Performing Environmental Management (EMA) and Material Flow Cost Accounting (MFCA) in SMEs[1]

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[1] This document has not been edited

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Introduction

Preventive industrial environmental management is a well-known concept for dealing with two seemingly competing goals: it enables to improve environmental performance of industrial sites while improving their economic performance. At the core of preventive strategies there are win-win solutions for better management of material and energy flows.

There are several proven tools that can be utilized for helping companies to integrate environmental management into their business operations, such as Cleaner Production Audit (CPA), Environmental and Energy Management Systems, Life Cycle Assessment and Eco-design, CSR, Environmental and Material Flow Cost Accounting (EMA-MFCA), etc.. However, stand-alone implementation of individual tools, although effective in identification of particular improvements, can easily lead to sub-optimization of solutions and as a result the company may have difficulties in initiating and maintaining the desired complex changes in the guiding ideas, strategies or systems and their alignment to sustainable production's outputs. Integrating some of these tools and their core elements can significantly accelerate organizational changes in the direction of sustainability in an effective way, taking advantage of the complementarity and the synergies that the combined use of specific tools can provide.

In 2000, UNIDO has developed an integrated approach named "TEST approach", which consists in the combination of a set of preventive environmental tools (CPA, EMS and EMA-MFCA), whose elements are applied in a customized way based on an enterprise needs. Implementation of TEST approach is done at the following levels:

1. At the level of processes, it gives priority to the preventive approach of Cleaner Production (CP) - systematic preventive actions based on pollution prevention techniques within the production process) and considers the transfer of additional technologies for pollution control (end-of-pipe) only after the feasible cleaner production solutions have been explored. This leads to a transfer of technologies aimed at optimizing environmental and financial performance at the same time: bringing desired win-win solution for both areas.

2. At the level of management systems, the integrated TEST approach addresses the managerial aspects of preventive environmental management. It establishes the necessary information system on relevant material, energy and related financial flows necessary for linking the strategic and operational level within an enterprise. This is done by using the basic elements of EMS and EMA-MFCA tools.

3. At the strategic level, it puts environmental management within the broader strategy of environmental and corporate social business responsibilities (CSR), by leading companies towards the adoption of sustainable enterprise strategies.

This document illustrates the concept and methodology of EMA-MFCA, which is one of the tools used within TEST to support and sustain the implementation of the other tools used within TEST, e.g. CPA and EMS. EMA-MFCA reveals the real costs of production inefficiencies and losses, by putting in place an information system to track and monitor the non-product output costs as well as the other environmental costs. This information is essential for the identification of priority material/energy flows and the priority areas to be addressed within a CPA for identifying improvements and saving opportunities. The information systems on flows that can be set up based on EMA-MFCA, enables an effective monitoring of the financial and physical performance of implemented CP programmes, which is essential to demonstrate their real impact on medium to long-term decisions, thus for promoting their continuous application. EMA also enables accountability and reporting of enterprise

members, as well as the calculation of the total environmental costs of a company, including hidden and contingency environmental.

This document, which is part of a broader TEST training kit, proposes a simplified step by step approach for introducing EMA/MFCA in SMEs including a case study conducted in a brewery. The TEST training kit also includes an EMA-MFCA excel tool and a related user guide, which incorporates another case study for a pulp and paper sector.

This EMA-MFCA document has been developed within the framework of the MED TEST programme, an initiative of UNIDO for promoting sustainable production in the southern Mediterranean Region (www.unido.org/MEDTEST). The MED TEST programme was first launched in 2009 with the support of the Global Environment Facility (GEF) and the Italian Government with a pilot phase in Egypt, Tunisia and Morocco. In 2013 the MED TEST programme was extended to other countries (Jordan, Lebanon, Palestine, Israel, Algeria and Libya) and incorporated within the Switch-Med initiative funded by the European Union (www.switchmed.eu).

1. Getting started

1.1 What are EMA and MFCA and what are they good for?

According to the definition developed by the United Nations EMA Expert Working Group, Environmental Management Accounting, **EMA** is the identification, collection, analysis and use of two types of information for internal decision making (Jasch, 2001):

- physical information on the use, flows and destinies of energy, water and materials (including wastes) and
- monetary information on environment-related costs, earnings and savings.

Starting point for EMA is the assessment of a material flow balance, also called mass balance or input output balance in volumes and monetary terms on the system boundary of the organization for the complete previous business year, as most data is available only for this system boundary. This is especially the case for small and medium sized companies (SMEs). In the first step of developing the material flow balance sheet, only a rough overview analysis may be performed, instead of a detailed data collection.

The ISO standard on Material Flow Cost Accounting, ISO 14051, 2011, defines **MFCA** as "a tool for quantifying the flow and stock of materials in processes or production lines in both physical and monetary units". MFCA is a tool for improving material productivity in order to reduce the relative consumption of materials, energy and water and closely linked to EMA. MFCA is regarded as an effective means by which organizations can simultaneously seek environmental and economic benefits. MFCA improves material productivity in processes or production lines and may consequently help reducing related environmental impact. In MFCA, the flow and amount of the inventory of materials used within an organization are measured in physical units (e.g. weight, capacity, and volume) and subsequently evaluated in monetary units, which are based on the manufacturing costs incurred.

To assess costs correctly, an organization should collect not only monetary, but also non-monetary data on materials use, personnel hours and other cost drivers. EMA places a particular emphasis on materials and related costs because:

(1) the use of energy, water and materials, as well as the generation of waste and emissions, are directly related to the environmental impacts of organizations and their products, and
(2) material purchase costs and materials lost in waste and emissions are the most prominent cost drivers in many organizations. Especially in countries with low enforcement of legal compliance and relatively low labor costs, material and energy use and related losses are a significant cost driver.

Both, the EMA and MFCA approach have the underlying assumption, that all purchased materials must by physical necessity leave the company either as product or waste and emission. Waste is thus a sign of inefficient production:

- All purchased materials must by physical necessity leave the company either as product or waste and emission.
- Waste is a material which has been purchased and paid for but which has not turned into a marketable product.
- Waste is being paid for 3 times: at purchase, at production and for disposal

- Waste comprises all **non-product output of input materials** including water and energy.
- Therefore when calculating environmental costs, not only disposal fees are calculated, but in addition the wasted material purchased value and the production costs of waste and emissions.

Environmental protection and management have proved to be environmentally as well as economically beneficial, especially when combined with integrated prevention technologies and material flow cost accounting. A prerequisite to demonstrate these effects are company internal information systems that allow calculating and demonstrating these benefits. However, many companies do not have the accounting and management systems in place that allow such calculations. Companies all over the world therefore find it difficult to analyze the benefits of Cleaner Production (CP) and Environmental Management Systems (EMS) properly and to obtain funding for their projects.

There is a growing consensus that conventional accounting practices simply do not provide adequate information for environmental and material flow management purposes. Preventive environmental protection is often hampered by the lack of systematic recording of corporate environmental data and costs limiting the scope and comparability of environmental management of production, distribution and consumption at the corporate level, across industries, at national and international level.

The fact that corporate environmental and material flow costs are not clearly defined and fully and systematically recorded often leads to distorted calculations for improvement options. Environmental protection projects, aiming at preventing or reducing emissions and wastes at source (avoidance option) by better utilizing raw and auxiliary materials and requiring less (harmful) operating materials, are not recognized and implemented; consequently the economic and ecological advantages to be derived from such measures are not used. The people in charge are often not aware that producing wastes and emission is more expensive than disposing them. By preventing the production of wastes and emissions through process optimization, the wastes of materials, energy and operation time can be reduced and in some cases totally eliminated. Therefore, the issue of disposing or treating wastes and emissions can be eliminated or drastically reduced at the sources.

Major challenges that have both triggered interest in EMA and pose challenges to EMA implementation are current accounting practices such as:

- **inadequate links** between accounting and other departments;
- unintentional **hiding** of environment-related cost information in overhead accounts;
- inadequate tracking of information on **materials use, flows,** and costs;
- **lack of some environment-related information** in the accounting records; and
- **investment decisions** made on the basis of incomplete environment-related information.

To fill the gap, Environmental Management Accounting (EMA) and Material Flow Cost Accounting (MFCA) have received international attention. MFCA can be seen as a subset of EMA, focusing mainly on the material flow balance and non-product outputs. MFCA is most appropriate to perform when the costs for environmental protection are negligible, which is often the case in companies in developing and transitional economies. Full scale EMA assessment becomes relevant for companies with significant additional environmental cost related to end of pipe or environmental management system.

The Working Group on EMA of the United Nations Division (UN DSD EMA WG) spurred much of this interest by its publications (http://www.un.org/esa/susdev, Jasch, 2001). The International Federation of Accountants (IFAC) commissioned a guidance document on EMA initiated by the first

two publications by the UN DSD EMA Working Group on EMA (IFAC, 2005). The International Standardization Organization, ISO, is working on standards for MFCA (ISO 14051, 2011). UNIDO has developed a software tool for investment appraisal – COMFAR *III* – that includes a separate project type for EMA based on the UN DSD and IFAC EMA approach.

