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A report on the origins of Material Flow Cost Accounting (MFCA) research activities

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ABSTRACT

This introduction provides an overview of the historical development of Material Flow Cost Accounting (MFCA). From its beginnings within an environmental management project at the textile company Kunert in Southern Germany in the late 1980s and early 1990s to ISO 14051: 2011 passed more than twenty years. This article analyses the development and provides several practical examples. Publicly funded projects had proven that MFCA works for companies and could be applied successfully in order to reduce environmental impact and reduce corporate costs simultaneously. This overview gives a detailed description of a research method, developing into an international standard. To understand the MFCA approach its history and roots have to be considered.

1. The early days – birth of an idea

Other than one might expect by the name, the method has not evolved from accounting, but from environmental management. It can be classified as a management control tool, interlinking accounting and management systems. In order to allow the reader to evaluate the status and future perspectives of the method and judge the articles in this special volume better, we will start with the history and developmet of the MFCA approach.

The concept of Material Flow Cost Accounting (MFCA), as it appeared later in the ISO 14051 standard, emerged as a logical consequence from environmental management projects within the textile company Kunert in Southern Germany in the late 1980s and early 1990s.

But the basic concept of MFCA was not just a sudden invention without any previous history. Some crucial elements, such as the concept of input-/output-mass-balances or assessing material flows of industrial production in physical and "value" terms, had already been discussed in Germany as early as the 1920s and '30s[1]. The technically dominated 1960s and '70s had stressed technical "environmental protection" measures. In the late 1980s and '90s a number of new environmental issues and terms began to appear in German and English literature, but also in corporate practice, e.g. starting from terms like environmental management (in contrast to the mentioned technical environmental protection measures), reaching to concepts of product or corporate eco-balances, environmental auditing, environmental bookkeeping (Müller-Wenk, 1978), environmental reporting, eco-accounting (BUS, 1984; Ahbe et al., 1990; Callenbach et al., 1990; Müller-Wenk, 1978; EPA, 1996) and eco-control (Günther and Wagner, 1993), to name just a few. Kunert published one of the first corporate environmental reports, based on a corporate input-/output-mass-balance, reporting data from 1989/90, in 1991. Quite surprisingly this report was widely covered by the German media and it resulted in an explosion of published corporate environmental reports in the following years (Fig. 1).[2,3]

Kunert's corporate input-/output-mass-balance was initially set up to develop resource efficiency indicators for environmental management purposes. This "balance sheet" showed the physical

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[1] For a historical review see Schmidt (2012) and Müller-Christ (2012); Schmidt refers to authors such as Daeves (1922), or Rummel (1936).

[2] A first compilation of the rapid nationwide spread of academic and corporate endeavours on environmental management, controlling, indicators and reporting can be found in a handbook published by the German Federal Environment Agency (UBA) in: (Bundesumweltministerium/Umweltbundesamt, 1995); unfortunately most of this literature at that time was only published in German. An early article on this topic in English: "Ecobalance": A Tool for Environmental Financial Management, was published by Wagner and White (1996).

[3] The first companies publishing environmental reports, sometimes also called Ecobalance/Ökobilanz, included Swiss Air (1991), AEG (1993), Daimler Benz AG (1993), J.M. Voith (1993) and Hewlett–Packard GmbH (1994).

