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Environmental management — Material flow cost accounting — General framework

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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

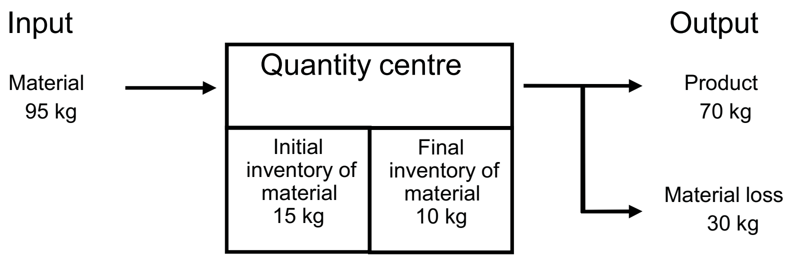
A quantity centre is a selected part or parts of a process for which inputs and outputs are quantified in physical and monetary units. Typically, quantity centres are areas in which materials are stocked and/or transformed such as storage, production units, and shipping points. The quantity centre serves 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.

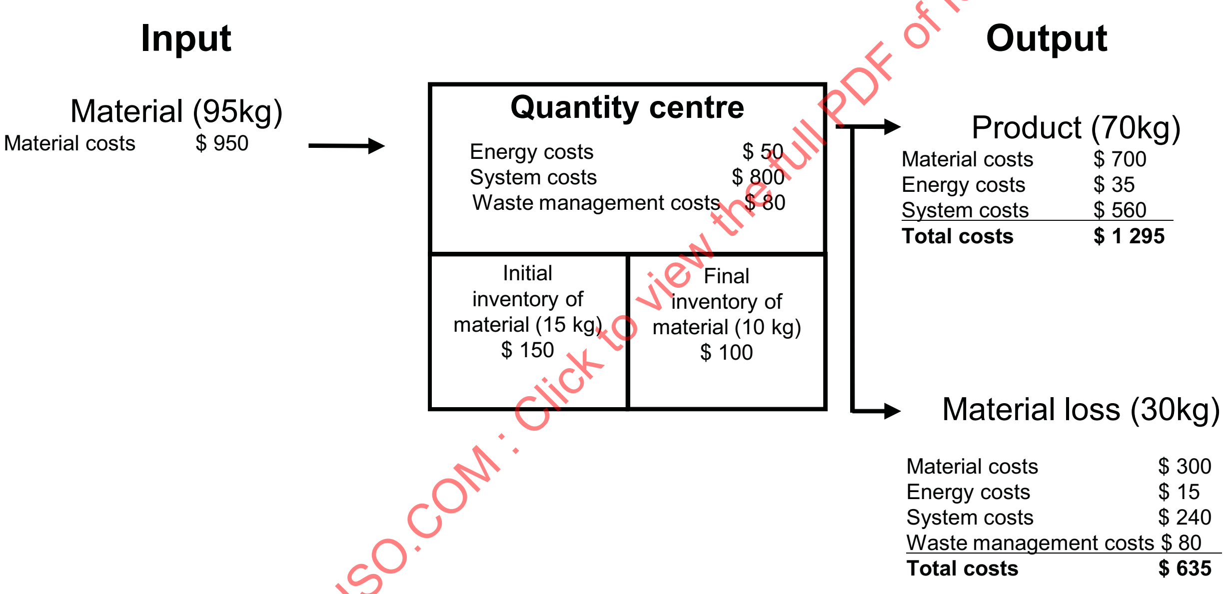


Figure 2 — Cost calculation in a quantity centre

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.

If material loss occurs in a quantity centre and is recycled internally, it should be handled in the same way as any other material loss. This means that the quantity centre costs should be allocated to products and material losses in accordance with 5.3.2. To properly assess the costs of internal recycling, the following should be taken into account:

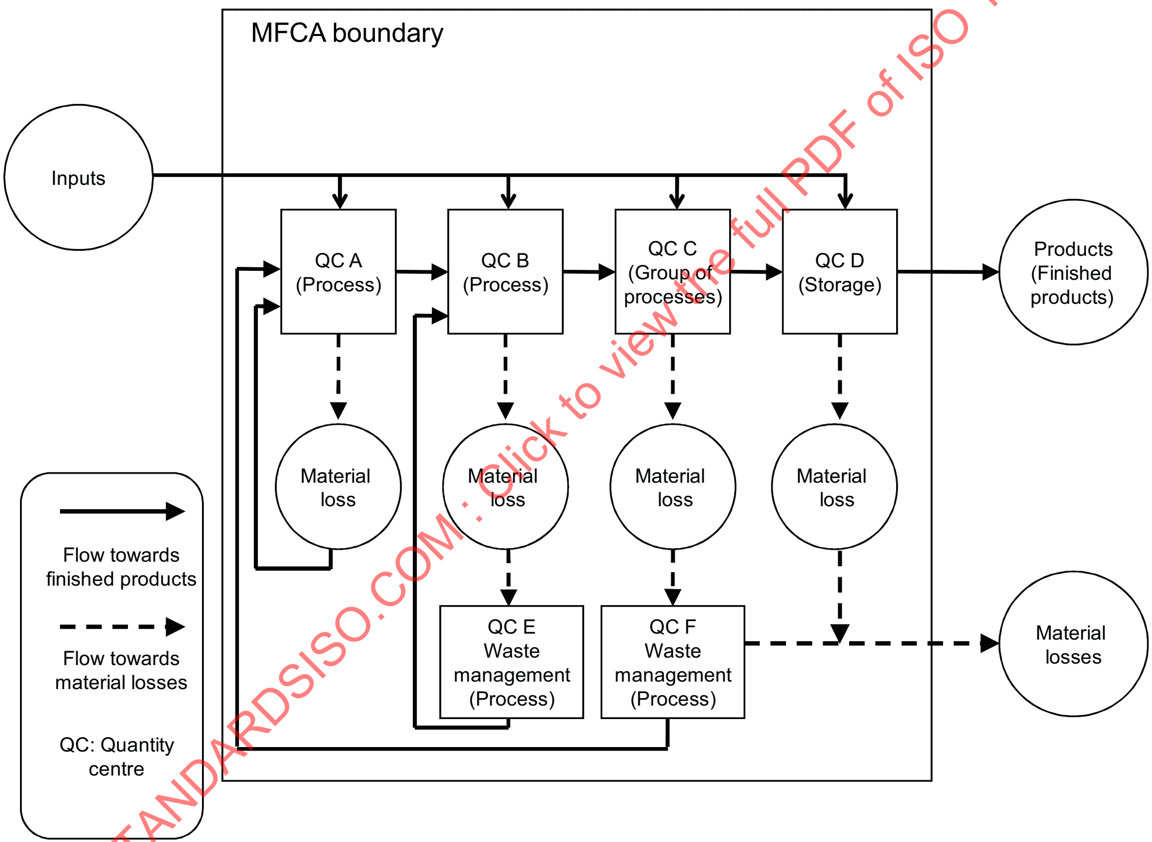
— cost savings of internal recycling, i.e. purchase value of substituted material;

— additional costs of the recycling process;

— additional costs in other quantity centres caused by the flow of recycled material through the system.

5.4 Material flow model

In MFCA, production, recycling, and other systems are represented by visual models that illustrate multiple quantity centres in which materials are stocked, used, or transformed as well as the movements of materials between those quantity centres. Such a material flow model illustrates the overall flow of materials within the boundary chosen for MFCA analysis. An example of a material flow model is provided in Figure 3.



NOTE The MFCA boundary can be extended to other organizations in the supply chain, both upstream and downstream.

Figure 3 — Material flow model for a process within the MFCA boundary

Figure 3 depicts a flow system, providing an overview of an entire process and identifying the points where material losses can occur. Products include both finished products and intermediate products, i.e. material inputs to other quantity centres. For each quantity centre illustrated in Figure 3, the modelling and calculation explained in 5.2 and 5.3 should be conducted. Where material losses or a certain percentage of them are recycled within the MFCA boundary directly or after a treatment process, they are shown as inputs. These input flows are shown in QC A and QC B in Figure 3.

6 Implementation steps of MFCA

6.1 General

Like any other management tool, MFCA requires a number of implementation steps, as outlined in this clause. The level of detail and complexity of the analysis will depend on a number of factors, such as the size of the organization, the nature of the organization's activities and products, the number of processes and quantity centres chosen for analysis.