Simply defined, environmental management accounting (EMA) is management accounting (MA) with a focus on ***physical information*** on the flow of energy, water, products and materials as well as ***monetary information*** on environmental costs and revenues and projects related to environmental protection. EMA is closely related to process costing as well as to environmental performance and management systems. Well-designed and implemented EMA helps to ensure better internal management and decision-making e.g. for investment appraisal, cleaner production, improving Eco-efficiency and calculating savings within organizations. EMA also serves as a basis for external reporting and life cycle assessments of products.

EMA helps the organization to more effectively track and manage its physical and associated monetary resources, and to identify opportunities for cost savings. The benefits of doing EMA include efficiency improvements, better decision-making based on consistent information systems and strategic advantages related with better planning tools.

The goal is to gradually replace costly end-of-pipe pollution control systems and inefficient material flows with significant non-product outputs (waste and emissions) with a strategy that reduces and avoids pollution and waste throughout the entire production cycle, from efficient use of raw materials, energy and water to the final product. But, the actual costs of existing technologies, the losses of materials inputs and the benefits of Cleaner Production Technologies must be visual in the accounting system to obtain the finance necessary for investment options.

Some of the general recommendations that came out of the UN's CP Financing program argue in the same direction (UNEP, 2001):

- Enterprises should establish practices to measure and reflect the cost of waste management and other environmental costs.
- There is a strong need to measure the economic benefits of Cleaner Production—what can be the costs and benefits of doing things in a different way.

What EMA is good for can be summarized as such:

- Bringing environmental impacts down is at least as important as to bring costs down.
  EMA makes environment-related costs, investments and benefits visible.
- Provides basic data in order to formulate targets and programs for integrated environmental prevention. Supports line managers and project managers in decision making with an additional point of view – the environmental impact and cost benefits.
  EMA helps to raise environmental awareness in the "normal" business.
- Provides data and information for the annual report (e.g. non-financial information in the Director's report).
  EMA tells the environmental story of costs.
- Gives the possibility to communicate the progressive shift: **from emission control →integrated prevention processes →integrated prevention products**
- Provides arguments why cleaner production pays:
  EMA provides the information needed to convince the financial department to invest in integrated prevention technologies and human resources for environmental management.
- May help to identify environmental risks and to adopt countermeasures where insurance is not possible and/or save costs with the right measures.
- **EMA is a tool for proactive risk management.**

1.2 Introduction to financial and cost accounting terminology

Conventional corporate monetary accounting comprises

- Financial accounting (bookkeeping, balancing, consolidation, auditing of the financial statement and reporting)
- Cost accounting (also called management accounting)
- Corporate statistics and indicators (past oriented)
- Budgeting (future oriented)
- Investment appraisal (future oriented)

Book keeping and cost accounting provide the data basis for the other instruments.

Cost accounting constitutes the central tool for internal management decisions such as product pricing and investment appraisal and is not regulated by law. This internal information system deals with the following questions: What are the production costs for different products and what should be the selling price of these products? For determining the inventories of finished goods and work-in-progress for the balance sheet, cost accounting also needs to be done for financial reporting. The main stakeholders in cost accounting are members of different management item (e.g. executive, site, product and production managers). For environmental management, the related costs (mostly hidden in general overhead costs) may be traced and allocated to products and cost centers.

Cost accounting is based on data obtained from financial accounting and from production planning systems. Sometimes the values from financial accounting are adjusted for cost accounting purposes, following the system of **transition from expenditure to costs**. However, most small and medium sized companies (SMEs) use the same figures with only minor adjustments.

Alas, many companies do not have a separate cost accounting system, but take their internal decisions on calculations based on financial accounting data from bookkeeping instead. For all companies, annual data must be available for the system boundary of the whole company based on financial accounting requirements.

Financial accounting, is mainly designed to satisfy the information needs of external shareholders and financial authorities, both of whom have a strong economic interest in standardized comparable data and in receiving true and fair information about the actual economic performance of the company. Therefore, financial accounting and reporting are being dealt with in national laws and international accounting standards. They regulate how specific items should be treated, specifying, e.g., whether investments should be capitalized or expensed, under which circumstances provisions may be made for future treatment liabilities, or when contingent liabilities should be disclosed. Imputed (calculatory) approaches as used in cost accounting are not permissible.

Financial accounting deals with revenues and expenditures as shown in the profit and loss account, and with assets and liabilities as listed in the balance sheet. More detailed information is available from the list of balances. In cost accounting, the terms dealt with are costs and earnings; there is no equivalent to the balance sheet.

Requiring a somewhat different assessment method, the various expenditure items in financial accounting correspond to the categories of costs which are allocated to the respective cost centers (in-house production processes) and cost carriers/objects (products) (Jasch, 2001).

Financial Accounting	**Cost Accounting**
Balance sheet	
Assets	No equivalent
Liabilities	No equivalent
Profit and loss accounts	**Cost statement**
Expenditures	Costs
Expenditure items	Cost categories
Revenues	Earnings
	Cost calculation
No equivalent	**Cost centers**
Calculation of production expenditure	Cost carriers/objects (Products)

Figure 1: Terminology of financial and cost accounting

The EMA assessment can be based on expenditures from the profit and loss account or on internal cost accounting documents, depending on the structure of internal information systems. It is the task of the company's controller or financial manager to define the most appropriate data base once the general outline of the approach to be adopted has been defined.

The level of detail of financial accounting and cost accounting is different. For financial accounting, the system boundary is the legal entity and therefore mostly the company as a black box, sometimes, aggregating over several production sites. Cost accounting steps further down, inside the company and traces the costs of production steps and products.

There is a continuous exchange of data and information evaluation between financial accounting, cost accounting, budgeting and statistics. Aside from this information and data exchange, cost accounting has the following main objectives:

- Identification of price floors and ceilings;
- Calculation of planned and past production costs**;**
- Evaluation of internal services, finished and unfinished products for sales or tax purposes;
- Improving economic efficiency;
- Providing basic data for company policy and decision-making;
- Short-term performance evaluation;
- Monitoring of operations.

When trying to assess environmental costs, one will find that not every company does cost accounting. More often, especially small and medium sized companies (SMEs), work with data from the profit and loss account. It is up to management to decide whether the company should use cost accounting, and if so, which system it should use and how it should be designed. In contrast to financial accounting, this decision is not influenced by tax and commercial law. It is however highly recommended that companies gradually improve their information systems and data availability for decision making.

Some important Terms to distinguish are:

Fixed Costs are costs independent of employment and production volume, such as rent, interest on bank loans etc.
Variable Costs are directly related to production volume, e.g. raw materials and production labor hours;

Individual Costs are directly attributed to the corresponding cost centers (process steps) and cost carriers (products). They include at a minimum raw materials and production wages;

Overhead Costs are costs that cannot be directly attributed (true overhead) or costs that are not directly attributed for reasons of economic efficiency (untrue overhead), e.g. administrative costs, insurance, advertising costs. There are a number of methods to attribute overhead to cost centers and cost carriers.

Calculated Costs are used in cost accounting because they are not – or in a different form - considered in bookkeeping, but influence operating results. If these costs are not matched by expenditure in financial accounting, they are called extraordinary rates, e.g. calculated equity capital interest, calculated rent/lease, calculated management wages. If these costs are matched by an expenditure in bookkeeping, they are also called Other Costs such as calculated borrowed capital interest, calculated write-offs on the basis of replacement prices, calculated risks**;**

Costs Centers are those parts of the company that are organized as independent clearinghouses; they should be connected to production processes. Maximum consistency between cost centers and process-oriented material flow analyses is the prerequisite for good data. Cost centers generate costs, are responsible for costs or are attributed costs, e.g. for production and administration.

Cost Carriers or Objects are products and services produced either for the market or for internal needs. By attributing types of costs to cost centers and cost carriers, production costs and sales price floors are calculated.

Cost-Category Accounting is the first phase of cost accounting and answers the question:
Which costs have been incurred in which amounts during the accounting period?

In cost-category accounting, data from financial accounting is being transferred into costs. These costs are recorded in accordance with a cost category plan and divided into direct costs and overhead.

Cost Center Accounting follows cost-category accounting and answers the question:
Where and in which amounts have which costs been incurred during the accounting period?

For this accounting procedure, the overhead allocation sheet is used. Cost center accounting is also responsible for internal cost assignments. Finally, it determines cost estimate rates or billing rates (or surcharge rates) should they be required for cost carrier accounting based on the company operational situation.

Cost Carrier Accounting is the final phase of cost accounting and determines the production costs for each product (or service). It provides the basis for price calculation. It answers the question:

- Which types of costs have been incurred in which amounts for a certain product or service?