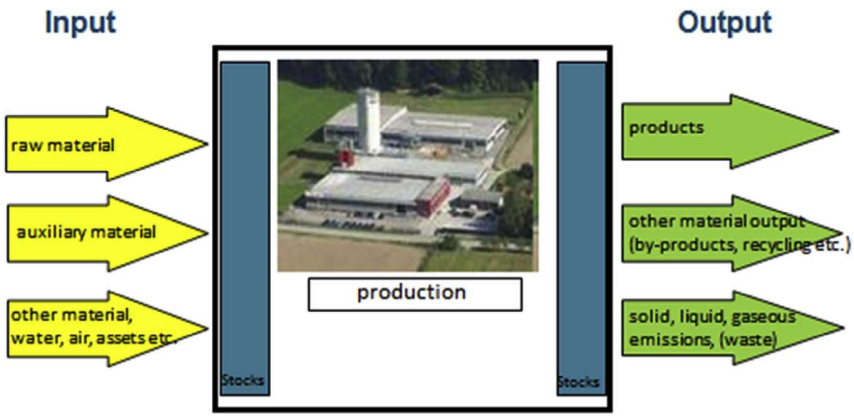

Fig. 1. Corporate input–output (mass balance).

amounts of input material balanced against output material ending in either the product or, inefficiently, in waste, emissions or effluent. This work was conducted as a research project by imu-augsburg, a research and consulting company affiliated with the University of Augsburg and headed by Bernd Wagner. The introduction of a corporate mass balance was based on the laws of thermo-dynamics and posited that material or energy in a company can neither be created nor destroyed, just transformed. In principle, this means that materials or energies that enter a company can be traced in exact (stoichiometric) amounts, either increasing stocks or leaving a company as outputs (Fig. 2).

First input–output comparisons revealed some interesting results. Only a small part of the ingoing knitting oil used in the textile workshop was later on disposed as outgoing material in due form. But where did the rest go? Was it evaporating to air? Was it lost by leakages or exported as residues on the textile products?

Also the water use raised questions: only half of the ingoing amount of water was later to be found in the effluents. After some research the project group found a then unknown underground leakage. The water lost through the leakage, discovered only after the initial input–output comparison, was paid for as ingoing tab water and according to this once more as outgoing effluent. These initial experiences in corporate material balancing soon revealed three key insights.

1. Firstly, in order to not just show input–output-differences or -inefficiencies, but also to actually become more resource-efficient, it is necessary to take a closer look at the material flows between input and output throughout the company and identify the precise locations where material losses appear and where control levers need to be applied.
2. Secondly, the project made it clear that resource efficiency optimisation processes have to consider the entire system of material flows and should not focus only on departmental improvements. This aspect became clear when the project showed that end-of-pipe waste could only be avoided by beginning-of-pipe measures, e.g. in R&D or product development.
3. Thirdly, the experience showed the gulf between two worlds and two perceptions. Corporate management and management control received financial information and decided on the basis of this. Production and Environmental Management worked with physical information or indicators (number of parts produced, scrap rates, kg of waste etc.). However, in order to reach higher efficiency levels both sides had to be considered simultaneously. As a result of the project, management was supplied with information in physical and in monetary terms, showing the entire flow of material from input to output, revealing precisely where high quantities of materials were treated, stored or lost and at what cost (Fig. 3).

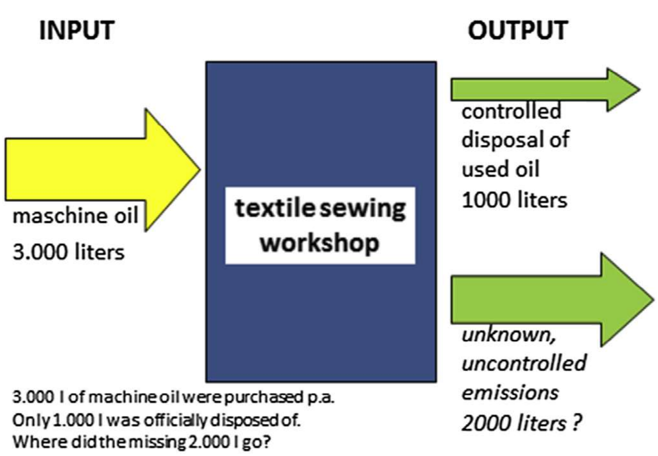

Fig. 2. Material flow: input–output difference of machine oil.