MFCA can be implemented in organizations with or without an environmental management system (EMS) in place (e.g. ISO 14001), but the implementation process is easier and faster in those that do so within the context of an existing EMS. MFCA can provide significant information in various stages of the Plan-Do-Check-Act (PDCA) continual improvement cycle. For example, the use of MFCA allows the organization to include financial considerations in establishing objectives and targets. The knowledge of potential environmental impacts and financial impacts can enhance the quality of the evaluation, providing useful information for decision-making.

Figure 4 provides an outline of the MFCA implementation steps constructed in accordance with a PDCA cycle. The MFCA PDCA cycle can be included and applied at different phases of the EMS PDCA cycle.

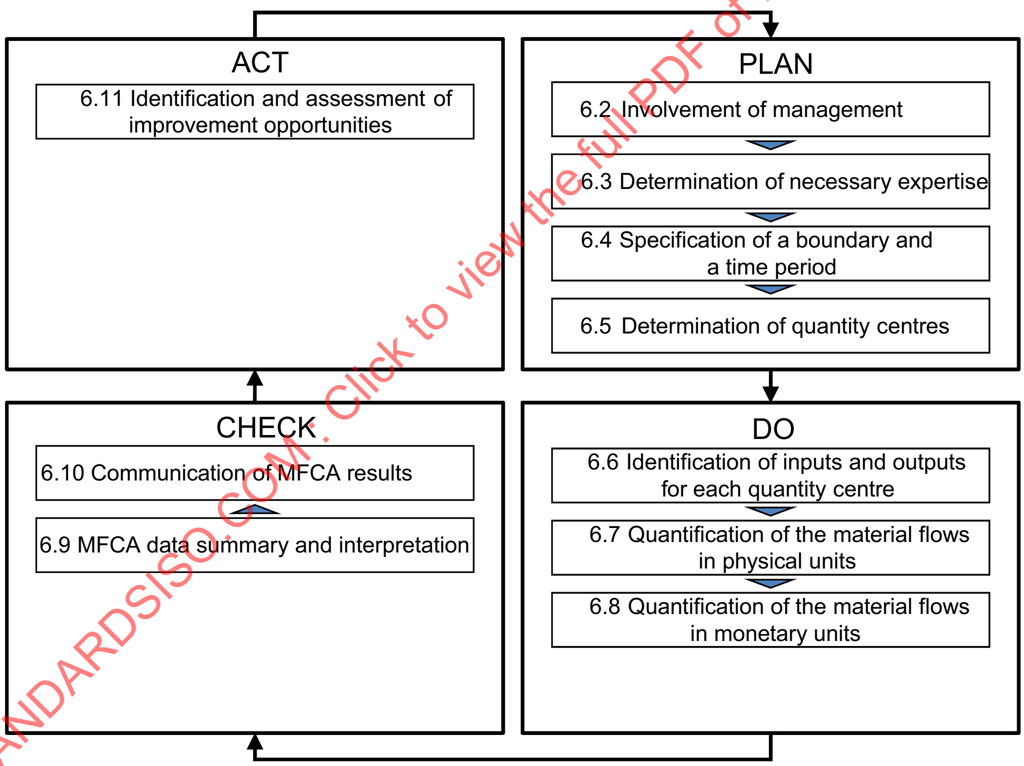


Figure 4 — PDCA cycle for MFCA implementation

A logical approach for implementing an MFCA analysis will take typical steps outlined in 6.2 to 6.11.

6.2 Involvement of management

Management level personnel should understand the value and practicability of MFCA in achieving an organization's environmental and financial goals. To be effectively implemented, MFCA should be strongly supported by management.

Management involvement should include the following:

— leading implementation;

— assigning roles and responsibilities, e.g. set-up of an MFCA task force;

— providing resources;

— monitoring progress;

— reviewing results; and

— deciding on improvement measures based on MFCA results.

6.3 Determination of necessary expertise

MFCA requires multiple types of expertise that can provide the diverse types of information needed for the analysis. Examples of the types of expertise useful for implementation of MFCA include:

— operational expertise from design, procurement, and production regarding the flow of materials and energy use throughout the organization;

— engineering and/or technical expertise on the material balance implications of processes, including combustion and other chemical reactions;

— quality control expertise on issues such as product reject frequency, causes, and rework activities;

— environmental expertise on environmental aspects and impacts, waste types, and waste management activities; and

— accounting expertise on cost accounting data and practices, e.g. cost allocation.

6.4 Specification of a boundary and a time period

Before an MFCA analysis can be undertaken, the MFCA boundary should be specified. The boundary can encompass a single process, multiple processes, an entire facility, or a supply chain at the discretion of the organization. However, it is advisable to focus initially on a process or processes with potentially significant environmental and economic impacts.

In the context of a supply chain, MFCA implementation follows approximately the same steps outlined in this clause, although the organizations belonging to the supply chain will need to modify or add steps to ensure sufficient communication and collaboration. In order to be more effective, the selection of the implementation steps should be agreed by all the relevant organizations that belong to the supply chain. See Annex C for examples of MFCA application for a supply chain.

After specifying the boundary, a time period for MFCA data collection should be specified. The period for data collection should be sufficiently long so as to allow meaningful data to be collected, and to take into account any significant process variations, e.g. seasonal fluctuations, inherent process variances that can affect the reliability and usability of the data. The appropriate time period can be a month, a half-year, or a year, depending on the analysis. For some industries, it can be convenient to define the data collection period to coincide with the manufacturing of a production lot.

6.5 Determination of quantity centres

Various processes, such as receiving, cleaning, cutting, mixing, assembling, heating, packing, inspecting and shipping, as well as material storage areas, can be considered as quantity centres. The quantity centres within the MFCA boundary can be determined from process information, cost centre records, and other existing information. If the material flows between two quantity centres cause relevant material losses or system costs, e.g. energy for transport, oil or air pressure leakage, these flows may be determined as an additional quantity centre.

6.6 Identification of inputs and outputs for each quantity centre

For each quantity centre within the MFCA boundary, the inputs and outputs should be identified. Possible inputs are materials and energy. Possible outputs are products, material losses and energy losses. Energy and energy loss can be either included under material and material loss respectively or estimated separately, at the discretion of the organization.

Once the inputs and outputs have been identified for each quantity centre, they can be used to connect the quantity centres within the MFCA boundary, so that data from the quantity centres can be linked and evaluated across the entire system being studied.

6.7 Quantification of the material flows in physical units

For each quantity centre, the amounts of inputs and outputs should be quantified in physical units such as mass, length, number of pieces, or volume, depending on the type of material. All physical units used should be convertible to a single standardized unit (e.g. mass) so that material balances can be conducted for each quantity centre.

A material balance requires that the total amount of outputs (i.e. products and material losses) is equal to the total amount of inputs, taking into account any inventory changes within the quantity centre. Ideally, all materials within the MFCA boundary should be traced and quantified, but materials that have minimal environmental or financial significance can be omitted, at the discretion of the organization.

6.8 Quantification of the material flows in monetary units

6.8.1 Material costs

For each quantity centre, the material costs for inputs and outputs (i.e. products and material losses), should be quantified. Material costs can be quantified in a number of different ways, e.g. historical cost, standard cost, replacement cost. The choice is at the discretion of the organization, and may also be influenced by the method which the organization is already using in its existing cost accounting. Depending on the selected approach, the results of the MFCA analysis may differ.

The material costs for each input and output flow are quantified by multiplying the physical amount of the material flow by the unit cost of the material over the time period chosen for the analysis. When quantifying the material costs for the outputs (i.e. products and material losses), the material costs associated with any changes in material inventory within the quantity centre also should be quantified.

The material costs in each quantity centre should be assigned to products and material losses, respectively. This method is explained further in Clause B.2.

NOTE Once the unit cost for the material is determined, it should be used consistently.

6.8.2 Energy costs

For each quantity centre, the costs of energy use should be quantified. In cases where the energy costs for individual quantity centres are not known and are difficult to measure or estimate, it will be necessary to allocate the total energy costs of the selected processes to the quantity centres. Subsequently, the energy costs for each quantity centre should be allocated to products and material losses. Cost allocation is explained further in Clause B.3.

6.8.3 System costs

System costs are all expenses incurred in the course of in-house handling of the material flows, except for material costs, energy costs, and waste management costs. Examples of system costs are the costs of labour, depreciation, maintenance, transport, etc. The system costs associated with each quantity centre should be quantified. In cases where the system costs for individual quantity centres are not known and are difficult to measure or estimate, it will be necessary to allocate the total system costs of the selected processes to the quantity centres. Subsequently, the system costs for each quantity centre should be allocated to products and material losses. Cost allocation is explained further in Clause B.3.

