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Environmental management — Material flow cost accounting — General framework

Management environnemental — Comptabilité des flux matières — Cadre général

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14051 was prepared by Technical Committee ISO/TC 207, *Environmental management*.

Introduction

The aim of this International Standard is to offer a general framework for material flow cost accounting (MFCA). MFCA is a management tool that can assist organizations to better understand the potential environmental and financial consequences of their material and energy use practices, and seek opportunities to achieve both environmental and financial improvements via changes in those practices.

MFCA promotes increased transparency of material and energy use practices via development of a material flow model that traces and quantifies the flows and stocks of materials within an organization in physical units. Energy can either be included as a material or quantified separately in MFCA. Any costs that are generated by and/or associated with the material flows and energy use are subsequently quantified and attributed to them. In particular, MFCA highlights the comparison of costs associated with products and costs associated with material losses, e.g. waste, air emissions, wastewater.

Many organizations are unaware of the full extent of the actual cost of material losses in adequate detail because data on material losses and the associated costs are often difficult to extract from conventional information, accounting and environmental management systems. However, once available via MFCA, these data can be used to seek opportunities to reduce material use and/or material losses, improve efficient uses of material and energy, and reduce adverse environmental impacts and associated costs.

MFCA is applicable to all industries that use materials and energy, including extractive, manufacturing, service, and other industries. It can be implemented by organizations of any type and scale, with or without environmental management systems in place, in emerging economies as well as in industrialized countries. MFCA is one of the major tools of environmental management accounting and is primarily designed for use within a single facility or organization. However, MFCA can be extended to multiple organizations within a supply chain, to help them develop an integrated approach to more efficient use of materials and energy.

This International Standard provides

- common terminologies;
- objective and principles;
- fundamental elements;
- implementation steps.

In addition, the annexes illustrate some of the differences between MFCA and conventional cost accounting, cost evaluation methods, and case examples of MFCA application from different sectors and a supply chain.

Environmental management — Material flow cost accounting — General framework

1 Scope

This International Standard provides a general framework for material flow cost accounting (MFCA). Under MFCA, the flows and stocks of materials within an organization are traced and quantified in physical units (e.g. mass, volume) and the costs associated with those material flows are also evaluated. The resulting information can act as a motivator for organizations and managers to seek opportunities to simultaneously generate financial benefits and reduce adverse environmental impacts. MFCA is applicable to any organization that uses materials and energy, regardless of their products, services, size, structure, location, and existing management and accounting systems.

MFCA can be extended to other organizations in the supply chain, both upstream and downstream, thus helping to develop an integrated approach to improving material and energy efficiency in the supply chain. This extension can be beneficial because waste generation in an organization is often driven by the nature or quality of materials provided by a supplier, or the specification of the product requested by a customer.

By definition, management accounting and environmental management accounting (EMA) focus on providing organizations with information for internal decision-making. MFCA, one of the major tools of EMA, also focuses on information for internal decision-making, and is intended to complement existing environmental management and management accounting practices. Although an organization can choose to include external costs in an MFCA analysis, external costs are outside the scope of this International Standard.

The MFCA framework presented in this International Standard includes common terminologies, objective and principles, fundamental elements, and implementation steps. However, detailed calculation procedures or information on techniques for improving material or energy efficiency are outside the scope of this International Standard.

This International Standard is not intended for the purpose of third party certification.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14050, *Environmental management — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14050 and the following apply.

3.1
cost
monetary value of resources consumed to perform activities

3.2
cost allocation
indirect attribution of a cost between different objects, such as a product or process, by using an appropriate apportionment basis.

NOTE In this International Standard, the object can be processes, quantity centres, products and material losses.

3.3
cost assignment
direct attribution of a cost to a specific object, such as a product or process

3.4
energy cost
cost for electricity, fuels, steam, heat, compressed air and other like media

NOTE Energy cost can be either included under material cost or quantified separately, at the discretion of the organization.

3.5
energy loss
all energy use, except energy incorporated into intended products

NOTE Energy loss can be either included under material loss or quantified separately, at the discretion of the organization.

3.6
energy use
manner or kind of application of energy

EXAMPLE Ventilation; lighting; heating; cooling; transportation; processes; production lines.

[ISO 50001:2011, definition 3.18]

3.7
environmental management accounting
EMA
identification, collection, analysis and use of two types of information for internal decision making:

— 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

[IFAC, 2005[15]]

3.8
input
material or energy flow that enters a quantity centre

3.9
inventory
stock of materials, intermediate products, products in process, and finished products

3.10
material
substance that enters and/or leaves a quantity centre

NOTE 1 Materials can be divided into two categories:

— materials that are intended to become part of products, e.g. raw materials, auxiliary materials, intermediate products;

— materials that do not become part of products, e.g. cleaning solvents and chemical catalysts, which often are referred to as operating materials.