2. From environmental management to managerial accounting

The Kunert project distinguished between “corporate balances” and “process balances”. “Corporate balances” started with the comparison of all purchased input material with the output material going either to product or to waste. “Process balances” were initially “flow accounting” exercises conducted in physical and monetary terms. A process balance “balanced” the material inputs at various spots along the process line against outputs by tracing the flow of material (movements) from corporate input (purchase) to the various locations of material transformation or storage (quantity centres) and up to corporate output as product or waste. “Quantity centres”, marking locations, where materials were transformed or stored, functioned like cost centres in financial management, but instead of tracing cash flows, physical inputs and outputs and changes of stocks were used for balancing. This concept of thermodynamic mass balancing contrasted with the prevailing managerial perception of material and energy as being “consumed” in production processes – meaning gone and lost, not just transferred into different states, e.g. emissions (Fig. 4).

Up to this point, as already mentioned, the corporate world was for the most part divided. Corporate management and management control measured and perceived business in costs and monetary terms. The environmental department measured

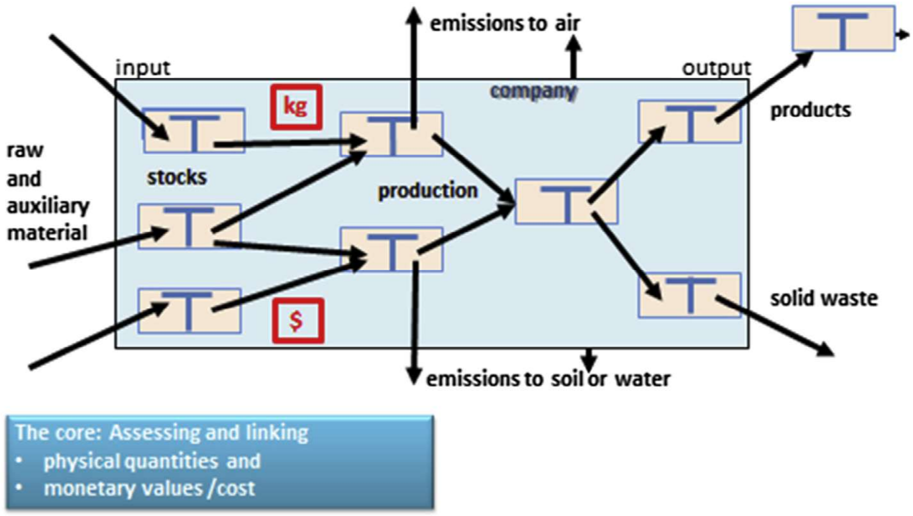

Fig. 3. Corporate material flow model.

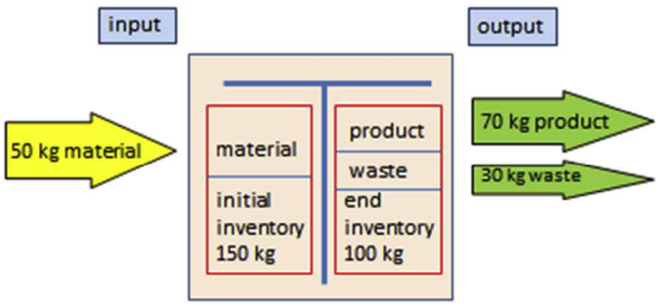

Fig. 4. Mass balance or input–output balance.

business activities in physical terms and according to the parameters of environmental laws. Production management considered quality and scrap rates, and if it included cost information, the focus was mainly on labour cost, not on material cost (Bundesumweltministerium/Umweltbundesamt, 2003). Now material flows provided the common denominator between the various groups and perceptions, looking at the same subject from two angles. By following the entire material flows, it became clear that management and production did neither have a clear picture of all physical amounts of materials being processed, stored or lost along the material flow. Nor did management know the “true” or “full costs” accumulating and hiding along the flow of material. By commonly posting material costs as direct cost to the products, the amount and value of material being processed was not known precisely at the workshop level. Workshop managers knew exactly the labour costs of their particular unit. Because of this, when asked to reduce cost by x%, they reacted (and worldwide still react) by firstly reducing labour cost. No precise information was available on material cost, on amount and value of material buffers and material losses. Overheads (e.g. for waste disposal or water treatment) were distributed evenly and not allocated to the locations where waste or wastewater occurred. It was not known exactly which locations along the production line (machining processes, transports, storage) caused which kind of cost, e.g. waste, emissions, labour, depreciation, energy, loss of heat, leakages etc., and in what amount.