6.8.4 Waste management costs

Waste management costs are associated with handling material losses generated in a quantity centre. The waste management costs associated with each quantity centre should be quantified. In cases where the waste management costs for individual quantity centres are not known and are difficult to measure or estimate, it will be necessary to allocate the total waste management costs of the selected processes to the quantity centres. The total of the waste management costs for each quantity centre should be attributed to the material losses leaving that quantity centre. Cost allocation is explained further in Clause B.3.

6.9 MFCA data summary and interpretation

The data obtained during the MFCA analysis should be summarized in a format that is suitable for further interpretation, e.g. in a material flow cost matrix, a material flow cost diagram. The data should first be summarized for each quantity centre separately. Table 1 illustrates a summary of the MFCA data for a quantity centre based on the data of Figure 2.

Table 1 — Example of a material flow cost matrix for a quantity centre

Period: XXX

	Mass kg	**Material costs** $	**Energy costs** $	**System costs** $	**Waste management costs** $	**Total costs** $
Total inputs	100	1 000	50	800	80	1 930
Product	70 (70 %)	700 (70 %)	35 (70 %)	560 (70 %)	0 (0 %)	1 295 (67 %)
Material loss	30 (30 %)	300 (30 %)	15 (30 %)	240 (30 %)	80 (100 %)	635 (33 %)
Total outputs	100	1 000	50	800	80	1 930

NOTE 1 For simplicity, this table only includes physical data on material, not energy.

NOTE 2 The total inputs and material costs include materials in inventory as follows (as illustrated in Figure 2):

Total material used (100 kg) = Input (95 kg) + Initial inventory (15 kg) − Final inventory (10 kg).

NOTE 3 This table presents a material flow cost matrix as an example of one way to summarize the results of an MFCA analysis. Other presentation formats are also possible (see Figure B.4).

The data in Table 1 indicate the total amounts of material inputs plus inventory changes that flow into products and material losses, respectively, as well as the costs associated with products and material losses. The material losses represent material inefficiency in the process, which can lead to significant financial losses and adverse environmental impacts.

In general, review and interpretation of the summarized data will allow the organization to identify quantity centres with material losses that are environmentally or financially significant. These quantity centres can be analysed in more detail to identify the root causes of the material losses and the associated factors that incur the costs. Data from individual quantity centres can also be aggregated for the entire target process being analysed. For more information on data aggregation within the MFCA boundary, see Clause B.4.

6.10 Communication of MFCA results

Once the MFCA analysis is completed, the results should be communicated to relevant stakeholders. Most MFCA stakeholders will be internal to the organization. Management can use MFCA information to support many different types of decisions aimed at improving both environmental and financial performance. Communicating the results to an organization's employees can be useful in explaining any process or organizational changes that will take place as a result of MFCA findings.

The tables, graphs and other instruments developed for MFCA data analysis can serve as the basis for creating effective communication instruments tailored to specific stakeholders in accordance with the communication strategies. One example might be the support of dialogue with external stakeholders on the organization's environmental performance as it relates to material use practices.

6.11 Identification and assessment of improvement opportunities

Once an MFCA analysis has assisted an organization to better understand the magnitude, consequences, and drivers of material use and loss, the organization may review the MFCA data and seek opportunities to improve environmental and financial performance. The measures taken to achieve these improvements can include substitution of materials, modification of processes, production lines or products, and intensified research and development activities related to material and energy efficiency. MFCA data can support the cost-benefit analysis of proposed measures, both those requiring additional investment and those requiring little or no initial investment.

It is also important to note that MFCA implementation creates opportunities for improvements in the organization's accounting and information systems. System improvements provide more precise data for all future projects and avoid some of the manual data collection and analysis that would be needed in the absence of system improvements. Possible system improvements that are discovered during MFCA implementation should be noted and included in the overall improvement plan resulting from the MFCA analysis in the organization.

Annex A
(informative)

Difference between MFCA and conventional cost accounting

A.1 General

Understanding the difference between MFCA and conventional cost accounting (CCA) is useful for the implementation of MFCA. It traces material flows in physical units and monetary units, emphasising material losses. One main difference between MFCA and CCA lies in the treatment of the costs of material losses and inefficiencies in processes. In CCA, all material costs and processing costs are assigned or allocated to product costs. Although material losses can be visibly recognized in CCA, the costs are not separately identified. Waste management costs associated with material losses are either incorporated in product costs or hidden in overhead costs. This approach does not highlight the costs of material losses and inefficiencies in the process due to a lack of understanding of the comprehensive costs of material losses. MFCA can also provide information regarding potential savings or efficiency in product material and corresponding packaging.

MFCA, on the other hand, treats material loss as a cost object, and calculates the costs of material losses and all processing costs associated with the material losses. To further enhance the analytical power of this approach, processing costs are differentiated as energy costs, system costs and waste management costs. The costs of material losses are the sum of the costs of the material that flows to the material losses, the energy costs and system costs that are allocated to material losses based on appropriate allocation criteria, as well as the total waste management costs associated with the material loss. This approach highlights the costs of material losses and inefficiencies in the process, and draws management's attention to these costs. In addition to reducing material loss costs, this approach can assist the organization in reducing its adverse environmental impacts by reducing the consumption of natural resources and the generation of waste and emissions.

A.2 Illustration of difference between MFCA and conventional cost accounting

In this example, which is based on Figure 2, the quantity centre (QC) has 15 kg initial inventory of material, and 95 kg material input enters the QC. The final inventory of material is 10 kg, and 70 kg product and 30 kg material loss are generated as outputs, as illustrated in Figure A.1. Material costs and processing costs amount to $ 1 000 and $ 930, respectively, resulting in total manufacturing costs of $ 1 930. In the case of CCA, the total costs of product are $ 1 930.

On the other hand, MFCA identifies material loss and valuates its cost. 30 % of the material input flows into material loss, resulting in material costs of $ 300 for the material loss. The processing costs are differentiated in energy costs ($ 50), system costs ($ 800), and waste management costs ($ 80). Based on an appropriate allocation criterion (the mass-based material distribution percentage between product and material loss), $ 15 of the energy costs and $ 240 of the system costs are allocated to the material loss. In addition, the total waste management costs of $ 80 are attributed to the material loss. As a result, the total costs of material loss are $ 635, as illustrated in Figure A.1. This means that 32,9 % of total manufacturing costs are wasted due to the material loss.

The visibility of this information may prompt management to investigate the reasons for the material loss and institute measures to reduce the material loss. Under CCA, the management does not generally have this information so readily available to act upon. MFCA can also provide information that allows management to consider options for reducing or substituting product material, for instance reducing weight more systematically, increasing recyclability, and supporting environmental improvements in products and processes.

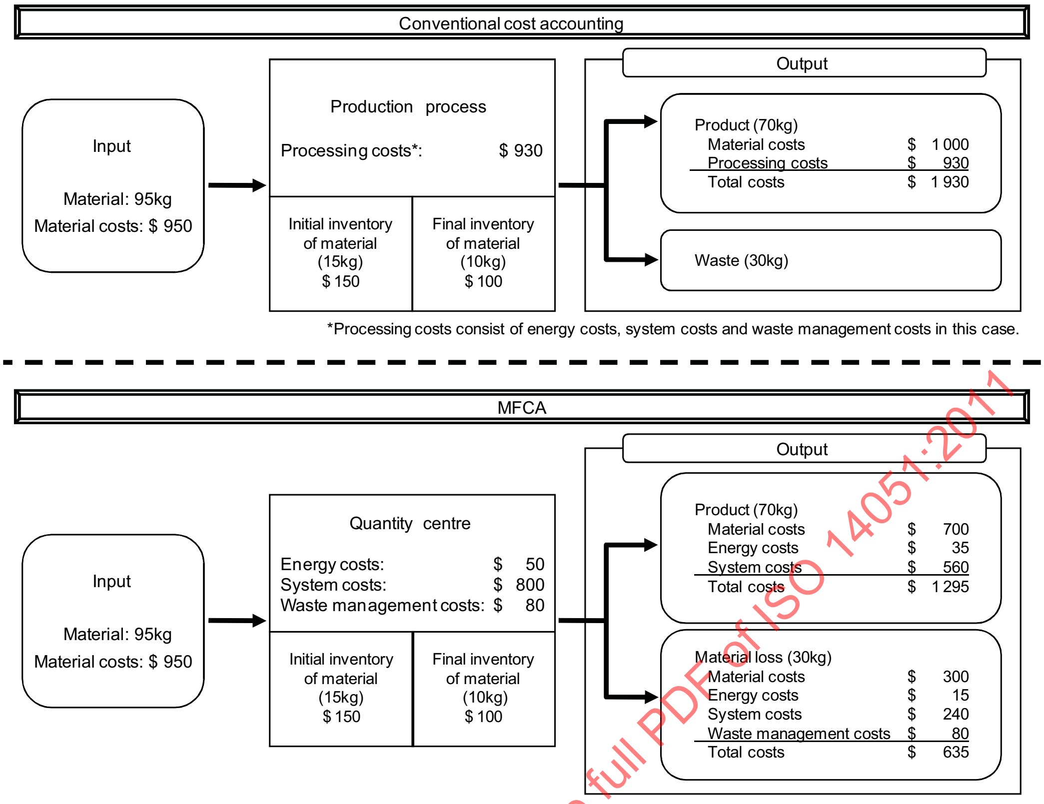


Figure A.1 — Difference between MFCA and conventional cost accounting

Annex B
(informative)