NOTE 2 Some types of materials can be classified into either category, depending on their use. Water is one such material. In some cases, water can become part of a product (e.g. bottled water), while in other cases it can be used as an operating material (e.g. water used in an equipment washing process).

NOTE 3 Energy carriers like fuels or steam can be identified as materials, at the discretion of the organization.

3.11
material balance
comparison of physical quantities of inputs, outputs and inventory changes in a quantity centre over a specified time period

3.12
material cost
cost for a substance that enters and/or leaves a quantity centre

NOTE Material cost can be calculated in various ways, e.g. standard cost, average cost, and purchase cost. The choice between cost calculation methods is at the discretion of the organization.

3.13
material distribution percentage
proportion of the material inputs that flow into products or material losses

3.14
material flow
movements of a material or group of materials between various quantity centres within an organization or along a supply chain

3.15
material flow cost accounting
MFCA
tool for quantifying the flows and stocks of materials in processes or production lines in both physical and monetary units

3.16
material loss
all material outputs generated in a quantity centre, except for intended products

NOTE 1 Material losses include air emissions, wastewater and solid waste, even if these material outputs can be reworked, recycled or reused internally, or have market value.

NOTE 2 By-products can be considered as either material losses or products, at the discretion of the organization.

3.17
output
product, material loss or energy loss that leaves a quantity centre

NOTE Any intermediate or semi-finished product that leaves a quantity centre is treated as a product in MFCA.

3.18
process
set of interrelated or interacting activities that transforms inputs to outputs

[ISO 14040:2006, definition 3.11]

3.19
product
any goods or service

NOTE Adapted from ISO 14040:2006, definition 3.9.

3.20
quantity centre
selected part or parts of a process for which inputs and outputs are quantified in physical and monetary units

3.21
system cost
cost incurred in the course of in-house handling of the material flows, except for material cost, energy cost and waste management cost

EXAMPLE Cost of labour; cost of depreciation and maintenance; cost of transport.

3.22
waste management cost
cost of handling material losses generated in a quantity centre

NOTE 1 Waste management includes management of air emissions, wastewater, and solid waste.

NOTE 2 Waste management cost includes the following:

— the costs for onsite activities, e.g. reworking of rejected products, recycling, waste tracking, storage, treatment, and disposal;

— the costs for outsourced activities, e.g. waste storage, transport, recycling, treatment, and disposal.

4 Objective and principles of MFCA

4.1 Objective

The objective of MFCA is to motivate and support the efforts of organizations to enhance both environmental and financial performance through improved material and energy use by means of the following:

— increasing the transparency of material flows and energy use, the associated costs and environmental aspects;

— supporting organizational decisions in areas such as process engineering, production planning, quality control, product design and supply chain management; and

— improving coordination and communication on material and energy use within an organization.

4.2 Principles

4.2.1 Understanding material flow and energy use

The flow of materials should be traced in order to create a material flow model (see 5.4) that illustrates the movements of materials and the use of energy for all quantity centres where materials are stocked, handled, used, or transformed (e.g. storage, manufacturing processes, and waste management operations).

4.2.2 Linking physical and monetary data

Environmental and financial decision-making within an organization should be linked by the collection of data on the physical quantities of materials and energy use, and data on the associated costs. These two types of data should be clearly integrated via the material flow model.

4.2.3 Ensuring accuracy, completeness and comparability of physical data

Physical data on material flows should either be collected in consistent measurement units or with sufficient conversion factors so that the data may later be converted to a common measurement unit, preferably mass, for purposes of analysis and comparison. These data should be used to balance input and output flows to determine if there are any significant data gaps.

4.2.4 Estimating and attributing costs to material losses

The total costs caused by and/or associated with material losses should be estimated as accurately and practicably as possible, and these costs should be attributed to the material losses that generated the costs, not to the products.