For the early “environmental management” endeavours of the 1990's Kunert projects in order to meet environmental targets, such as reducing resource consumption, waste, emissions or heat loss, the consequences were not only to locate exactly where inefficiencies and losses occurred but also what the resulting costs and cost savings were. Until then in environmental management, cost terms were only used for disposal fees or recycling gains. One typical finding was that while waste costs had previously been evenly distributed as overheads, using closer flow assessment made it possible to demonstrate that e.g. only a single product at certain points along its production line was responsible for 50% of a company's entire waste cost (Fig. 5).

Thus in order to help managers to reduce waste effectively, it was necessary to show them the “true material cost” aggregated along the flow of materials from purchase to disposal, including costs such as for purchasing, handling and administration, storage, losses to air or water, waste treatment and disposal. This required establishing a direct link between the physical information on material flows, which were the basis for technical and environmental considerations, and the information and data from managerial accounting. By this physical indicators used to steer production or waste disposal (e.g. amount of waste per production unit) can be translated into monetary accounting indicators and vice versa (Fig. 6):

The idea of “waste flow costs” here does not only include waste disposal fees, which in many companies still are identified comprehensively as “waste costs”. Waste flow cost also show the value of material in the waste as well as the cost for handling and storing these materials ending up as “waste”. This idea of flow costs also applies to energy flow costs including besides purchasing costs of oil, coal, electricity or other energy carriers also the costs of energy installations or facilities, energy related labour costs etc. And, as shown above, the compilation of flow costs might consider all or selected raw or auxiliary material, water, building material, electrical equipment etc.

The three examples above also show the combination resp. difference of absolute and relative indicators that can be derived from mass balances: Absolute indicators give the total amount of material used per annum and by this can function as indicators for eco-effectiveness or total environmental burden, stating the overall amount of resources used or emissions discharged. Relative indicators can be used as measure for eco-efficiency by relating the amount of material used to a defined denominator, e.g. material or energy used per unit of production, per capita, per machine etc.

From these basic indicator categories an indefinite number of detailed indicators can be deduced. Here some examples from a tin can producing company (Fig. 7):