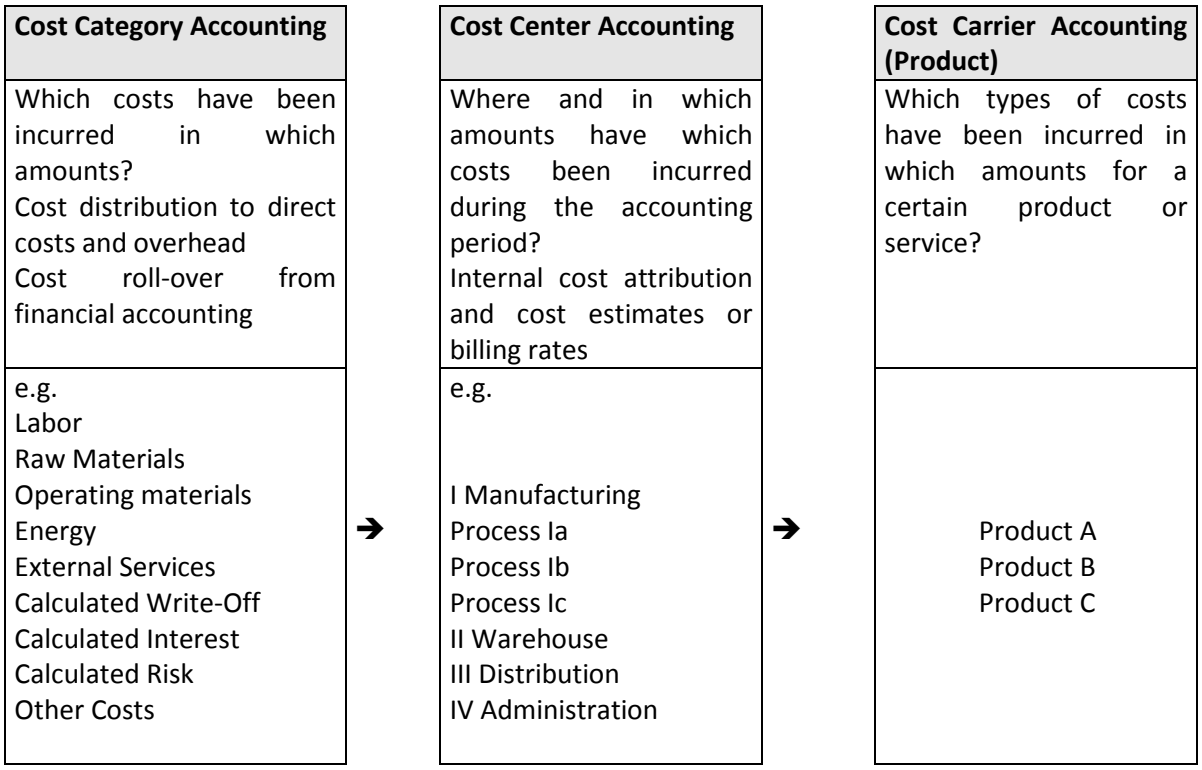

Figure 2: Relationship between Cost Category, Cost Center and Cost Carrier Accounting

Cost attribution is done in two steps, first from joint cost centers like waste management and emission treatment, to the responsible cost centers in the production process and secondly from the production cost centers to the respective cost carriers/objects (Product A and B).

A simple example in figure 3 +4 shows how overhead cost-attribution can significantly change the production costs of products. Whenever possible, costs should be allocated to the respective cost centers and cost carriers/objects (products).

	Product A	Product B	Example		
			Overhead	Product A	Product B
Materials by recipe/formula and stock issuing	Direct costs	Direct costs		70	70
Working hours by time records	Direct costs	Direct costs		30	30
Overhead	**distribution by % product turnover**				
Depreciation			50		
Rent			10		
Energy			5		
Communication			10		
Administration			25		
Top management's salary			10		
Waste & Emission Treatment			10		
Total Overhead			**120**	**60**	**60**
Total Product Costs				**160**	**160**

Figure 3: Environmental Costs hidden in Overhead Accounts

	Product A	Product B	Example		
			Overhead	Product A	Product B
Materials by recipe/formula and stock issuing	Direct costs	Direct costs		70	70
Working hours by time records	Direct costs	Direct costs		30	30
Energy	**Attribution to cost centers and products by actual process flows**		1	1	3
Waste and Emission treatment			1	3	6
Depreciation			7	13	30
Overhead	**distribution by % product turnover**				
Rent			10		
Communication			10		
Administration			25		
Top management's salary			10		
Total Overhead			**64**	**32**	**32**
Total Product Costs				**149**	**171**

Figure 4: Environmental Costs attributed to Cost Centers and Products

2. Step by Step Approach to EMA and MFCA

The **EMA assessment** is done in a step-wise approach:

1. Assessment of **materials inputs and outputs** for the previous business year.
2. Assessment of total **annual NPO** and, if significant, **environmental costs**
3. Distribution of the annual costs to **cost centers** or more specific processes
4. Selection of specific processes or material flows for in depth investigation
5. Application of **MFCA for selected processes**
6. Definition of **improvement options** for the accounting information system, in order to allow for better future data management
7. Appraisal of **investment options** (for example comparing cleaner technologies and/or end-of-pipe solutions between each other and to the last business year or to existing technologies)

Starting point of an EMA project is putting the right team members together. Experience shows that the environmental manager barely has access to the actual cost accounting documents of the company and only is aware of a tiny fraction of aggregate environmental costs. On the other hand, the financial accountant/controller does have most of the information but is unable to separate the environmental part without further guidance. In addition, he or she is limited to thinking within the framework of existing accounts. Also, the two departments tend to have a severe language problem.

So combining the competencies for monetary accounting and process engineering/environmental management and gaining support from both sides is vital for the success of any EMA project.

Another important guideline on the way is to focus the assessments on what is easily available from existing records and to note, where improvements to the information system would be recommended, so that future assessments will provide better data in shorter time. It is NOT the goal of an EMA assessment to come up with “complete data” for the past and spend a lot of time tracing old invoices. It is rather the goal to open the eye for improvement necessities and develop an overview on the most significant material flows and related costs.

It may be difficult determining the environmental portion of these costs. As with integrated clean technologies that are often more cost and material efficient, the environmental portion of health and safety or risk prevention activities can most often not be exactly determined. In general, it may be stated that assets that are allotted 100% to the environment may be bad for the environment as they are often End-of-pipe technologies that do not solve the problem at the source, but rather shift it from one environmental medium to another (e.g. from the air to the ground, and then into the water). These approaches are expensive and not efficient.

The resulting recommendation for the assessment is: don’t be shy to use estimates! The people at the production processes often can provide very good estimates for loss percentages, which are much more accurate than the figures used in the cost accounting department. Estimates can at a later stage be improved by more detailed measurements, but for the first assessment don’t worry not to be perfect. It is better to have an estimate than no figure. But the calculation procedure or the information source for the estimate should be recorded.

The goal of the first assessment is to:

- be able to present the entire material inputs and total environmental costs of the previous business year to top management, and

- come up with improvement recommendations and
- gain support to improve the information system and technical processes.

The first EMA assessment for the previous business year for any given company should not take longer than a 1 to 2 days workshop with the accountant and process engineer.

The cost assessment reveals improvement options in two areas:

1. What always can be found, are options and measures necessary to improve the quality and consistency of data and information flows in an organisation. This is the starting point of EMA most projects and the focus of most follow up projects.
2. In companies, that have not done environmental management projects for several years, also technical improvement options may immediately become obvious. What always is made visible, mostly for the first time, are the costs related to inefficient production, wasting materials and energy. So even if the technical solution might not be known at the end of the first assessment, the priority areas for deeper investigation will have been defined and the total range of environment related costs will be clearer.

The **MFCA and EMA Assessment Templates** (in Microsoft Excel format) can be used to assist in the assessment of total annual environmental and material flows and related costs and provide the option to distribute them to different cost centers, which should be equivalent to production processes and therefore provide good quality data for investment appraisal of specific processes. For material flow cost account (MFCA) the system boundary for the material flows can focus on more detailed processes within cost centre.

This guideline provides a simplified EMA and MFCA Assessment tool developed for SMEs. The UNIDO COMFAR III EMA Guideline and Module provides a full scale assessment tool for EMA + MFCA costs. While the EMA pre-assessment of material flows and annual environmental costs is done in separate Microsoft Excel templates, the subsequent investment appraisal can be calculated by applying the standard COMFAR *III* procedure.

The focus of EMA is to allow data assessment of material flows and fates and related costs for the previous business year. Once the data has been assessed on a company level, it can be distributed to cost centers, reflecting production processes, and thereby providing a much better basis for the application of investment appraisal.

The MFCA-EMA excel tool consists of 3 worksheets, which are interconnected. The first worksheet is designed for the input/output mass balance at the company system boundary: it records both physical and cost related information on inputs/outputs of a company, as well as sources of information and the generated non-product outputs percentages on volumes and costs of each production input. The second worksheet provides a breakdown of the non-product output costs and the other environmental costs by cost center or major production processes. The third worksheet calculates the total environmental costs (focussing on NPOs costs), both in absolute and relative values.

The *input-output mass balance sheet* records the physical and monetary values of material inputs and product outputs in one work step, as these amounts should be consistent. The worksheet contains two columns for the source of information for both values. The enterprise resource planning system and the accounts for materials used for production should provide this information in a consistent and detailed manner.

The actual cost assessment is performed in the *environmental cost breakdown worksheet* only. It can be done in any currency, which should be noted in the heading where EURO stands in the tool.

All the cost categories are already set but the several different cost items related to cost accounts or taken from cost centre reports should be listed with indicating the reference. The excel tool automatically aggregates the costs of each cost category, but when adding lines to fill in more details a last cross check is recommended to make sure all aggregates are complete.