Cost calculation and allocation in MFCA

B.1 General

This annex provides guidance for cost calculation and allocation in MFCA, as follows:

— calculation of material costs (see Clause B.2);

— calculation and allocation of energy costs, system costs, and waste management costs (see Clause B.3);

— integrated presentation and analysis of cost data (see Clause B.4).

B.2 Calculation of material costs

B.2.1 General

In this clause, the calculation of material costs is illustrated for two types of situations:

— a basic manufacturing process, where the flow of each material can be traced from beginning to end;

— a more complex process, where initial material inputs are converted into intermediate products and cannot be recognised separately in the final products.

B.2.2 Calculation of material costs in a basic manufacturing process

Figure B.1 shows the boundary of this material flow model, within which the nature of each material is maintained throughout the process, e.g. a parts assembly operation, a bulk mixing operation. In this example, two QCs are defined and each QC generates product and material loss, respectively.

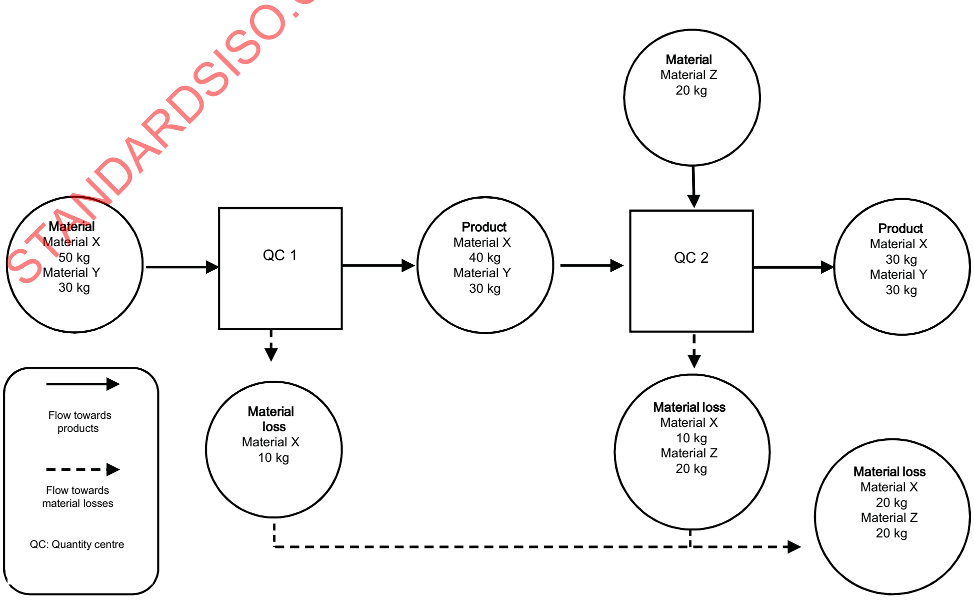


Figure B.1 — Material flow model for a basic manufacturing process

Table B.1 illustrates the summarized information of Figure B.1.

Table B.1 — Material quantities and compositions for a basic manufacturing process

Period: XXX

Total material inputs in this process	Composition of products and material losses		QC 1	QC 2	Result of production (mass)
Materials: 100 kg	Products		70 kg	60 kg	60 kg
		Material X	40 kg	30 kg	30 kg
		Material Y	30 kg	30 kg	30 kg
		Material Z	—	—	—
Material X: 50 kg Material Y: 30 kg Material Z: 20 kg	Materials losses		10 kg	30 kg	40 kg
		Material X	10 kg	10 kg	20 kg
		Material Y	—	—	—
		Material Z	—	20 kg	20 kg

In the next step, the total amount of the material costs in each QC should be calculated by multiplying the physical amount of each material by a unit cost determined by the organization, in order to convert both outputs (i.e. products and material losses) into monetary units over the analysis time period. The results of this step are presented in Table B.2. The material inputs are Material X, Material Y and Material Z, with unit costs of $ 100, $ 40 and $ 20, respectively.

Table B.2 — Material costs for a basic manufacturing process

Period: XXX

Composition of products and material losses		QC 1			QC 2			Result of production (mass)	Total
Products		Mass	Unit costs	Costs	Mass	Unit costs	Costs	60 kg	$ 4 200
	Material X	40 kg	$ 100	$ 4 000	30 kg	$ 100	$ 3 000	30 kg	$ 3 000
	Material Y	30 kg	$ 40	$ 1 200	30 kg	$ 40	$ 1 200	30 kg	$ 1 200
	Material Z	—	$ 20	—	—	$ 20	—	—	$ 0
Materials losses		Mass	Unit costs	Costs	Mass	Unit costs	Costs	40 kg	$ 2 400
	Material X	10 kg	$ 100	$ 1 000	10 kg	$ 100	$ 1 000	20 kg	$ 2 000
	Material Y	—	$ 40	—	—	$ 40	—	—	$ 0
	Material Z	—	$ 20	—	20 kg	$ 20	$ 400	20 kg	$ 400
Total material costs in this process									$ 6 600

B.2.3 Calculation of material costs for intermediate products

Ideally, MFCA traces all inputs to final products and material losses, however, complex production processes such as chemical reactions may require a huge variety of material inputs that are transformed into one or several outputs, e.g. products, intermediate products, material losses. If such processes are determined as quantity centres in MFCA, exact tracing of all inputs to outputs may be impossible for technical or financial reasons. In these cases, the outputs are considered intermediate products (illustrated as "Material XY" in Figure B.2).

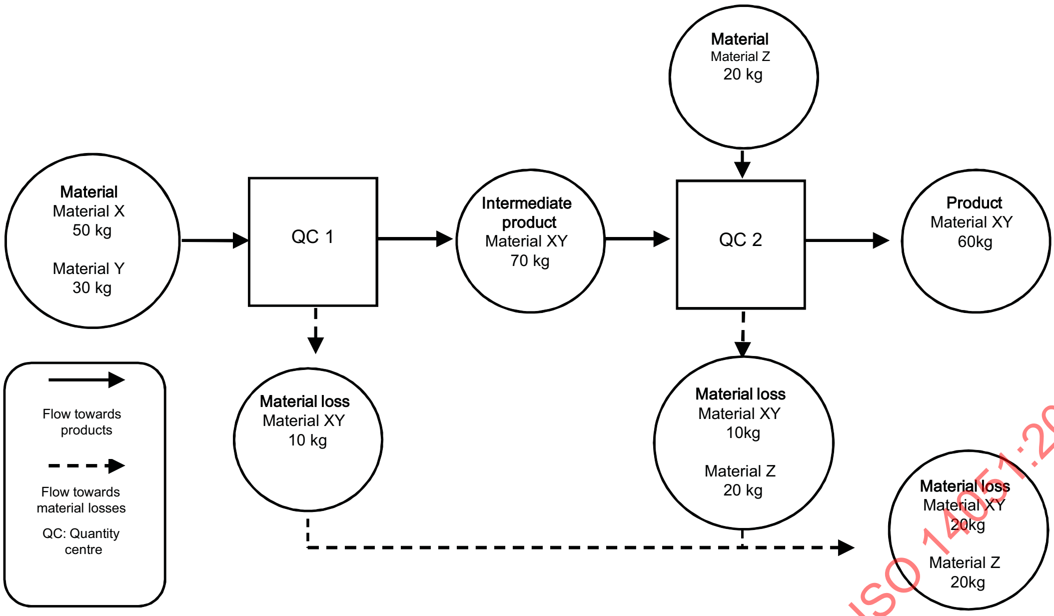


Figure B.2 — Material flow model including intermediate products

Since the exact composition of the intermediate product flows and material loss flows for these complicated systems is unknown, it is not possible to calculate an exact unit material cost for these flows. Therefore, a single unit material cost for all of the flows of uncertain composition is estimated using the unit material costs of the original materials inputs. A unit material cost for the flows of Material XY (as intermediate products) illustrated in Figure B.2 can be calculated as follows:

$$\frac{(50\text{ kg} \times \$\,100) + (30\text{ kg} \times \$\,40)}{(50\text{ kg} + 30\text{ kg})} = \frac{(\$\,5\,000 + \$\,1\,200)}{80\text{ kg}} = \$\,77{,}5\text{ /kg}$$

Table B.3 shows the material cost computation for the material flow model in Figure B.2. Eventually, the total material costs for products and material losses are not the same as those in Table B.2 because the unit costs are different.