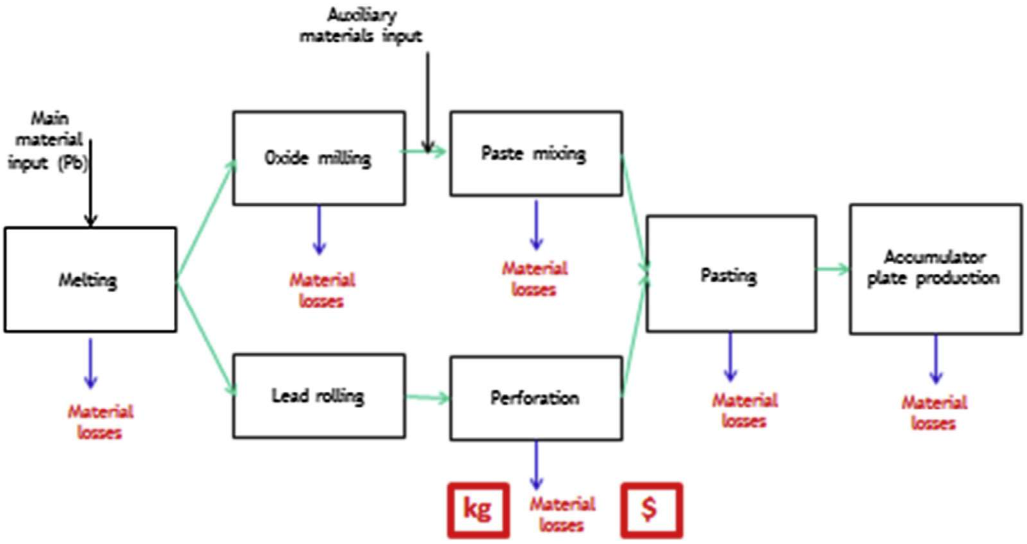

Fig. 5. Accumulator plate production: tracing material losses along production line.

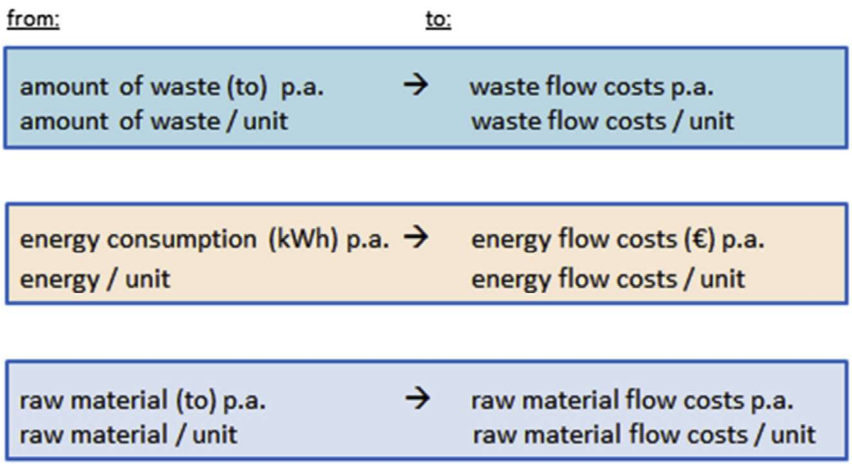

Fig. 6. From physical (environmental) indicators to cost indicators.

3. Further Kunert project experiences: second stage and first publications

Initial publications on the Kunert experience argued that quantifiable environmental information (such as on emissions or waste) in order to become a subject of management awareness has to be converted into cost and profit values. Management did not react on amounts of waste but on waste cost. By considering and making transparent both sides, environmental and financial aspects, of the same coin – the material flows,[4] new terms and concepts appeared, such as "flow accounting", "flow cost accounting" or "extended cost accounting". However, the most commonly used term at that time was "environmental cost accounting" ("Umweltkostenrechnung") (Bundesumweltministerium, 1996, also Schmidt, 2012). For a long time this term caused widespread misunderstanding. It was frequently interpreted as meaning the accounting of environmental protection costs, which mainly covered costs of end-of-pipe technical measures for the treatment of solid, liquid or gaseous waste streams. This focus did not help to locate areas for avoiding material inefficiencies along the production line or even better: beginning-of-pipe. Instead, as many managers identified "environmental cost" with legally required and costly end-of-pipe technologies, they were rather inclined to cut down cost of environmental protection measures, then to target resource efficiencies.

In 1993 this concept and the Kunert experiences attracted the attention of the Deutsche Bundesstiftung Umwelt DBU (German Federal Environmental Foundation), which was at that time sponsoring a project at the Kunert Mindelheim production site (1994–96) to further develop the "Flow Cost Accounting" approach, covering concurrent cost and environmental aspects of the common denominator, the material flows. The concept of Material Flow Cost Accounting was born with the idea of assessing the cost as well as physical properties of material flows more closely throughout the entire company, not just end-of-pipe. Even though the term MFCA had not yet been coined, its underlying conceptual elements with the mentioned projects had been outlined and first publications appeared in German language (Bundesumweltministerium/Umweltbundesamt, 1995).