The sum of the costs of all categories in the *environmental cost breakdown worksheet* is automatically transferred to the worksheet environmental cost summary providing an overview and a better presentation layout, which shows the aggregated totals by cost category and calculates the costs into percentages to show the most relevant environment related costs. This figure can also be compared to total production costs.

It is recommended for costs that are incurred by defined environmental equipment to simultaneously collect the data on external services, personnel, and operating materials, especially if this information is available from cost centre reports. Care needs to be taken to avoid double counting, if e.g. operating materials are collected from cost centre reports under cost category 2 and 3 and from accounts under cost category 1 or if external services are taken from expenditure accounts and costs centers as well.

The column *Account* is to keep record of the cost centers and accounts for the years to come without having to spend a lot of time finding them again. It is also practical to document the type of calculation used to estimate/acquire a certain figure. It is possible to add lines into the sheet, just be aware of maintaining the automatic excel calculations.

There is a control function in the sheet, which makes sure that the value in column *Costs in €* is identical to that of *Sum*. If this is not so, an error will show. The values are only identical if all costs in the *Costs in €* are assigned to a medium.

2.1 Input-Output Analysis of Material Flows and Estimation of Non-Product Output

The mass balance is based on the assumption that whatever enters an organization must (at some point) also leave it. The mass balance includes all materials inputs, as well as the resulting amounts of products and waste and emissions. The purchased inputs (or materials inputted into production) are compared to the production volume, the sales statistics, as well as the records of waste and emissions.

For product output and non-product output only the volumes, but no monetary values are collected, as companies don't have to disclose their turnover for EMA and the NPO costs are assessed later in the cost category "waste and emission treatment" under fees.

Improvement of environmental performance is based on the evaluation of material flows through an input-output analysis of the material flow in kilograms and monetary values. The system boundaries can be the organization or it can be further divided into sites, cost centers, processes, and products. This is the focus of MFCA. As a stating point it is recommended to take the last business year and

work with the list of accounts, as only this information source is available in all organizations and should be quite complete. Volumes and total purchase costs are assessed at the same time.

In the first EMA assessment, the Input-Output-Balance hardly balances off to zero. It is often recommended to deal with water and energy separately, as they further complicate the calculation. Companies may find it useful to separately calculate the mass, the energy and the water balance with the help of their process technician. In addition, with increased quality of information systems, the differences between inputs and outputs can be reduced.

The mass balance is not automatically calculated in the EMA Excel Template, as in most organizations the data necessary is not available for the first assessment and depending on the production process adjustments may be needed.

Materials Inputs	**Product Outputs**
Raw and Auxiliary Materials, Packaging	Products (including Packaging)
Operating Materials	**Non-Product Outputs (Waste and Emissions)**
Water	Waste
Energy	Wastewater
	Air Emissions

Figure 5: Physical materials accounting: Input and Output Types

The input-output types are in line with the standard practice of mass balancing and the general structure of ISO 14031 for environmental performance indicators for operational systems. These physical categories may be further detailed as needed to suit specific sectors or individual organizations.

As noted in several case studies, much of the required physical accounting information unfortunately is not easily available to accounting personnel, as it is not systematically recorded or is not recorded in a way that reflects the real-world flow of materials. Personnel in other areas, such as production, environmental or other operations, generally have more detailed estimates and measurements of physical flows of materials, but often this information is not cross-checked with that of the accounting department. Accountants need to work more closely with personnel from other departments to accurately do the physical accounting side of EMA.

In order to compile an Input-Output Analysis of material flows, it is best to start with the accounts in the list of balances (also called list of accounts) of conventional bookkeeping of the previous business year. Only this list provides a complete overview (in monetary terms) of purchased raw materials, auxiliary and operating materials in a given month or year as well as the cost of disposal, repair, insurance, transportation etc. Each account of the profit and loss statement should be examined to determine whether any material flows are recorded there. Personnel costs are not considered in a material flow balance but in later steps as part of the EMA assessment.

Clear definitions as to which elements of the Input/Output analysis are recorded on what accounts, which material numbers are assigned to which accounts and which materials are also recorded in stock management are essential. The objective is to obtain as complete as possible a listing of all material inputs by main material categories. This will help avoid having to break down accounts at a later date to show quantities used.

Figure 5 shows the structure of the material balance. First the types of raw-, auxiliary-, and operating materials consumed in the previous business year are added in detail. Then the quantities (e.g. kg) and monetary values (e.g. in €) are added to the input side. On the output side the products produced and the volumes of waste and emissions are added and checked for consistency with the input side. Nevertheless, in most organizations the Input/Output analysis does not balance in the first years of data assessment.

The material purchase cost of wasted materials is the most important environmental cost category, depending on the value of raw materials and the labor intensity of the sector. In companies with stock management, not the value for materials **purchased**, but **consumed for production** is used respectively.

In some enterprises the entire material purchase is booked on one account only and it is only possible to evaluate manually the extensive cost centre accounts or stocktaking lists to expose the actual material use into the material groups. As an aid, the recordings of the production manager can be multiplied with the assigned quantities with average prices, in order to at least be able to indicate orders of magnitude. It is unfortunately obvious that such a system cannot strengthen cost consciousness in handling raw, auxiliary and operating materials.

Once the mass balance and related purchase costs have been established, the question is: How much of the related inputs actually leave the company as product and how much is wasted as Non-Product Output?

1. MATERIALS COSTS OF PRODUCT OUTPUTS	**%**
➢ Raw and Auxiliary Materials	80
➢ Packaging Materials	90
➢ Water	5
2. MATERIALS COSTS OF NON-PRODUCT OUTPUTS	
➢ Raw and Auxiliary Materials	20
➢ Packaging Materials	10
➢ Operating Materials	100
➢ Energy	100
➢ Water	95

Figure 6: Separating Material Inputs in Product Output and Non Product Output

In the traditional EMA/MFCA approach "energy is considered a "waste". Indeed, apart from companies in the utility sector, energy is neither sold as a product nor it is visible in the final product. Energy is necessary for production, but at the same time it can be considered as operating materials. Moreover energy inputs generate CO^2 and other emissions and thus should be considered part of NPO.

In the example presented in Figure 13 for the total environment related cost, 100% of the energy input is recorded as NPO and represents approximately 27% of the total cost, which is quite a relevant figure. It would be a considerable loss of information, if the data related to energy inputs would not be consistently and completely recoded within the EMA assessment.
Nevertheless for some sectors, like utilities or the steel manufacturing, total energy inputs would be so high to make insignificant all the other figures in the EMA.

The following approaches can be used for recording data related to energy use within EMA/MFCA:

1. Evaluating energy as non-product output (NPO): Since in most cases energy does enter in the product, but rather escape as heated water, air, and radiation, it is considered to be 100% NPO. This allows for the best possible consistency with the input-output balance of the environmental report, and the data collection can continue without technical estimation.
2. Evaluating energy loss: Since energy is required in most processes of production, it may be reasonable to separated energy input into PO and NPO based on transformation and transportation losses (combustion losses, pipe losses, etc). The efficiencies are known (e.g. with combustion) or can be estimated (e.g. propulsion, conduction, etc.). This approach is probably only reasonable in the utility sector and requires a lot of assessment effort.
3. Recording the energy use of the environmentally relevant equipment: The energy use of environmentally relevant equipment (e.g. compressors, waste water plants, after burners, etc.) is just as the other operating costs of such equipment, 100% environmentally relevant and may be recorded not in the NPO but in the cost categories for waste and emission control and integrated technologies (if the energy consumption is recorded on specific cost centres or otherwise available).

2.2 Assessment of Annual Corporate Environmental Costs

The main EMA cost categories described in the IFAC EMA guidance document are shown in Figure 8. Also in the IFAC EMA guidance document the Mass Balance is the starting point of EMA.

Material Flow related Costs
1. Materials Costs of Product Outputs
2. Materials Costs of Non-Product Outputs
Environmental Protection related Cost
3. Waste and Emission Control Costs
4. Prevention and other Environmental Management Costs

Figure 7: MFCA and EMA cost categories

Statistical agencies only ask for **environmental protection expenditures** (EMA cost categories 3 and 4). This includes all expenditure for measures for environmental protection of a company or on its behalf to prevent, reduce, control and document environmental aspects, impacts and hazards, as well as disposal, treatment, sanitation and clean up expenditure. It mostly relates to End-of-Pipe technologies. The amount of corporate environmental protection expenditure is not directly related to the environmental performance of a company.

For company internal calculation of environmental costs, expenditures for environmental protection are only one part of the coin. The costs of waste and emissions include much more then the respective treatment facilities and disposal fees. Several EMA and MFCA case studies have shown that the costs of waste disposal and emission treatment are typically 1 – 20 % of total environmental

costs, while the purchase costs of the wasted materials represent 40 to 90 % of environmental costs, depending on the business sector examined (e.g. Bouma, Wolters, 1998, Fischer et.al., 1997, Jasch, Schnitzer, 2003, Jasch, Danse, 2005).

