of emissions to the air									
2. Environmental management and pollution prevention									
3. Material costs of non-product output									
4. Processing costs of non-product output									
ENVIRONMENTAL COSTS IN TOTAL									
ENVIRONMENTAL RENEVUES IN TOTAL									

Source: [21]

Implementation of environmental accounting into the practice of the Czech enterprises in the second half of the 1990s primarily consisted in the tracing and analyzing of environmental costs. A need to manage environmental costs resulted from an increase in funds expended by enterprises on environmental protection or in connection with environmental damaging. Information on environmental aspects and impacts has become integral part of corporate decision-making processes. The enterprises traced mainly the costs relating with waste disposal, costs resulting from non-compliance with environmental protection regulations, and services purchased in relation with environmental management systems (EMS). In enterprises, information on environmental costs was generally not

linked with information on material and energy flows.

The development in the area of environmental accounting application after 2000 is documented by research conducted in 2002 by the University of Pardubice and by Brno University of Technology [7]. In total 208 enterprises which had implemented EMS were addressed. Filled-in questionnaires were returned by 89 firms, i.e. 43%. Four fifths of the respondents considered the information on environmental costs beneficial for corporate management, and 76 % of the respondents individually traced environmental costs. From the research it has resulted that mainly the following corporate costs were considered environmental costs:

- costs expended on solid waste disposal,
- costs of waste transportation,
- environmental pollution charges,
- fines and penalties relating with environmental damaging,
- operating costs of end of the pipe technologies, i.e. waste water treatment plants, incinerating plants, etc.,
- payments to external organizations for services relating with EMS implementation and certification.

From the research it is evident that in decision-making again mainly the costs resulting from waste management are considered, but material purchase value and processing costs of non-product outputs are not taken into account.

In 2005, next research in the area of environmental accounting application at microeconomic level¹ was conducted by Czech Environment Management Centre and by Czech Environmental Information Agency. To acquire the primary information, again a questionnaire was used, in total 1265 organizations were addressed. These were largely enterprises which at the moment of research had EMS implemented. Filled-in questionnaires were returned by 222 enterprises (i.e. 17 %). From the research, the following findings have resulted [13]:

- The term environmental costs was known to corporate practice; 80 % of the respondents have met with this term.
- Eighty-two percent of the respondents considered to be part of environmental costs those cost items which are being incurred by enterprise in connection with the requirements of environmental protection legislation (for example, costs relating with waste water treatment plant, costs of waste disposal, environmental pollution charges). Fifty-two percent of the respondents considered to be part of environmental costs also costs expended voluntarily by enterprise on environmental protection (for example, costs of implementation of EMS). Only 20 % of the respondents stated that an integral part of environmental costs is also the costs expended by enterprise on purchase and processing of that part of materials which are not transferred into products and leave the enterprise in waste flows (for example, costs of production of

defective products and rejects; purchase cost of material, which is later disposed of as waste). These costs were taken into account primarily by enterprises in processing industry.

- Sixty-seven percent of the respondents have confirmed that environmental costs in their firms are traced and evaluated. The enterprises paid particular attention to corporate costs being incurred in connection with the requirements of environmental protection legislation and also to the costs expended voluntarily by enterprise on environmental protection. Only 22 % of them confirmed the tracing and evaluation of costs of non-product outputs.
- The respondents have confirmed that information on environmental costs are beneficial to corporate management; 73 % of the respondents considered the information to be significant for both corporate environmental management and economic management.

The research has indicated that certain enterprises are shifting from the traditional concept of environmental costs as environmental protection costs to the concept based on material flows. This means that a shift occurs in perception of environmental costs, which is demonstrated in Table IV, based on the above described example. This approach to environmental costs may contribute to the optimization of production processes and bring significant material and cost savings. It is very important mainly in connection with decision-making on investments (see, for example, Ref. [29]).

Table IV Approaches to environmental costs

TRADITIONAL APPROACH		MATERIAL FLOW-BASED APPROACH	
Item	Costs (CZK)	Item	Costs (CZK)
Costs of waste management: - costs of waste disposal	50 000	Costs of waste management: - costs of waste disposal	50 000
		Subtotal	50 000
		Costs of non-product outputs: - purchase costs of materials leaving enterprise in waste flows	210 000
		-costs of processing of non-product outputs	243 000
		Subtotal	453 000
Total environmental costs	50 000	Total environmental costs	503 000

Source: Our calculation

Conclusion

EMA is a tool which helps enterprise to improve its environmental and economic performance and thus continue on the way towards sustainable development. It is a very significant source of information for environmental management. Within EMA, an extensive range of methods (tools) can be used. The particular tools serve to support decision-making processes and are used always in dependence on the type of a decision-making problem which is to be sorted out, according to the purpose which the information is intended to serve for, and in link to the level at which the decision is realized. One of the tools is MFCA.

The aim of MFCA is to identify and analyze the system of material flows that represent cost drivers. MFCA improves the current accounting approaches in two levels:

1. Economic level. MFCA primarily focuses on material costs. In manufacturing enterprises they represent a very significant cost item; in comparison with them, costs relating with, for example, waste management, are insignificant. Traditional accounting systems do not provide sufficient information on material costs, in enterprises there is not available detailed information on how particular materials pass through enterprise. Within MFCA, the data in physical units are interconnected with the data expressed in monetary units. The progress of materials through enterprise is identified, it is evident what part of materials is put in a product and what part of materials leaves enterprise in waste flows (and the system provides not only information in physical units, but also the value of particular material flows is expressed). The acquired information can be used to support decision-making processes. Ways are searched to “rectify” material flows and measures are proposed, leading to a reduction of consumption of materials and to increased efficiency of production processes – for example, material handling is improving to avoid their damage and wastage, waste quantities (volumes) are being reduced (for example, through new techniques within production process, and also through avoidance of completion of poor quality products), improvements are being achieved in the area of material productivity, etc.
2. Environmental approach level. MFCA focuses on reducing the costs through a reduction in quantities (volumes) of consumed materials and energies. This has also positive environmental impacts. Materials and energies are better used and waste flows burdening the environment are being reduced. MFCA so represents a very important tool for environment-oriented management and for improvements of eco-efficiency. Environmental benefits are realized even if it is not a willful intention of enterprise.

MFCA cannot be considered a mere tool of environmental management. MFCA information can be exploited in the optimization of production processes.

MFCA facilitates to trace operations and places where losses and wastage occur and where poor quality products and wastes are produced. Based on such information measures can be proposed, which will lead to better use of materials and energies, mitigation of environmental impacts, reduction of environmental risks and, in final phase will bring improved corporate economic results.

Within MFCA, a number of partial steps have to be taken and large quantities of data have to be processed. MFCA may be realized only with adequate computer support [19]. Experience confirms that the current corporate databases, material record systems, production planning systems and other information subsystems functioning in enterprise largely contain major part of the required data. Nevertheless, for the MFCA purposes, the current systems need to undergo one-shot modification.

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