5 Fundamental elements of MFCA

5.1 Quantity centre

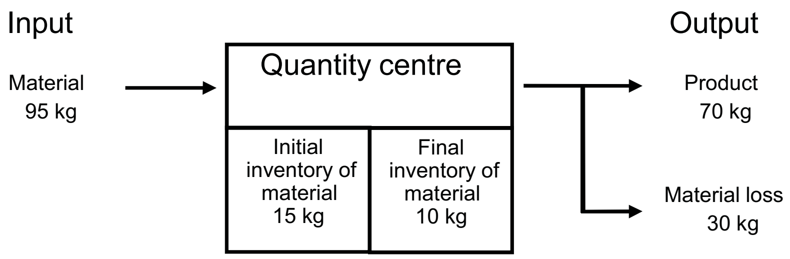
A quantity centre is a selected part or parts of a process for which inputs and outputs are quantified in physical and monetary units. Typically, quantity centres are areas in which materials are stocked and/or transformed such as storage, production units, and shipping points. The quantity centre serves as the basis for data collection activities under MFCA. First, material flows and energy use are quantified in quantity centres. Second, material costs, energy costs, system costs and waste management costs are quantified.

5.2 Material balance

Material that enters a quantity centre eventually leaves the quantity centre in the form of either product or material loss. Material can also reside within the quantity centre (e.g. storage) for a period of time, contributing to changes in inventory within the quantity centre (initial inventory minus final inventory).

Because mass and energy can neither be created nor destroyed, only transformed, the physical inputs entering a system should be equal to the physical outputs from the system, taking into account any inventory changes within the system. Thus, in order to ensure that all of the materials subject to the MFCA analysis are accounted for, material balance should be performed, comparing the quantities of material inputs to outputs (i.e. products and material losses) and changes in inventory to identify any significant "missing" materials or other data gaps. Quantification of material flows and the assurance of a balance between material inputs and outputs (i.e. products and material losses) are both essential requirements for MFCA.

An example of a simple material balance around a quantity centre is illustrated in Figure 1. In this example, 95 kg of material enters the quantity centre. Over the analysis time period, the inventory of the material changes from initial inventory of 15 kg to final inventory of 10 kg. The amount of material leaving the quantity centre is 100 kg, i.e. input (95 kg) plus initial inventory (15 kg) minus final inventory (10 kg). That 100 kg is distributed to product (70 kg) and material loss (30 kg) as illustrated in Figure 1.



NOTE For simplicity, this figure only includes information on material flows, not energy use.

Figure 1 — Material balance in a quantity centre

In practice, imbalances between inputs and outputs can occur due to the intake of air or moisture, chemical reaction effects that are not easily quantified, or measurement errors. Any significant imbalances should be investigated.

Physical data are often available in a variety of different measurement units. In order to perform material balance, conversion factors may be necessary for converting the available physical data to a single standardized unit (e.g. mass) for purposes of comparison. The need for data comparability should be taken into account when MFCA data collection is ongoing. The usefulness of the data units for the purpose of environmental impact assessment should also be considered.

5.3 Cost calculation

5.3.1 General

Decisions in organizations often involve financial considerations. Therefore, material flow data should be translated into monetary units to support decision-making. To that end, all costs caused by and/or associated with the material flows entering and leaving a quantity centre should be quantified and assigned or allocated to those material flows.

Under MFCA, three types of costs are quantified: material costs; system costs; and waste management costs. Energy costs can either be included under material costs or quantified separately, at the discretion of the organization. For the purposes of this International Standard, energy costs will be calculated and shown separately.