Table B.3 — Material costs for a process including intermediate products

Period: XXX

Composition of products and material losses		Result of production (mass)	Unit cost	Total
Products		60 kg		$ 4 650
	Material XY	60 kg	$ 77,5	$ 4 650
	Material Z	0 kg	$ 20	$ 0
Materials losses		40 kg		$ 1 950
	Material XY	20 kg	$ 77,5	$ 1 550
	Material Z	20 kg	$ 20	$ 400
Total		100 kg		$ 6 600

NOTE For simplicity, this table does not show each cost in QCs.

B.3 Calculation and allocation of energy costs, system costs and waste management costs

B.3.1 General

After material costs have been calculated and assigned to products and material losses, the next step is to calculate energy costs, system costs and waste management costs, and to allocate those costs to product and material loss. Ideally, energy costs, system costs and waste management costs should be calculated directly from available production cost data for each QC. If this is not possible, as is often the case, these costs should be estimated from other available data, as described below.

B.3.2 Allocation of energy costs, system costs and waste management costs to QCs

In cases where energy, system and waste management costs cannot be obtained directly from production data for each QC, more aggregated data for an entire process or facility can be used to quantify the QC costs, in a two-step procedure. Firstly, energy costs, system costs and waste management costs are calculated for the entire process within the MFCA boundary. Secondly, these costs are allocated to each QC by appropriate criteria, e.g. machine hours, production volume, number of employees, labour hours, number of jobs performed and floor space.

Table B.4 shows an example of the cost allocation. The criteria are not specified here.

Table B.4 — Allocation of energy costs, system costs and waste management costs to each QC

Period: XXX

Type of cost	QC 1	QC 2	Total
Energy costs	$ 400	$ 300	$ 700
System costs	$ 800	$ 1 200	$ 2 000
Waste management costs	$ 300	$ 400	$ 700

B.3.3 Allocation of energy costs, system costs and waste management costs to products and material losses in each QC

Energy costs and system costs are allocated to products and material losses by appropriate criteria. As mentioned in 5.3.2, the most appropriate allocation criterion for different types of costs will not necessarily be the same. It is noted that total waste management costs are attributed to material losses.

Table B.5 shows the result of the allocation of energy costs, system costs and waste management costs to products and material losses in each QC, based on the material distribution percentages in QC 1 and QC 2 as a criterion. Total waste management costs allocated to QC are attributed to the material losses.

In this case, the material distribution percentages in QC 1 are 87,50 % for products (70 kg/80 kg) and 12,50 % for material losses (10 kg/80 kg), and those in QC 2 are 66,67 % for products (60 kg/90 kg) and 33,33 % for material losses (30 kg/90 kg).

Table B.5 — Allocation of energy costs, system costs and waste management costs to products and material losses in QC 1 and QC 2

Period: XXX

Type of cost		QC 1	QC 2
Energy costs		$ 400	$ 300
	Products	$ 350	$ 200
	Material losses	$ 50	$ 100
System costs		$ 800	$ 1 200
	Products	$ 700	$ 800
	Material losses	$ 100	$ 400
Waste management costs		$ 300	$ 400
	Products	$ 0	$ 0
	Material losses	$ 300	$ 400

B.3.4 Alternative to material distribution percentage

This example uses the material distribution percentage as an allocation criterion, based on the mass of all materials in each QC. When the material distribution percentage based on all the materials is not readily available or appropriate for management decisions, it is recommended that the material distribution percentage of the main material, which is directly related to processing, be used as the allocation criterion.

For example, when a proportionally significant volume of water is used in a QC as a washing material, the volume of material losses can be much larger than the volume of products. If the material distribution percentage is based on all materials, it potentially results in the allocation of a disproportionate amount of energy costs and system costs to material losses. This is obviously not useful for management decision-making.

B.3.5 Alternative approach to allocation criteria for energy use

In many cases, the mass distribution of material inputs into products and material losses will be used as the criteria for allocating energy use to products and material losses. However, if additional information is available on the energy efficiency of machinery used in a quantity centre, a more accurate quantification of energy inefficiency and wastage can be made. The following example illustrates this point. Each item below corresponds to the items (a, b, and c) given in Figure B.3.

a) If 10 % of the running time of a machine is used for setting up, closing down and maintenance, as opposed to actual production, the 10 % of energy use for these purposes could be considered as wastage and as not being used for production. This proportion of energy should, therefore, be allocated to material losses rather than to products.

b) Material inefficiency of 20 % will result in the allocation of 80 % of the remaining energy use to products.

c) If it is found that the machine is 15 % less efficient than an optimally running machine, these results in the allocation of only 85 % of the remaining energy use to products.

If only the material distribution percentage is to be used as the allocation criteria, the energy use is allocated as follows:

— energy allocation to products: 80 %

— energy allocation to material losses: 20 %

If the alternative approach described above is used as basis for the allocation criteria, the energy use in this QC is allocated as follows:

— energy allocation to products: 90 % × 80 % × 85 % = 61,2 %

— energy allocation to material losses: 100 % − 61,2 % = 38,8 %

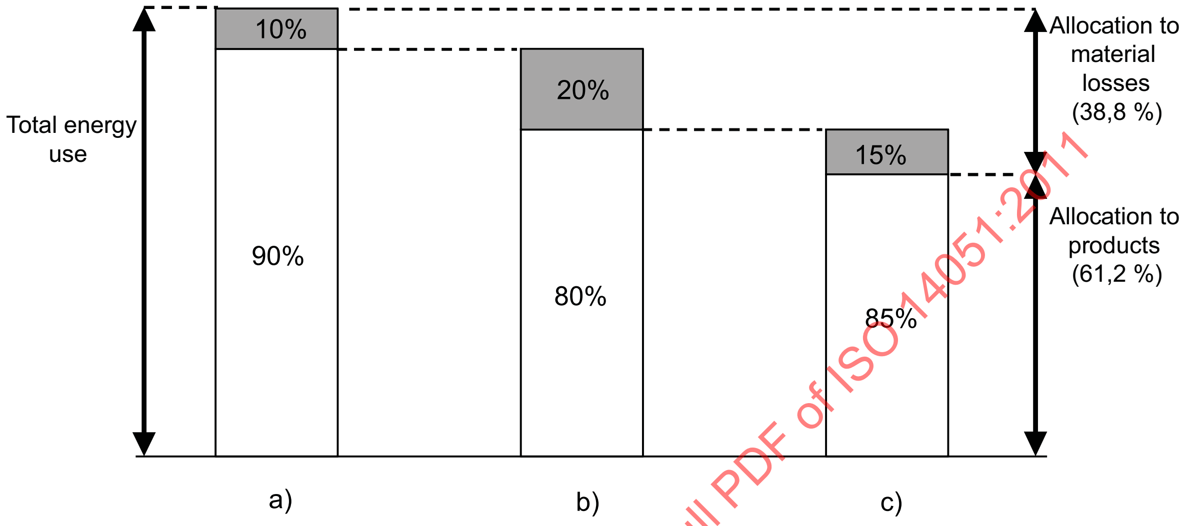


Figure B.3 — Quantification of energy loss

As a result, the higher percentage of energy allocated to material losses indicated by using the alternative approach provides a more accurate reflection of inefficiencies on which management should focus its attention.

B.4 Integrated presentation and analysis of cost data

The material, energy, system and waste management cost data can be summarized in various ways for further analysis. Table B.6 provides an example of a material flow cost matrix illustrating data from the two QCs from Figure B.1.