	Environmental protection expenditure (emissions treatment, control and waste prevention costs)
+	**Costs of Non Product Output** (Costs of unproductive material, capital, and personnel)
=	**Total corporate environment related costs**

Figure 8: Total corporate environment related costs

Adding the purchase value of non-product output to the corporate environmental costs increases the share of environmental costs in relation to other costs. However, it is not the goal to show that environmental protection is expensive, but rather to highlight the scope for savings potentials. It is also not the most important task to spend a lot of time defining exactly which costs are environmental or not, or what percentage of something is environmental or not, or if Energy belongs to NPO and to what degree. Environmental protection projects not only have effects on nature, but also on neighbors (noise, odors, pollution) and employees (health and safety), if related to material and energy flows. In addition they result in a reduction of risks for employees, nature and neighbors in case of accidents and other occasional production events.

It is often difficult to determine the environmental portion of these costs. As with integrated cleaner technologies that are often more cost and material efficient, the environmental portion of health and safety or risk prevention activities usually cannot be determined precisely. In general, it may be stated that assets that are allotted 100% to the environment are bad for the environment as they are often end-of-pipe technologies that do not solve the problem at the source, but rather shift it from one environmental medium to another (e.g. from the air to the soil and then into the water). These approaches are expensive and inefficient.

The most important task is to make sure that ALL relevant and significant costs are considered when making business decisions. This is why Figure 9 calls the total sum: **total environment related costs**. This is the **universe of costs**, that the environmental manager deals with and that can possibly be reduced by pollution prevention and material and energy efficiency projects.

In other words, corporate environmental and material flow costs are just a subset of the bigger cost universe that is necessary for good decision-making. Environmental costs are part of an integrated system of materials, energy and money flows through a corporation, and not a separate type of cost. Doing EMA and MFCA is simply doing better, more comprehensive Management Accounting, while wearing an environmental hat that opens the eyes to hidden costs. Therefore, the focus of MFCA is no longer on assessing total environmental costs, but on a revised calculation of production costs on the basis of material flows (including energy and water).

For the assessment of total annual environment related costs the IFAC cost categories are further divided into cost categories that confirm to standard accounts.

ENVIRONMENT-RELATED COST CATEGORIES	% share of PO or NPO	Data source or estimation procedure	Total annual costs
1. MATERIALS COSTS OF PRODUCT OUTPUTS			
➢ Raw and Auxiliary Materials	80		
➢ Packaging Materials	90		
➢ Water	5		
2. MATERIALS COSTS OF NON-PRODUCT OUTPUTS			
➢ Raw and Auxiliary Materials	20		
➢ Packaging Materials	10		
➢ Operating Materials	100		
➢ Water	95		
➢ Energy	100		
3. WASTE AND EMISSION CONTROL COSTS			
➢ Equipment Depreciation			
➢ Operating Materials, Water and Energy			
➢ Internal Personnel			
➢ External Services			
➢ Fees, Taxes and Permits			
➢ Fines, Remediation and Compensation			
4. PREVENTIVE AND OTHER ENVIRONMENTAL MANAGEMENT COSTS			
➢ Equipment Depreciation			
➢ Operating Materials, Water and Energy			
➢ Internal Personnel			
➢ External Services			
➢ Other Costs			
TOTAL ENVIRONMENT RELATED COSTS			
5. ENVIRONMENT RELATED EARNINGS			
➢ Other Earnings			
➢ Funding for CP/EMS Projects			
TOTAL ENVIRONMENT RELATED COSTS AND EARNINGS			

Figure 9: Environmental Costs, detailed by Financial Accounts

2.2.1. Materials Costs of Non-Product Output

Once the total material input has been recorded in physical and monetary term, the next step is to estimate loss percentages. The losses for each material input category (non-product output, NPO) need to be traced or estimated. Advice on the calculation of NPO is provided as follows:

Raw materials
Non-product raw material output will mostly be disposed of as solid waste. Only if the products are gaseous (e.g.: industrial gases, perfume) it will be emitted to the atmosphere. More common are liquid products (e.g.: beer, milk). The Non-product raw material output is then disposed as wastewater.

For a first estimate, company internal calculation percentages for scrap can be used to estimate the non-product output of raw materials. Eventually, with more detailed material flow balances, scrap percentages may need adjustment. The reasons, why raw materials do not become products are manifold and well worth to study. Product returns, obliteration, repackaging for other countries or specified customer requests, quality control, production losses, spoilage, wastage, decay in storage, shrinkage, etc. are some of the causes of waste generation that call for measures to increase production efficiency, which may be profitable both from an economic and ecological point of view.

Auxiliary materials
These materials become part of the product, but are not its main components (e.g. glue in furniture or shoes). Often, they are not monitored separately. Again, their non-product output should be estimated in a first assessment and may then be monitored in more detailed cost accounting projects. The employees at the related production lines often can provide very good estimates, which are not known to the environmental and financial departments.

Packaging
Purchased packaging for products will mostly leave the company with the product, but again a certain percentage for internal losses, e.g. due to repackaging for specific destinations, should be estimated.

Operating materials
Operating materials are by definition not contained in the product. Some materials may be put into the buildings, but the major part of chemicals, solvents, detergents, paint, glues etc. goes to non-product output. They can contain dangerous substances that need to be disposed of separately. These materials are usually not recorded in the warehouse management system, but are assigned to expenditure at the time of purchase. In most organizations, their consumption is not recorded on the production cost centers, making it practically impossible to trace who has used how much of them. In cost calculation, only estimates are used for the calculation of product prices, but hardly ever somebody checks if these estimates confirm to real consumption.

Administrative operating materials (like paper and other office supply) are not regarded in the first assessment. All other operating materials (especially chemicals, maintenance materials, etc) are assigned to NPO by definition.

Energy
All energy input causes environmental impacts, escapes as heated water, air, and radiation and unless the company involved is a utility, energy is not the product. Energy input in most organizations is therefore 100 % NPO. This allows for the best possible consistency with the input-output balance of the environmental report, and the data collection can continue without technical estimation.

Some companies however prefer to record 100 % energy input in the mass balance, but to consider only the energy use of environmentally relevant equipment defined in the later cost categories (e.g. compressors, waste water plants, after burners, etc.), just as the other operating costs of such equipment, for the annual total EMA compilation.

Water
Water consists of all the fresh water from public grids, water from private wells, and surface water. The purchase cost of water is attributed to material input. For some sectors, especially in the food industry, some water goes to the product, in which case only a percentage of water input should be quoted under purchase value of non-product output.

2.2.2. Classification of Equipment

The next step after the Mass Balance and NPO classification is the assessment of environmentally relevant equipment. The term "equipment" may comprise a single machine or an entire production hall. It is recommended to investigate the equipment types by the list of cost centers.

Four categories can be distinguished (Jasch, Schnitzer, 2001):

1. **End of pipe equipment – emission control** : equipment, machines, constructions, etc. that exist solely for environmental protection or clean up, and are not necessary for production (e.g. wastewater treatment, dust removal, waste separation, etc.). This is the traditional focus of reporting requirements to environmental agencies and statistical institutes. The equipment is comparatively easy to trace, as it is stand alone equipment not related to production. It is perceived as additional burden and expensive. It clearly falls under the End-of-Pipe Category and may often be found on a separate cost centre (e.g. for waste water treatment).

2. **Cleaner technologies:** Integrated pollution prevention equipment comprises a certain share of equipment, machines, constructions, etc. that may have been slightly more expensive as they produce less waste or emissions in production (enamelling line with after-burning, boiler plant with flue gas cleaning, bottle washing line with separate discharge of glass, paper, and metal, all equipment capsuled for noise reduction, etc.). But they are much more effective from an environmental protection point of view and much more cost efficient. As they are integrated into production processes, the „environmental share" is difficult to estimate and should only be recorded in the EMA template, if it was significant.

3. **Product oriented prevention measures**: Sometimes equipment is installed to reduce the environmental impact of products, e.g. desulphurisation of petrol, which may partly be considered integrated prevention.

4. **NPO producing equipment**: Since producing emissions and waste is environmentally relevant, so is equipment, which produces them. This equipment could be old boiler plants and non-insulated pipes that cause avoidable energy losses requiring higher energy input. Other examples are equipment that produce extra waste, require over proportionate cleaning or a fleet of cars that uses too much fuel. The environmentally relevant portion of this equipment may be calculated by the portion of avoidable waste or emissions (avoidable loss of heat, too high water use in cleaning, etc). Since this equipment produces avoidable emissions and waste (e.g. old boilers, enamelling lines that paint products that have to be painted again, steam supply with heat losses, etc.), it is the most relevant category from an

Cleaner Production point of view. This is, where significant savings can be expected and where good data for investment appraisal would be required. Relating material loss percentages to the responsible inefficient production equipment is therefor most relevant for internal cost accounting. The equipment may be recorded in the EoP-Category as it is directly responsible for producing waste and emissions that need to be treated.

2.2.3. Waste and Emission Control Costs

This cost category comprises **conventional waste disposal and emission treatment costs** including related equipment labor and maintenance materials. It comprises all treatment, disposal and clean-up costs of existing waste and emissions and can often be directly traced from cost centers like waste water treatment or waste management.

Depreciation for related equipment
This cost category contains the depreciation for EoP equipment. Depreciation spreads the investment costs over the expected life time for the equipment. Depreciation can be based on financial or cost accounting procedures, or simply be estimated as 10 % of investment costs, depending on the accounting preferences of the organization.