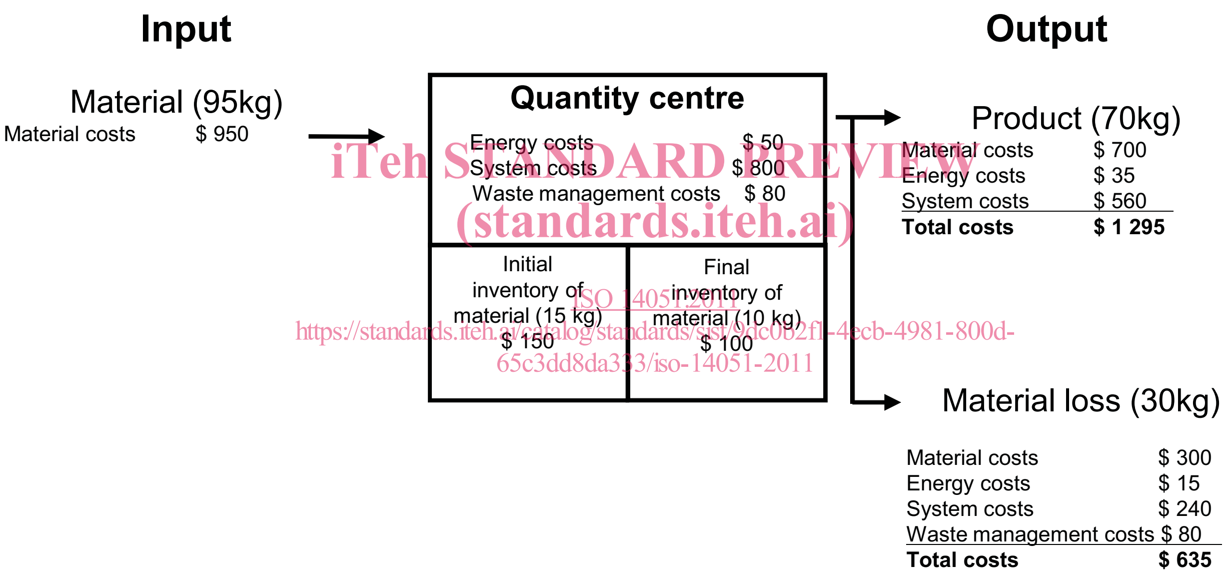


Figure 2 — Cost calculation in a quantity centre

In Figure 2, the costs incurred for the quantity centre are as follows:

— material costs: $ 1 000;

— energy costs: $ 50;

— system costs: $ 800;

— waste management costs: $ 80.

NOTE 1 Material costs ($ 1000) = input ($ 950) + initial inventory ($ 150) − final inventory ($ 100).

Material costs, energy costs and system costs are subsequently assigned or allocated to the quantity centre outputs (i.e. products and material losses) based on the proportion of the material input that flows into product and material loss. Of the 100 kg of material used, 70 kg flows into product and 30 kg flows into material loss, as illustrated in Figure 1. Thus, the material distribution percentages of 70 % and 30 % are used to allocate energy and system costs to the product and material loss, respectively. In this example, the material distribution percentage based on mass is used to allocate these costs, but determination of the most appropriate allocation criterion is at the discretion of the organization. In contrast, 100 % of the waste management costs of $ 80 are attributed to material loss, since the costs are caused solely by this material loss. In the final analysis, the total costs of material loss in this example are $ 635.

NOTE 2 The difference between MFCA and conventional cost accounting is illustrated in Annex A.

5.3.2 Cost allocation

In order to maximize analysis accuracy, all costs should be calculated from data available for individual quantity centres and individual material flows, rather than estimated by cost allocation procedures. However, costs such as energy costs, system costs, and waste management costs often are available only for an entire process or facility. Thus, in practice, it will often be necessary to first allocate these costs to individual quantity centres, and subsequently allocate them to products and material losses, in a two-step procedure, as follows:

— allocation of process-wide or facility-wide costs to different quantity centres; and

— allocation of quantity-centre costs to products and material losses (see Figure 2).

During each allocation step, an appropriate allocation criterion should be selected that reflects as closely as possible the main driver for the costs being allocated. When process-wide or facility-wide costs are being allocated to quantity centres, appropriate allocation criteria may include machine hours, production volume, number of employees, labour hours, number of jobs performed, floor space, etc. For the second step, allocation of costs from a quantity centre to products and material losses, another appropriate allocation criterion should be selected, e.g. the total material distribution percentage, the material distribution percentage of the main material. In all cases, determination of the most appropriate allocation criteria is at the discretion of the organization.

NOTE 1 The most appropriate allocation criteria for different types of costs, e.g. energy costs and system costs, will not necessarily be the same.

NOTE 2 Different allocation criteria can also be used for different components of system costs, e.g. labour costs, depreciation costs, if this will reflect the distribution of actual costs more realistically.

NOTE 3 All waste management costs within a quantity centre are attributed to material losses, by definition, as illustrated in Figure 2.

5.3.3 Cost carryover between quantity centres

An output from one quantity centre often becomes the input for another quantity centre. For example, Figure 2 illustrates a quantity centre with 70 kg product output. The costs associated with that product output are estimated as $ 1 295, i.e. a combination of material costs, energy costs and system costs that are expended to make that product. The total costs of $ 1 295 should be carried over and included as the costs associated with the input for the next quantity centre. Clause B.4 presents an example both visually and with quantitative data to illustrate how cost data are carried over when more than one quantity centre is involved. When carrying over the costs, the cost items (material cost, energy cost and system cost) can be expressed separately (see Table B.6).

5.3.4 Cost carryover of internally recycled material

Another example of an output that becomes an input is provided by the case of internally recycled materials. If materials are recycled internally within the MFCA boundary, both financial and environmental benefits can result. However, the fact that materials need to be recycled points to inefficiencies in the original process.

Internally recycled materials pass through quantity centres several times and each time may cause additional material, system, energy and waste management costs. For example, the energy use in a quantity centre often depends on the amount of material throughput. Therefore, the inefficiency that leads to internal recycling increases the throughput of the quantity centre to achieve the same amount of product output, and increases the energy use and related energy costs as well.