Table B.6 — Material flow cost matrix

Period: XXX

	QC 1					QC 2				
	Material costs	**Energy costs**	**System costs**	**Waste management costs**	**Total**	**Material costs**	**Energy costs**	**System costs**	**Waste management costs**	**Total**
Inputs from previous QC						$ 5 200[a]	$ 350[b]	$ 700[c]		$ 6 250[d]
New inputs in QC	$ 6 200	$ 400	$ 800	$ 300	$ 7 700	$ 400	$ 300	$ 1 200	$ 400	$ 2 300
Total in each QC	$ 6 200	$ 400	$ 800	$ 300	$ 7 700	$ 5 600	$ 650	$ 1 900	$ 400	$ 8 550
Products	$ 5 200[a]	$ 350[b]	$ 700[c]		$ 6 250[d]	$ 4 200	$ 433	$ 1 267		$ 5 900
Material losses	$ 1 000	$ 50	$ 100	$ 300	$ 1 450	$ 1 400	$ 217	$ 633	$ 400	$ 2 650
Total costs of material losses in this process						$ 2 400	$ 267	$ 733	$ 700	$ 4 100
Total costs in this process						$ 6 600	$ 700	$ 2 000	$ 700	$ 10 000

NOTE 1 The data are taken from Tables B.2, B.4 and B.5.

NOTE 2 Calculation of energy costs at QC 2: energy costs at QC 2 are calculated to be $ 433 for products and $ 217 for material losses, based on application of the QC 2 material distribution percentage (i.e. 66,67 % for products and 33,33 % for material losses) to the total energy costs ($ 650), which are sum of the energy costs for products at QC 1 ($ 350) and new input at QC 2 ($ 300).

NOTE 3 Calculation of system costs at QC 2: system costs at QC 2 are calculated to be $ 1 267 for products and $ 633 for material losses based on application of the QC 2 material distribution percentage (i.e. 66,67 % for products and 33,33 % for material losses) to the total system costs ($ 1 900), which are sum of the system costs for products at QC 1 ($ 700) and new input at QC 2 ($ 1 200).

[a] Value of material costs transferred from QC 1 to QC 2.

[b] Value of energy costs transferred from QC 1 to QC 2.

[c] Value of system costs transferred from QC 1 to QC 2.

[d] Value of total costs transferred from QC 1 to QC 2.

Figure B.4 provides an example of a graphical presentation (Sankey diagram) of this information.

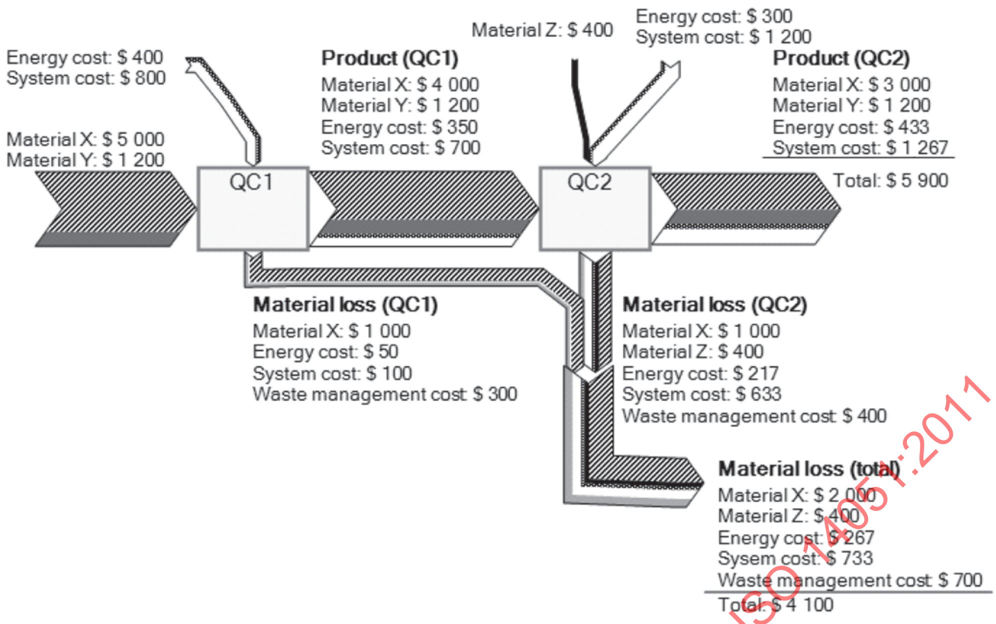


Figure B.4 — Sankey diagram of summarized information

Annex C
(informative)

Case examples of MFCA

C.1 General

This annex contains a number of case examples on the application of MFCA. The various case examples illustrate MFCA in different types and sizes of organizations, such as manufacturing (see Clauses C.2 and C.3), pharmaceutical industry (see Clause C.5), food processing (see Clauses C.4 and C.6), agricultural (see Clause C.4), small- and medium-sized enterprises (see Clause C.3) and the supply chain (see Clauses C.2 and C.4). The results of all case examples are commonly given in US dollars, or in Euros as well. Because examples of larger and smaller sized companies and from industrialized countries and emerging economies are included, the results are not always comparable.

C.2 Case example 1: Lens manufacturing factory

C.2.1 General

A lens-manufacturing factory of Company A based in Japan, which is one of the world-class companies in this field, achieved significant environmental and financial improvements after the introduction of MFCA. The number of factory employees exceeded 1 000 at the time of adoption of MFCA. The targeted process was the manufacturing of lenses used in cameras.

C.2.2 Material flow model of main targeted process

The material flow model of the targeted process is illustrated in Figure C.1.

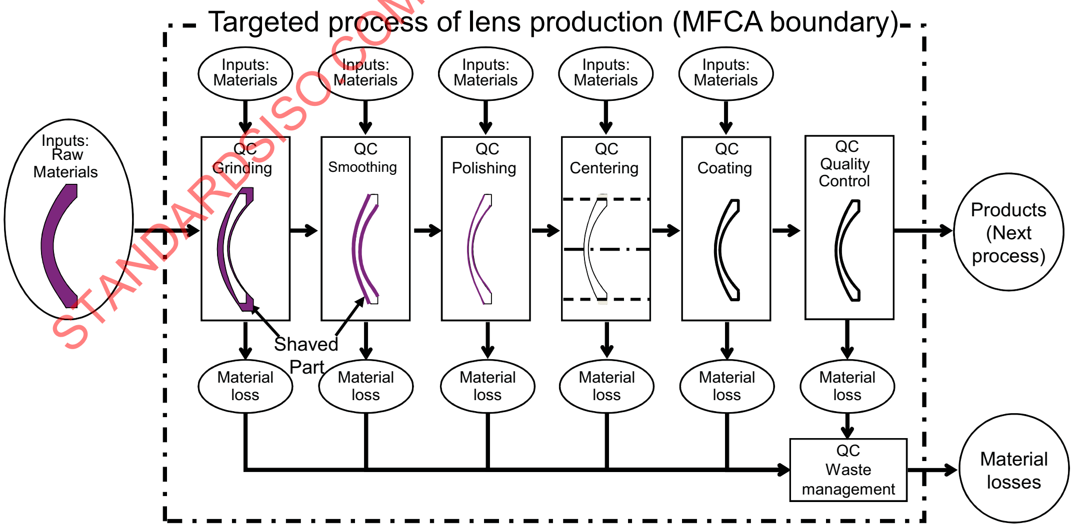


Figure C.1 — Material flow model of the main targeted process

C.2.3 Description of material losses

The types of material losses included the following:

— sludge generated from the grinding and other processing of glass material;

— sludge from supplementary materials;

— coating materials not applied to the lens product; and

— off-specification products.

The percentage of the above material losses per initial material inputs by mass was approximately 30 %.

C.2.4 Findings through MFCA analysis

Prior to the introduction of MFCA, Company A believed that its existing process for producing lenses had a very high product yield rate, i.e. 99 %, as illustrated in Figure C.2. Its conventional production management measurements were based on final product yield data. Because only one unit per 100 lens units was defective, the product yield rate was considered to be 99 %. However, in the MFCA analysis, the mass of both the input and output materials were measured in each QC, and the material, system and waste management costs incurred were allocated to the final products and material losses. As a result, Company A realized that the material loss cost was approximately 32 % of the total cost of the lens manufacturing process, a fact which was overlooked by the conventional production management measurement system, as illustrated in Figure C.2. Significant room for environmental and financial improvements were revealed by using MFCA.