Related Personnel
Labor time related to waste and emission relevant equipment is recorded here as well as personnel for waste collection and disposal and members of a wastewater treatment plant that are directly related to the existing waste and emission flow and equipment.

Taxes, Fees, Charges, Permits
Disposal fees, wastewater fees, packaging-license charge, energy taxes, emission permits and other eco-taxes are to be recorded.

Fines and Penalties, Clean up costs, remediation, etc.
The fines for surpassing pollution restrictions are to be recorded. In some sectors costs for clean up, remediation and landscaping may be required, especially in the mining and oil industry, for gas stations, power plants, etc.

2.2.4. Prevention and environmental management costs

This cost category is termed **prevention and environmental management** and records the labor costs and external services for good housekeeping as well as the "environmental" share of cleaner integrated technologies, if significant. Prevention activities are actually inherent to environmental management. Research and development for environmental projects is also part of pollution prevention. The main focus of this category is on annual costs for prevention of waste and emissions, but without calculated cost savings.

Depreciation for related equipment
Also this cost category starts with identifying prevention related equipment and estimating its “environmental share”, if significant.

External services for environmental management
Outside help is usually required for developing an environmental management system. These costs, plus costs for environmentally relevant inspections and audits, and the costs for environmental trainings, reports and other dissemination materials are to be recorded.

Internal personnel for general environmental management activities
In this cost category the time for internal personnel for general environmental management activities, not directly related to emission treatment or the production of non-product output should be recorded. Work hours for training programs including travel expenses, environmental management activities and projects, audits, compliance and communication should be estimated and evaluated with the respective work hour costs including social security and taxes.

Other environmental management costs
In case the business is active in environmental sponsoring, this and any other non assigned costs should be recorded. It is recommended that the environmental team does a brainstorming on the significant activities of the previous year, and that all projects of the environmental program are included. Research and development costs could also be recorded in this category.

2.2.5. Environment related Earnings

Revenues from selling recycling materials and other by-products, as well as funding for CP/EMAS projects and awards are recorded here. It is recommended not to offset sales of materials in the input category, but to separately account for it.

2.3 Mapping Process Flow Charts with Cost Centers

The next step after environmental cost assessment and material flow balances on a corporate level is to allocate the data from the system boundary of the company fence to internal processes.

Process flow charts, which trace the inputs and outputs volumes of material flows (solid, liquid and volatile) on an engineering process level, give insights into company-specific processes and allow the determination of losses, leakages and waste streams at the originating source. This requires a detailed examination of individual steps in production - again in the form of an input-output analysis, but sometimes linked to technical Sankey diagrams.

The process flow charts may be used to combine technical information with cost accounting data. This can be done on a yearly basis, but also for a specified production unit, machinery or cost center. In total, they should aggregate to the yearly amount.

This level of material flow analysis will be in the responsibility of technicians, but the data gathered should be cross-checked to ensure consistency with the cost accounting system. Usually a harmonization of technical data with data from financial bookkeeping is not undertaken due to lack of inter-departmental communication. Experience has shown that such a consistency check provides great optimization potentials, and has thus become a major tool in environmental accounting. Consistent data and information systems for process engineering and financial accounting are vital for efficient production management.

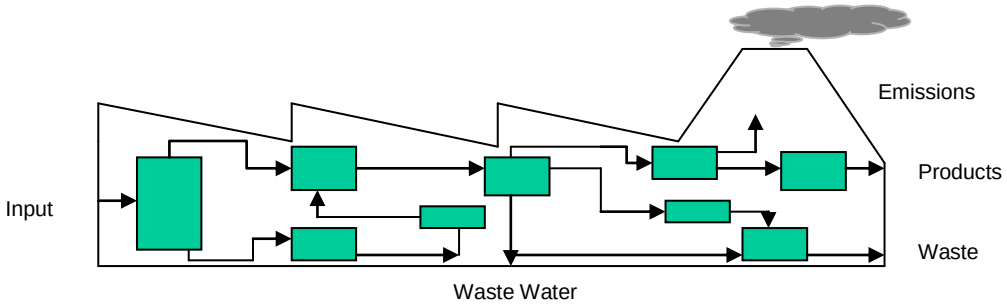

Figure 10: Process flow charts: Opening of black box

Splitting up the corporate flows into cost centers, or even down to specific production equipment allows for more detailed investigation of technical improvement options, but also for tracing the sources of costs. Special attention should be drawn to the quantitative recording of materials on a consistent kilogram basis. The key questions are:

- What cost center have processed how much of the materials?
- Can material inputs be further divided to production lines or specific equipment?
- How large are the resulting emissions, scrap and waste, preferably recorded separately for each cost center, production line and machinery?

The process level is the main focus for pollution prevention and cleaner production projects. Data on the process level is also necessary for further analysis by products. It is crucial that the system boundaries for financial calculation by cost centers and for technical monitoring can be related to each other. To ensure consistency between data from cost centers and process flow charts, the methods of activity based costing and of material flow cost accounting have been developed.

2.4 Application of MFCA for selected processes

Material Flow Cost Accounting is based on the Assessment of the Input-Output-Analysis as described in Chapter 2.2. In addition, it creates a convention for the calculation of related costs. While in conventional cost accounting all material purchase and processing costs are being attributed to the product, MFCA attributes the Costs of Material Inputs to Product Output and Non Product Output based on the volume flows (and related loss percentages).

Chapter 2.2. and 2.3. described the procedure for the company level, but once the process flow charts and the cost centers have been mapped, the cost of NPO can also be attributed following the flow of raw materials through all cost centers.

Material Flow Cost Accounting (MFCA) also starts at the company level and may then being divided into the various production steps, cost centers and single processes. It may also be enlarged to include the material flows along the value-added chain, from incoming goods, by way of various processing stages, through to product distribution to the customer. It includes all the material losses incurred at various stages along the logistics chain (e.g., rejects, scraps, chippings, destruction of

expired items or damaged goods), which then leave the company as environmentally and economically undesirable Non Product Output (solid waste, effluent, emissions).

In March 2008 the technical committee of the International Standardisation Organisation, ISO TC 207 Environmental Management, as adopted a new work item on MFCA, ISO 14051. Annex B of the new work item proposal (ISO/TC 207 SC N 856) provides a simple example highlighting the different costs calculation procedure between conventional cost accounting and MFCA. The production process in the example produces one product from 100kg materials with materials purchase costs of 1,000 € and processing cost of 600 €. The value of the waste is not recorded separately in conventional cost accounting, but automatically included in the cost of product output. Mostly, companies include disposal fees in general overhead which is levied to production costs.

However, in MFCA waste is treated as a separate negative product (identical to the definition of NPO), and proper amounts of costs are allocated to it based on the weights of product and non-product output. Therefore, the value of the waste as a negative product is calculated as 320 € based on the loss percentages for raw materials. This information provides an incentive to management to reduce these costs. In well-developed MFCA systems this cost allocation is performed for each production step, which results in considerably high costs of negative products.

Material flow cost accounting at a cost centre or process level may be recommended, if:

- The portion of material costs of the entire operational expenditures are least 30%.
- There are production procedures, where a broad product range can go through alternatively various production steps.
- Product prices are being calculated on basis of the cost center accounts.

In business sectors, where basically one product is produced with a closed procedure (breweries, paper industry, and energy industry) an extensive allocation of material flows to different cost centers and production process does not necessarily need to be installed. In these sectors it may be sufficient to perform the MFCA on an annual basis for the system boundary of the company and only collect additional data for specific processes and/or projects.

2.5 Recommendations for the improvement of the information systems

Some recommendations for the improvement of data collection and information systems have resulted from several company case studies:

- **Data recording of material purchase by material groups in financial accounting**

In many companies the entire material purchase is booked on one account only (material purchase) and not to several accounts according to the different materials. Even if materials are also assigned numbers it is difficult to expose the actual material use into material groups. As an aid, the recordings of the production manager can perhaps be multiplied with average prices, in order to be at least able to indicate orders of magnitude. The fact that such a system cannot strengthen cost consciousness in handling raw, auxiliary and operating materials is obvious. It is recommended, that the purchase for each material group is recorded on a separate account and that inventory differences are recorded separately.

- **Separate accounts for material groups**

A clear distinction between the accounts for raw, auxiliary and operating materials is necessary, especially when non-product output (NPO) costs are intended to be assessed. Raw and auxiliary materials are part of the product, thus loss percentages need to be calculated or estimated. Operating materials are by definition not part of the product and thus must become part of waste and emissions. The amounts and values used are often not consistently recorded.

- **Separate materials from services**

Accounts for materials and utilities should be clearly distinguished from accounts for services. If only materials are collected on an account than the volumes used may be estimated dividing with average prices. Materials and supplies for maintenance need to be separated from maintenance services, thus allowing total materials input to be calculated.

- **Posting of inventory losses**

The posting of inventory changes should be carried out separately for the different materials accounts and include a separate recording of the price and volume difference. This way, accurate data on materials inputs and outputs in volume and price can be obtained for each material group and the total amounts and values of materials used are available for further controlling measures. Posting of the total difference of inventory change to one separate account leads to ignorance regarding actual materials used.