[4] Wagner (1993) Betriebswirtschaftliche Aspekte des Umweltmanagements im Unternehmen, in: Landesanstalt für Umweltschutz (eds), Projekt "Angewandte Ökologie", Baden-Württemberg, vol. 7, p. 17–42. This title might be translated to "Managerial and Financial Aspects of Corporate Environmental Management". Unfortunately, all these early experiments and corresponding publications were done only in German language.

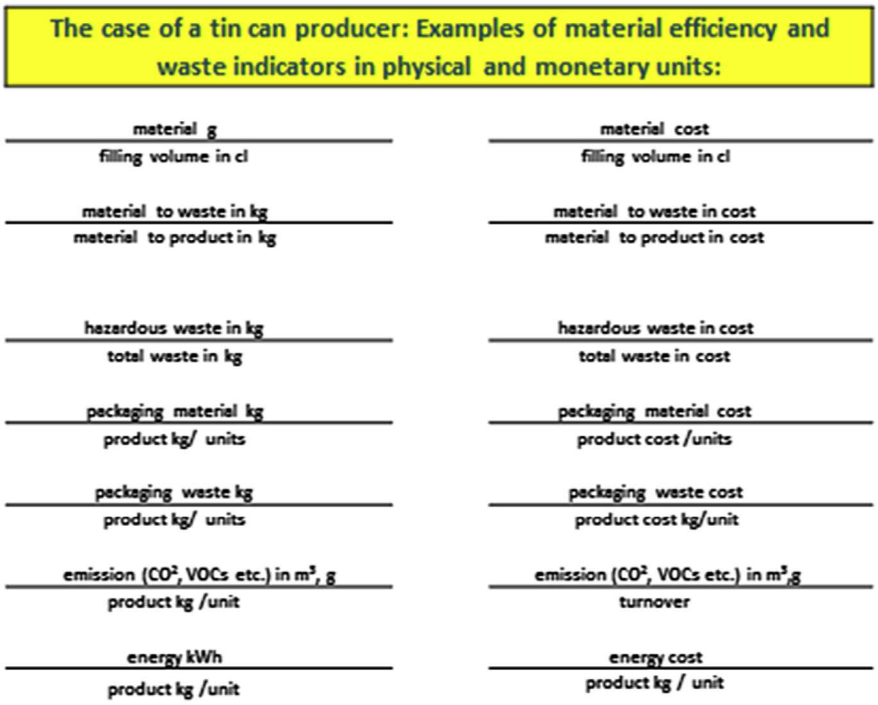

Fig. 7. Material efficiency and waste indicators.

At the same time several closely related approaches were also emerging in Germany, e.g. work by Fischer and Blasius, the German title translates to "Environmental Cost Accounting" (Bundesumweltministerium/Umweltbundesamt, 1995) or by Letmathe (1998), translating to "Environmentally Oriented Accounting", later published under the title of "Resource Cost Accounting" (2002). These approaches were close to a comprehensive Material Flow Cost Accounting concept, but focused more narrowly on material losses and waste reduction, thus framing the notion of "Waste Cost Accounting" (Schmidt, 2012). This approach was able to show waste costs and thus the amount of possible savings more comprehensively, but it did not indicate how and where waste cost might be reduced (Schmidt, 2012). By concentrating on waste, the approaches missed all efficiency opportunities regarding product material, opportunities for reduction, substitution, more efficient handling or recycling of product material.