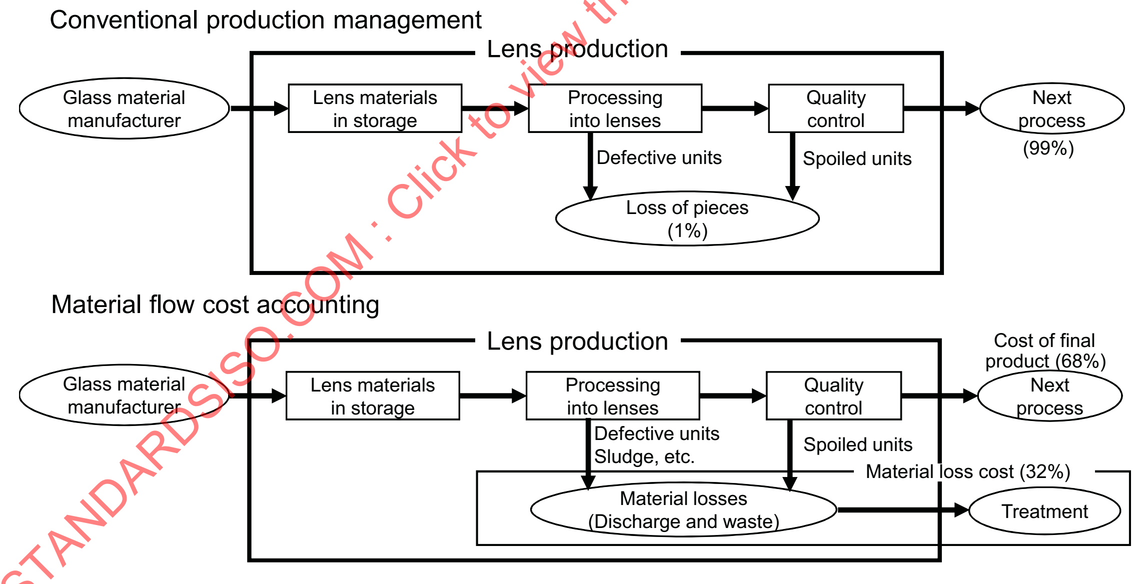


Figure C.2 — Comparison of conventional production management and MFCA

C.2.5 Improvements based on MFCA analysis

Company A implemented improvement initiatives to reduce the amount of waste generated in the grinding process through collaboration with its glass material supplier for further effective improvement. As a result of the collaboration with the supplier, Company A developed a new input lens designing called a "near-shaping" lens, which resulted in 80 % reduction of material loss, as illustrated in Figure C.3.

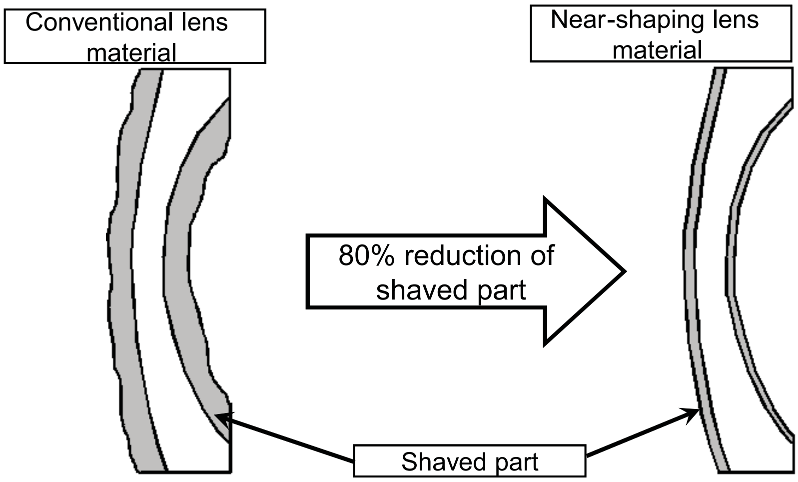


Figure C.3 — New near-shaping lens

Consequently, the supplier needed much less glass material for the same product yield as compared to conventional lens production. In addition, the amount of sludge and waste generated in the lens processes of the supplier and Company A decreased significantly. The environmental benefits of reduced resource consumption and reduced waste generation were accompanied by significant cost reductions with respect to material, energy, system and waste management costs for both companies. This is a typical example of eco-innovation in the supply chain through MFCA.

C.2.6 Conclusion

After the success of this initial MFCA project, Company A began to introduce MFCA into other factories, including those located in Asian countries. As of the end of 2008, MFCA was being used by more than 20 company facilities worldwide. After analysing how material losses occur in the manufacturing processes in those facilities, the facilities have adopted various improvements that have resulted in significant reductions in adverse environmental impacts and costs. The total financial benefit to Company A was 1,0 billion Japanese Yen (USD 11,0 million) as of 2008.

NOTE US dollar amounts were converted from Japanese Yen at the approximate exchange rate at the end of 2008.

C.3 Case example 2: Furniture manufacturing factory

C.3.1 General

This case example focuses on a manufacturing factory of a small company in the Czech Republic, which for more than 10 years has been carrying on business in the area of job-order manufacturing of furniture. The products are manufactured in accordance with customers' requirements, with detailed specification of materials, surface finishing, colours and special complements.

C.3.2 Material flow model of main targeted process

The targeted process was the manufacturing process of furniture, as illustrated in Figure C.4. The basic material for manufacturing is chipboards sized 2 700 × 2 750 mm.

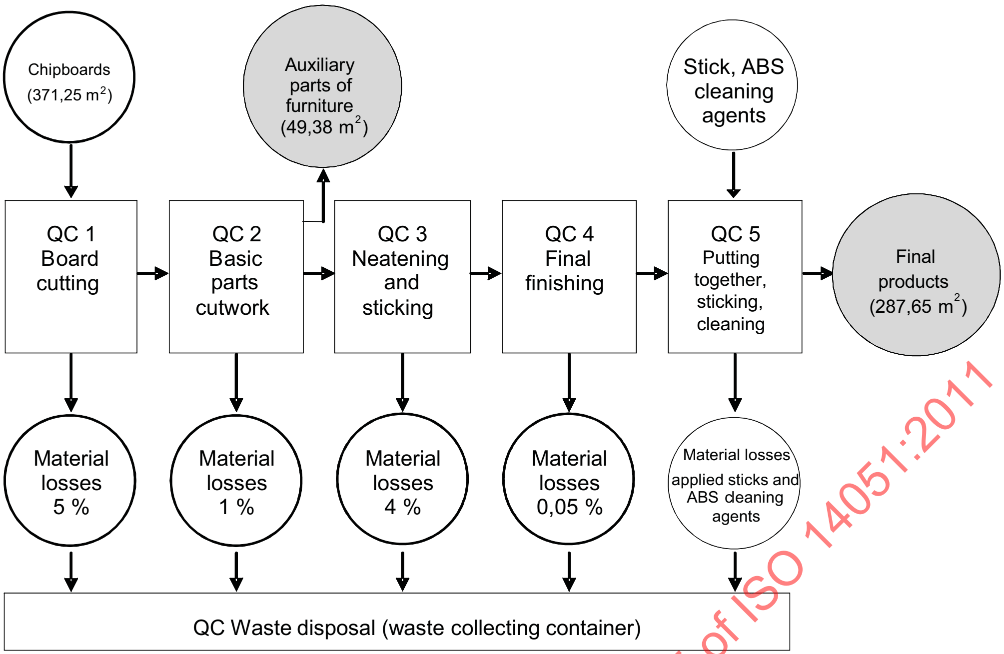


Figure C.4 — Material flow model of the main targeted process

C.3.3 Description of material losses

The types of material losses included those outlined below.

— In QC 1, the basic material has to be trimmed by a saw. In this trimming process, solid waste (material loss) amounting to approximately 5 % of input raw material is produced.

— This is followed by QC 2, with furniture parts being cut by the same saw in accordance with the cutting plan. Solid waste (material loss) amounting to approximately 1 % of input raw material is produced.

— In QC 3, furniture edges are neatened and if products are to be fitted with plastic or veneered edges, they are stuck on. Waste produced in this manufacturing phase is sawdust extracted into collecting bags. Solid waste (material loss) amounting to approximately 4 % of input raw material is produced.

— QC 4 involves the use of an NC machine tool, where, based on customers' requirements, furniture parts are shaped and formed, complemented by supports or hinges. Solid waste (material loss) amounting to approximately 0,05 % of input raw material is produced.

— This is followed by QC 5, in which product parts are put together, stuck together and agglutinated. Using ABS cleaning agents, the product is cleaned to have a glossy surface.

C.3.4 Findings through MFCA analysis

The total material balance (per month) is illustrated in Table C.1.