- **Recording of material numbers in production planning systems**

It should be clearly defined, which material numbers belong to which material group and account. The material groups should be traceable, e.g. by separate accounts. This recommendation calls for a consistent hierarchy between accounts, material groups and material numbers on stock.

Volumes should be added gradually to the recordings of material numbers in stock management. This way, consumption would be aggregated automatically into volumes. Consistent use of volumes (kg), nit units (pieces) in the information system ensures that the total sum automatically aggregated does not have to be manually corrected.

- **Estimation and recalculation of scrap percentages**

The loss percentages for raw materials, packing material, auxiliary materials and the final product are often based on outdated estimated values and only are recalculated for a few material groups. The employees on-site usually have more precise estimated values than the accountants. A correct recalculation mostly raises frightening results.

Strive for consistency of system boundaries for MFCA in technical and financial information systems and define, which accounts, cost centers and cost categories must be consistent by amount and value.

The input-output material balance is hardly ever consistent with the system boundaries of the accounts and cost center reports. For the recording of the costs and amounts of waste in one company project three different values and records were provided for one site (record of the environmental manager without the costs for weighting, transport and rent of disposal cans, the financial account with some wrong postings and the accounts of the several suppliers with additional services).

- **New Accounts**

Separate accounts for the utilities (energy, water) should be established, defined as direct costs of production.

Earnings from sales of scrap metals; steam condensate etc. should not be offset directly against the materials purchase account. Instead separate accounts for other earnings from by-products should be established.

- **Mass, water and energy balances for defined process steps**

During the first MFCA assessment, the mass balance is split up to the main production steps or cost centres. Establish data monitoring points to regularly repeat this exercise and check consistency with existing information systems.

- **New Cost Centers**

Reworke the structure of cost centres and make it consistent with technical data monitoring interfaces, so that regular performance measurement became possible. The creation of own cost centers is recommended for:

- Waste disposal dumps (in the case of existing or planned own waste disposal dumps, but not, if waste management is basically outsourced and no equipment and land is used)
- Waste water treatment plants (especially if related with own personal, significant maintenance and chemicals consumption)

2.6 EMA for investment appraisal of CP technologies

Environmental managers face a typical dilemma when it comes to investment decisions related with environmental protection. Firstly, they often have an engineering background and are not so familiar with accounting tools. Secondly, they often have no direct access to the financial information system. Thirdly, the data that would be needed to show the costs of existing inefficient equipment are not visible in the existing accounting information systems. Thus, the benefits of integrated pollution prevention are often underestimated.

Conclusions from several case studies thus emphasize the need for

- Improved consistency between physical and monetary data of organizations and operations,
- Improved communication between the related departments.
- Material flow accounting as a basis for good cost accounting.

Investment appraisal is used to determine the cost savings of an investment option with regard the current situation or for comparing two investment choices. It is thus essential, that the current status of operating cost of equipment and related physical material flows are known.

The economic variables for assessment in static financial analysis include:

- Initial investment costs
- Operating costs and earnings,
- Profit,
- Return on Investment, and
- Pay-back period.

All methods of investment appraisal assume that all future inputs and outputs of an investment decision are quantifiable and financial values can be attached to them.

In dynamic financial analysis, the expected future monetary inflows and outflows are discounted to the time of the investment and calculated into internal discount rate or annuity. The opportunity costs of capital (the lower value of cash flows which don't occur today, but only in the future) are considered by discounting them with the interest rate of financial markets. The sum of all discounted future cash flows determines the net present value of a project or investment, which is compared to the value of the old equipment and to the interest rate of financial markets. A planned investment has to be more profitable then gaining interest on a bank deposit.

Payback methods for capital budgeting do not consider cash flows beyond the payback period. Some companies adopt internal rules that only projects with a payback period of two or three years will be accepted, regardless of possible longer term benefits. Discounted cash flow methods in principle consider all relevant future cash flows until the project ends, but as many companies apply excessively high interest rates, which result in a negligible present value for medium and long term costs and savings, only the first three years count in effect for the investment decision.

The approach and shortcomings of methods such as the payback period, internal rate of return, or internal interest rate (IIR) are discussed in any textbook on corporate finance.

For cleaner production and environmental protection, the task is not so much to change the basic concept of discounting future monetary flows, but to ensure the inclusion of all relevant earnings and expenses. Measures for pollution prevention help to reduce not only disposal and emission treatment costs but also increase the efficient use of purchased materials and energy. Costs of lost input materials are usually much higher than pollution treatment costs, however, when calculating

investments, the reduced costs for materials and emission treatment are often not completely calculated. This results in distorted investment decisions.

The calculation sheet for environmental costs by financial accounts in Figure 10 may also be used to calculate several investment alternatives and comparing them, or to directly estimate resulting cost savings. An annual assessment of total environmental expenditures should have been performed beforehand, in order to provide a sound data basis. Depending on the project or investment, only some cost categories may be relevant, but the likelihood of forgetting significant cost factors is decreased.

Once the total costs of two alternatives have been assessed for one year, they can be extended into time series for capital budgeting. Estimates of monetary inputs and outputs for the first three years should be more detailed. For years 4 to 10 rough annual estimates would be sufficient.

Once the data is available in good quality, the actual calculation can then be made by applying the related functions in Microsoft Excel or by using the UNIDO COMFAR III EMA tool. The procedures how to apply COMFAR III Environmental Management Account (EMA) project type for the financial appraisal of Cleaner Production (CP) Technology Options does not differ significantly from the methodology applied for the COMFAR project types.

3. Case study of a brewery

Obermurtaler Brauerei is a small country side brewery with about 150 people. It has implemented 14001 and EMAS for 12 years and was actually the first Austrian site to be EMAS verified. EMAS is the European certification scheme for environmental management, which uses ISO 14001 as basis for the environmental management system but in addition focuses on environmental performance improvements and publication of the environmental statement. The brewery also carries the Austrian Ecolabel for returnable beer bottles. It has also participated in pilot studies to develop the UNDSD and IFAC EMA approach. The following data is based on the extensive environmental report for 2005 (www.murauerbier.at) and pilot studies, where also other breweries were involved (Jasch, Schnitzer, 2002). The data does not directly relate to the actual figures of the brewery.

The total annual environmental costs are assessed together with an extensive performance indicator system on an annual and partly monthly basis. The environmental costs are traced from the list of accounts, the cost centre reports and performance indicator reports from production statistics (e.g. materials input per beer produced, loss percentages and production volume) and environmental management (e.g. waste volumes).

The EMA excel template for the data assessment shows

- the aggregated input output balance in values and volumes,
- the material flows by cost centers and
- the detailed environmental cost assessment,
- which is aggregated to an overview and
- a percentage distribution of costs.
- The costs are also distributed by cost centre, which provides a good basis for investment appraisal.

The brewery uses the following production cost centers:

- Brewing malt and mills
- Brew House, Wort production
- Fermentation and Storage Cellar
- Filtration
- Bottling and barrel filling

In addition, the following supportive cost centers/sub cost centers are used:

- Storage facilities for Brewing and Operating Materials
- Maintenance
- Steam/Heat production
- Refrigeration
- Waste Water Treatment
- Logistics
- Health Safety Environment and Quality Management System
- Administration

Input	Production CC	Supportive CC	Output
		Storage facillities for Brewing and Operating Materials including CIP plants	
Malt, Brewing Water, Cleaning agents, Energy	Brewing malt and mills (Grinding, Mashing and Purification)		Spent grains, Dust, Heat, Waste Water
Hop, Water, Cleaning agents, Detergents, Energy, Refrigerant	Brew House, Wort Production (Stammwürze)		Hops waste, Brewing residue, Heat, Waste water
Yeast, Sterile Air, Refrigerant, Water, Energy	Fermentation and Storage Cellar (Fermentation of the malt sugar with yeast)		Yeast, Wasted beer, Carbon dioxide, Waste Water
Water, Energy, Carbonic Acid, Cleaning agents, Disinfectants, Refrigerant,Auxiliary materials	Filtration (Separation of yeast and proteins)		Waste water, Filtrate, Auxiliary materials, Carbon dioxide
Water, Energy, Carbonic Acid, Cleaning agents, Disinfectants, Packaging materials	Botteling and barrel filling		Waste Water, Sludge, Solid Waste, Heat, Residue, bottled wasted beer
Operating materials, Energy		Maintenance	Operating materials
Energy, Refrigerant		Steam/Heat production	Heat, Air emissions
Refrigerants, Energy		Refrigeration	Air Emissions
Operating materials, Energy		Waste water treatement	Waste Water, Waste
Petrol		Logistics	Air Emissions
Operating materials, Energy		HSEQ MS	Operating materials
Operating materials, Energy		Administration	Operating materials
Total cost centres	5	8	

Figure 11: Process flow charts and cost centres of the brewery

3.1 Input- Output Material Flows

Figure 12 shows the Material Flow Balance of the brewery. The physical mass balance doesn't balance off to zero, as not all volumes are recorded yet (e.g. packaging volumes, tools and maintenance supply) and as water is part of the product, the mass balance is rather tricky, having to include the energy and water balance as well. But even without balancing the input output analysis provides a very good controlling instrument and figures are monitored for each relevant material group on a separate account.