In view of the close conceptual links, Fischer was also incorporated into the DBU-Kunert project and results were published in 1997, once more under the title of "Environmental Cost Management". This book focused on the question of how to reduce cost using "Environmental Control" (Fischer et al., 1997). It included articles illustrating the Kunert project by imu-researchers, e.g. R. Rauberger, as well as Kunert employees targeting the "allocation of costs to material flows and energy flows" (p. 95), and by H. Fischer on waste costing. It also outlined the first comprehensive model of a Material Flow Cost Accounting application by Strobel and Wagner (1997) based on the Kunert data.[5] A first English paper on the Kunert project covering "material flows and costs" appeared in 1999 by R. Rauberger and B. Wagner in a book on Sustainable Measures (Bennett et al., 1999). For the book's specific "measuring" purpose, this article focused strongly on the idea of "mass-" or "eco-balancing". It differentiated between corporate and process balances. Process balances meant material flow cost accounting exercises. They were composed of various sub-balances, balancing the various quantity centres as centres of material transformation along the material flows. The paper also distinguished between input, throughput, and output costs. Input cost was mainly caused by material purchasing prices. Throughput costs later became known as "System Costs" that covered all material handling costs, including labour and depreciation. And output cost resulted from delivery of products as well of waste or recycling material, including disposal fees etc. If these flow costs and corresponding physical quantities are recorded per quantity center, inefficiencies can be revealed where they occur (Fig. 8).

In the same book on Sustainable Measures, Christine Jasch, who was later significantly involved in the UN DSD Working Group on Environmental Management Accounting (EMA) (UNDSD, 2001), the IFAC Guidance document on EMA (IFAC, 2005) and the ISO standardisation process on MFCA, laid the groundwork for further upcoming MFCA developments, by focussing on the link with accounting systems. Jasch's article also referred to the basic concepts of eco-balance ("Input-Output Analyses") and flow assessment by "Process Flow Charts".

After the Kunert projects, starting with the corporate eco-balance in 1989 and through the publication of project results in 1995 (Umweltcontrolling/Environmental Controlling)[8] and 1997 (Umweltkostenrechnung/Environmental Cost Accounting)[9], rapid dissemination of the MFCA concept occurred in Germany (EPA Baden-Württemberg (eds.), Betriebliches Material-und Energieflussmanagement, Karlsruhe, 1999) (Freimann, 1999). Public attention led to the most extensive MFCA project up to that time in terms of sponsored amount and twenty participating companies, under the heading "Eco-Efficiency". This project was sponsored by the Bavarian Government and coordinated by imu-augsburg and its

[5] This article in German translates as "Structuring and Developing Corporate Material- and Energy Flows". (Strukturierung und Entwicklung der betrieblichen Stoff-und Energieflüsse, in Fischer et al. (1997), p.28–59).

[9] Fischer H., Wucherer C., Wagner B., Burschel C., Umweltkostenmanagement: Kosten senken durch praxiserprobtes Umweltcontrolling Hanser Fachbuch, München 1997.

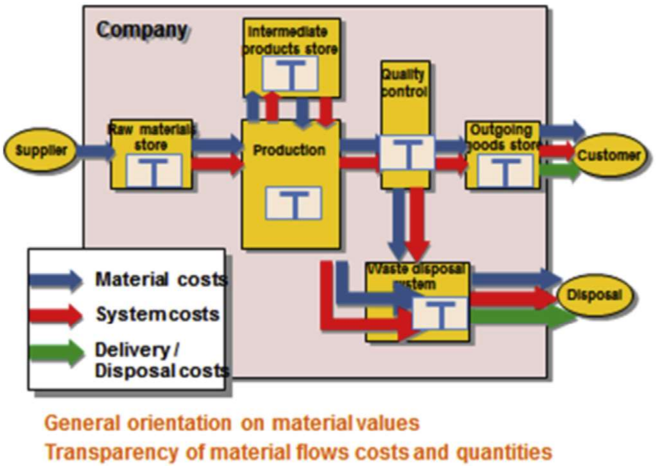

Fig. 8. Basic idea of flow cost accounting.

founder Bernd Wagner. With this project direct links between the material and environmental data from "Flow Accounting" on the one hand and conventional cost accounting data from ERP-systems, such as SAP, on the other hand were introduced into the participating project companies' management processes for the first time. The project's experience was summarised in 2003 in a "Guideline" on "Flow Management for Manufacturing Companies – Sustainable Re-organisation of Material and Information Flows" (Wagner and Strobel, 2003).