Table C.1 — Material balance

Inputs		Outputs		
Material	**Quantity**	**Material**	**Quantity**	**Percentage of clipboards input**
Chipboards 50 × (2 700 × 2 750 mm^2)	371,25 m^2	Final products	287,65 m^2	77,48 %
		Auxiliary parts of furniture	49,38 m^2	13,30 %
		Material losses in QC 1	18,56 m^2	9,22 %
		Material losses in QC 2	3,53 m^2	
		Material losses in QC 3	11,99 m^2	
		Material losses in QC 4	0,14 m^2	
Stick	0,300 l	Final products	0,291 l	
		Material losses	0,009 l	
ABS cleaning agents	0,500 l	Final products	0,475 l	
		Material losses	0,025 l	

Within the framework of the manufacturing process, material losses to the amount of 9,22 % of input raw material as chipboards is incurred. Other material losses (stick, ABS cleaning agents) are negligible.

Table C.2 illustrates the material flow cost matrix based on this case example.

Table C.2 — Material flow cost matrix

	Material costs (CZK)	**System costs (CZK)**	**Waste management costs (CZK)**	**Total costs (CZK)**
Products	31 835	182 770	—	214 605
Final products	27 180	155 993	—	183 173
Auxiliary parts of furniture	4 655	26 777	—	31 432
Material losses	3 230	18 563	4 000	25 793
Total costs (CZK)	35 065	201 333	4 000	240 398
(US$[a])	1 872	10 751	214	12 837

[a] Exchange Rate: 1 CZK = 0.0534 US$ (as of January 12th, 2011).

Table C.2 shows that material costs represent 14,6 % of the total production costs. The cost of the material losses amounts to 25 793 CZK per month (i.e. 10,7 % of the total production costs). The waste management costs represent 15,5 % of the total costs of the material losses. The system costs are allocated to products and material losses, using the quantity (m^2) of chipboards as the allocation criterion.

C.3.5 Targeted points to be improved on the basis of MFCA analysis

From the existing cost accounting system, it appeared that the enterprise monthly incurs 4 000 CZK on waste management. Corporate management was not informed about the amount of other costs expended in connection with the material losses (see Table C.3).

Table C.3 — Costs associated with material losses

Existing cost accounting		MFCA	
Item	**Costs (CZK)**	**Item**	**Costs (CZK)**
Waste management costs	4 000	Waste management costs	4 000
		Other costs of material losses: — material costs — system costs	 3 230 18 563
Total costs (CZK)	4 000	Total (CZK)	25 793
(US$)	214	(US$)	1 377

In the demonstrated example, this expenditure amounts to 25 793 CZK monthly (i.e. 10,7 % of the total production costs). Although it is evident that in the course of the manufacturing process there will generally always be produced waste, given the technical and technological character of material input transformation to final products, the information gained from the MFCA can contribute to searching for ways to improvements.

C.3.6 Conclusion

MFCA focuses on reducing the costs through a reduction in quantities of consumed materials. This has also positive environmental impacts. Better utilization of materials leads to a reduction of waste flows burdening the environment. Hence, MFCA represents a very significant tool of environmentally oriented management and a tool of improving material efficiency.

C.4 Case example 3: Coffee bean manufacturing factory

C.4.1 General

This case from Vietnam highlights the importance of supply chain aspects in MFCA and provides an example of MFCA application in the agricultural sector. The case example company, a medium-sized exporter of coffee beans, employs about 200 workers and is situated in the southern part of Vietnam. The company purchases robusta coffee beans from farmers and middlemen and applies several refinement processes before eventually exporting different quality grades of coffee beans to overseas.

C.4.2 Material flow model of main targeted process

The major refinement processes at the site of the coffee exporter are cleaning, gravity sorting, colour sorting and wet polishing. The major material inputs into the refinement processes are green coffee beans.

C.4.3 Description of material losses

The coffee exporter sorts and refines the purchased coffee beans to achieve several homogeneous quality grades for export. Ideally, all coffee beans purchased could end up as export products. The supplied coffee, though, does contain inhomogeneous beans, broken beans, and coffee dust and dirt. Therefore, about 1 % is wasted in the form of coffee dust and weight loss and about 7 % ends up as low quality product achieving a price below the purchasing price of the coffee beans.

A crucial material loss within the supply chain is the wastage of fertilizer in coffee farming. According to Vietnamese coffee experts, farmers apply almost double the amount of fertilizer that is needed. This is mainly caused by inexperience, inappropriate information of fertilizer sales agents and the belief in "the more the better".

C.4.4 Findings through MFCA analysis

Figure C.5 summarizes the major findings of MFCA analysis at the coffee exporter's site.

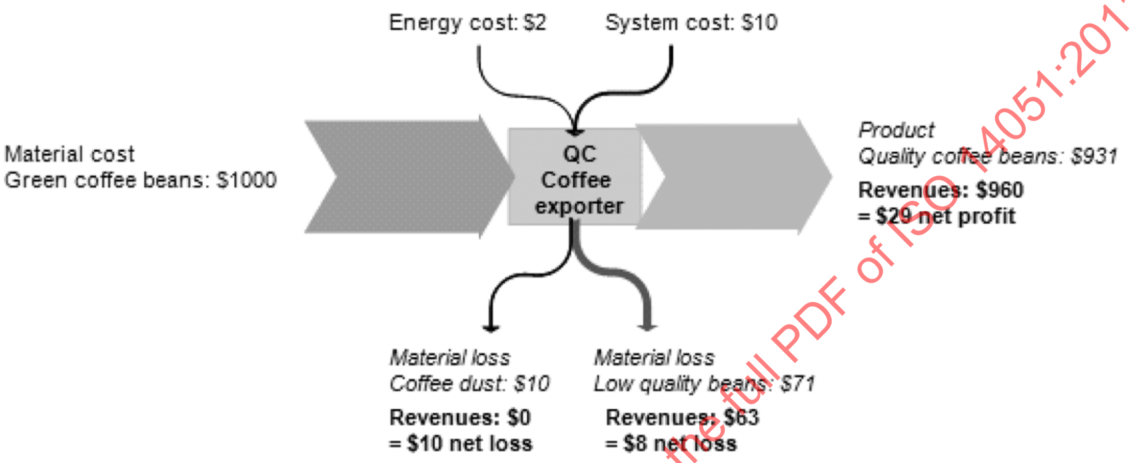


Figure C.5 — MFCA analysis

The cost of material loss, coffee dust and low quality beans, amount to $ 81 per metric ton of green coffee beans, that equals 8 % of total cost. The low quality beans still have a market value. Therefore, revenues have been considered in addition, which reduces the net loss of low quality beans to $ 8 and the total net loss associated with material losses to $ 18. According to the coffee exporting company, the only way to reduce these losses further is to increase the quality of the supplied material input (green coffee beans). This is exactly what the purchase managers steadily work on.

A different approach supported by MFCA analysis are attempts to improve efficiency of supply chain processes leading to lower material input cost in general. Including supply chain aspects into the MFCA analysis at the coffee exporter underpins this view as illustrated in Figure C.6.

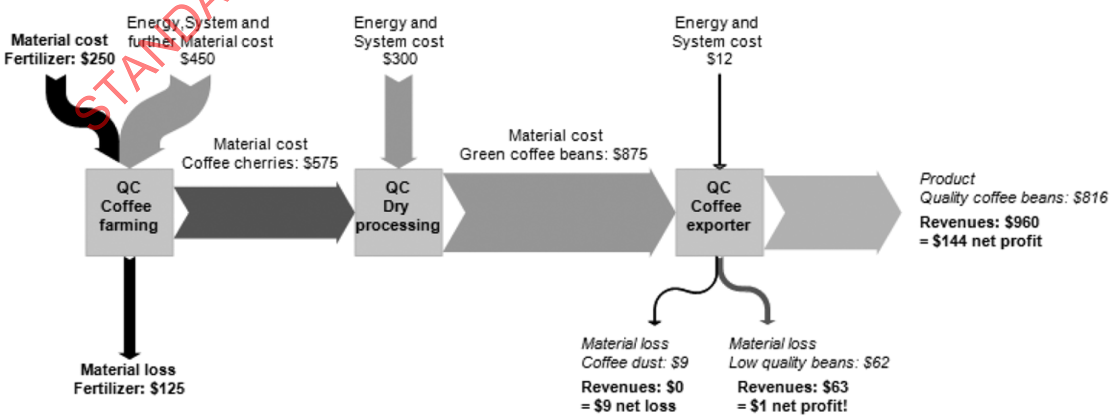


Figure C.6 — MFCA analysis including suppliers