The monetary value of non-product output is traced in the subsequent assessment of financial data, but not in the mass balance. Turnover needs not be accounted for EMA purposes.

The focus in recent years has been to record also operating materials in the enterprise resource planning system and record their also on a cost centre level in order to be able to better monitor material flows.

MATERIAL Flow Balance/ INPUT / OUTPUT	**EURO**	**tonnes(unless otherwise indicated)**	**Source of information for EURO**	**Source of information for tonnes**
1. Materials Inputs			Account number	
1.1. Raw and Auxiliary Materials				entreprise resource planning system
Malt	1.000.000	4.000	5100	
Hop	120.000	500	5101	
Burst rice	120.200	200	5102	
Auxiliary materials	12.150	100	5110	
CO2 Purchase	100.000		5111	
Subtotal	**1.352.350**	**4.800**		
1.2. Packaging Materials				not yet recorded in volumes
Bottle caps lemonades	17.000		5301	
Bottle caps beer	80.000		5302	
Labels Beer	100.000		5310	
Beer cases 100% of new purchase to the closed loop system	30.000		5320	
Label glue	15.000		5330	
6 bottle-trays	160.000		5340	
Beer bottles	45.000		5341	
Pallets	14.200		5350	
Subtotal	**461.200**	**0**		
1.3. Operating Materials				
Cleaning agents	190.000	210	5400	entreprise ressource planning system
Refrigerants	40.000	50	5401	

Neutralisation agent	35.000	250	5402	
Filtering agents	20.000	30	5403	
Laboratory material	20.000	1	5404	
Lubricants	11.000	1	5405	
Tools and maintenance supply	5.000		5500	not yet recorded
Subtotal	**321.000**	**542**		
1.5. Water				
Ground water consumption in hl	0	0		not in use
Water from own wells in hl	0	1.300.000		metering system
Water consumption from public supply (hl)	50.000	1.000.000	5650	invoice
Subtotal	**50.000**	**2.300.000**		
1.6. Energy				
Electricity (kWh)	275.000	2.700.000	5600	invoice
Heating oil extra light (Liter)	200.000	700	5601	invoice
Fuels (Liter)	21.300	300	5602	invoice
Diesel vehicle fleet (Liter)	200.000	370.000	5603	invoice
Subtotal	**696.300**			
TOTAL MATERIALS COSTS / INPUT	**2.880.850**			
2. Product Output			Account number	
2.1. Products				
beer (in hl), bottled or in KEGs	1.000.000	260.000	total production costs from financial statistics and calculation sheet for production costs	production statistics
Subtotal	**1.000.000**	**260.000**		
2.2. Byproducts				
brewing residue for agricultural composting	-3.500	280	4101	production statistics
semi-solid mineral silt for agricultural composting	0	240	delivered free of charge	production statistics
wet Draff for agricultural composting	-35.000	5.500	4100	production statistics
Subtotal	**-38.500**	**6.020**		
TOTAL TURNOVER / PRODUCT OUTPUT	**961.500**	**266.020**		
3. Non-Product Output				
3.1. Solid Waste				
Waste to Municipality		20		waste recording system
Waste for Recycling		430		waste recording system
Hazardous Waste		7		waste recording system
Waste oil		0		waste recording system
Subtotal		**457**		

3.3. Waste Water				
Quantity of waste water in m^3		96.200		metering system
COD		153		calculated from laboratory results
Subtotal				
3.4. Air Emissions				
CO^2 emissions heating plant		2.500		calculated from energy input
CO^2 emissions vehicle fleet		1.000		calculated from energy input
Subtotal		**1.000**		
TOTAL NON-PRODUCT OUTPUT				

Figure 12: Input-Output Material Flows of the Brewery

3.2 Total annual environmental costs

The detailed cost assessment is automatically aggregated into a one page display of the totals of the sub-cost categories. The interpretation of results is simplified by referring to the automatically converted excel template of the percentage distribution of the total annual environmental costs.

ENVIRONMENT-RELATED COST CATEGORIES	Euro	%
1. MATERIALS COSTS OF NON-PRODUCT OUTPUTS	**1.631.557**	**66,1%**
1.1. Raw and Auxiliary Materials	338.273	13,7%
1.2. Packaging Materials	240.184	9,7%
1.4. Operating Materials	321.000	13,0%
1.5. Water	50.000	2,0%
1.6. Energy	682.100	27,6%
2. END-OF-PIPE	**598.570**	**24,2%**
2.1. Equipment Depreciation	121.370	4,9%
2.2. Operating Materials	75.200	3,0%
2.3. Water and Energy	5.000	0,2%
2.4. Internal Personnel	192.300	7,8%
2.5. External Services	34.000	1,4%
2.6. Fees, Taxes and Permits	169.000	6,8%
2.7. Fines, Remediation and Compensation	1.700	0,1%
3. INTEGRATED PREVENTION	**285.600**	**11,6%**
3.1. Equipment Depreciation	37.800	1,5%
3.2. Operating Materials, Water, Energy		
3.3. Internal Personnel	222.500	9,0%
3.4. External Services	10.300	0,4%
3.5. Other	15.000	0,6%
TOTAL ENVIRONMENT-RELATED COSTS (1. + 2. + 3.)	**2.515.727**	**101,9%**
4. ENVIRONMENT-RELATED EARNINGS		
4.1. Other Earnings	-38.500	-1,6%
4.2. Subsidies	-8.000	-0,3%
TOTAL ENVIRONMENT-RELATED EARNINGS	**-46.500**	**-1,9%**
TOTAL ENVIRONMENT-RELATED COSTS & EARNINGS	**2.469.227**	**100,0%**

Figure 13: Total annual environmental costs of the brewery

The percentage distribution of total annual environmental costs clearly shows that emission control costs are comparatively expensive in relation to prevention activities. But even in a company that has practiced environmental management and integrated prevention for 20 years, the most significant cost category are the materials costs of non product output with 66 % of total costs. This is where one still finds saving potentials.

On the other it must be said, that price changes also influence these figures. In the light of rising resource prices many companies are horrified by the thought of what they would have to pay today had they not invested into efficiency improvements in the last years. It must also be said that total energy input already constitutes 28 % of environmental total costs.

Several companies don't publish their actual cost but do disclose the percentage distribution. The figure for energy provides a good estimate of the total relation of the cost structure. Energy related impact on air and climate is also the most important cost category by environmental media.

The next two significant cost items are the losses of raw materials and operating materials, which each account for 14% and 13 % of total EMA costs. Together they are in the range of total energy input. While raw materials are more commonly monitored by organizations, the recording of operating materials by production processes and cost centers is not so common.

Only 3 % of the total costs relate to the operating materials directly attributed to the waste water treatment pant (line 2.2.) but another 13 % of total costs relate to operating materials that go down the drain (cleaning materials, lubricants, detergents, etc.).

Much of the solid waste is recycled and some is even sold which shows in line 4.1. other earnings.

4. References

- Bouma J.J., Wolters J. Management Accounting and Environmental Management: A survey among 84 European companies, Erasmus Center for Environmental Studies, Rotterdam, 1998
- Fischer, H., Wucherer, Chr., Wagner, B., Burschel, C. Umweltkostenmanagement. Kosten senken durch praxiserprobtes Umweltcontrolling, München, Wien, 1997.
- IFAC, Environmental Management Accounting International Guidance Document on environmental management accounting (EMA), International Federation of Accountants, IFAC, New York 2005, www.ifac.org
- International Organization for Standardization (ISO) ISO 14031, Environmental Performance Evaluation - Guideline and general principles, Geneva, 1999.
- International Organization for Standardization (ISO) ISO 14051, Material Flow Cost Accounting, Geneva, 2011
- Jasch Ch., Danse M., Environmental Management Accounting pilot projects in Costa Rica, in Bennet M., Rikhardson P., Schaltegger S. (Eds.) Implementing Environmental Management Accounting: Status and Challenges, Kluwer Academic Publ. , Dordrecht, NL, 2005
- Jasch Chr. Environmental Management Accounting: Procedures and Principles, UN Divisions for Sustainable Development, 2001.
- Jasch Ch., Schnitzer H., Umweltrechnungswesen – Wir, zeigen, wie sich Umweltschutz rechnet, Beispielsammlung zur Umweltkostenrechnung und Investitionsrechnung, Im Auftrag von Bundesministerium für Verkehr, Innovation und Technik sowie Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasser, Wien, erschienen als Schriftenreihe 29/02 des IÖW Wien, Oktober 2002 und in den Berichten aus Energie- und Umweltforschung des BM VIT 4/2003
- C. Jasch, Institut für Ökologische Wirtschaftsforschung, Vienna, Austria, Environmental and Material Flow Cost Accounting - Principles and Procedures, (Eco-Efficiency in Industry and Science, Vol. 25), Springer, Heidelberg, New York, 2009
- UNEP. 2001. Promoting financing of Cleaner Production Investments – UNEP Experience. Ari Huhtala. UNEP: Paris, 2001. www.financingCP.org
- UNIDO COMFAR III Expert, COMFAR III EMA Module, Vienna, 2009
- UNIDO, Jasch C., Funding options for SMEs to finance CP projects and EST investments, draft version, Vienna, 2007