Publicly funded projects had proven that MFCA works for companies and could be applied successfully under commercial aspects. The method was well developed. Links with ERP systems had been established and tried out. It was really to be expected that manufacturing companies would now use this method of their own accord and that software companies such as SAP would implement the method in their standard software in order to profit from obvious competitive advantages through increased material efficiency. However, without the subsidies from the public sector the industry did not undertake much effort to profit from the new approach. This might have been connected with required innovative change of accounting procedures and management thinking, understanding that environmental management and cost accounting can work together and environmental topics are not just moral issues but can become crucial and core business. It was only when raw material prices began to rise worldwide and Japan suggested standardising MFCA under the umbrella of the ISO 14000 family that a MFCA renaissance started in Germany. This was driven essentially by the discussion on resource efficiency, which was also reflected in government programs at European level, as well as at central and state level in Germany.

4. *International spread of Material Flow Cost Accounting*

The Eco-Efficiency project was accompanied by international workshops[6] and received a large number of visitors, including a Japanese delegation with Professors Katsuhiko Kokubu and Michijasu Nakashima. A close cooperation arrangement was soon established that still continues today to help bring this concept to the Japanese corporate world. This effort was strongly supported from the beginning by the powerful Japanese Ministry of International Trade and Industry (METI). With the support of METI the concept experienced a dynamic dissemination and implementation phase throughout Japan's industry.[7] In a recent presentation, M. Nakajima (2004, 2014) distinguished the following historical MFCA introductory phases in Japan:

- 1999: The Japanese Ministry of International Trade and Industry (METI) initiates the Environmental Management Accounting Project (continues to this day).
- 2000: The Working group of Material Flow Cost Accounting, introduced from Germany, was established in METI Project and MFCA was introduced to Nitto Denko as a trial.
- 2001: MFCA was introduced to 4 companies (Nitto Denko, Canon, Tanabe, Seiyaku and Takiron) as a trial in METI Project.
- 2004: METI starts a new project encouraging the use of MFCA."

In 2007 METI initiated the development of a new ISO standard on MFCA within the ISO 14000 family on Environmental Management. A condensed version of the MFCA approach was then prepared by an ISO working group ISO/TC 207/WG 8 as a "General Framework"[8] and was discussed in 28 national committees worldwide within the ISO standardisation process. The ISO standard was finalised and published in September 2011 as "ISO 14051:2011 – Environmental management – Material flow cost accounting – General framework". Today, Material Flow Cost Accounting (MFCA) is an instrument standardized within the exclusive ISO 14000 family of standards on Environmental Management, following the Plan-Do-Check-Act cycle.

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[6] One workshop (2000) in Elmau, Germany, discussed project results together with later leading Environmental Management Accounting (EMA) and MFCA protagonists from US EPA, from Australia Roger Burritt, from UK Martin Bennett, from the corporate world Siemens, Ralph Turm, the later COO of the Global Reporting Initiative (GRI) and Prof. Nobuyuki Miyazaki from Japan. The latter already one year later in 2001 published the most extensive elaboration on "Integrated Environmental Accounting" (8 cm thick), unfortunately only in Japanese, including a first comprehensive translation of the imu-MFCA approach into Japanese.

[7] See e.g. a first overview of Japanese MFCA case studies: Material Flow Cost Accounting, MFCA Case Examples, published in 2010 by METI and coordinated by Kokubu and Nakajima.

[8] Main contributors to this working group ISO/TC 207/WG 8 were: Martin Bennett (UK), Seakle Godschalk, Maryna Möhr-Swart (South Africa), Paula Eskola (Finland), Miroslav Hajek (Czech Republic), Yoshikuni Furukawa, Katsuhiko Kokubu, Michiyasu Nakajima, Hiroshi Tachikawa (Japan), Deborah Savage (USA), Edeltraud Guenther, Martina Prox, Mario Schmidt, Bernd Wagner, Tobias Viere (Germany) and Christine Jasch (Austria).

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