

1 Introduction

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Within the scope of the German Federal Government's "Research for the Environment" programme, the *Bundesministerium für Bildung und Forschung* [BMBF (German Federal Ministry of Education and Research)] is funding research work on the subject of integrated environmental protection. Within this programme, various topics are compiled into funding focuses. Since 1999, the BMBF funding focus "Corporate Instruments for Sustainable Management" (INA) has bundled numerous research and development work on the following topics:

- IT tools for sustainable management
- Controlling tools for sustainable management (monetary and non-monetary assessment tools)
- Planning tools for sustainable management (operative and strategic planning tools)
- Communication tools for sustainable management.

Within these four funding fields, sustainability approaches are examined on an internal and cross-company basis, which are aligned both along value-added chains and span across the various levels of corporate function areas (such as design, work planning/ scheduling, production planning, management and control systems, accounting and controlling). Within the INA funding focus, research and development resulted in the emergence of practically-oriented concepts for integrating the requirements of sustainable management into entrepreneurial and business decision-making. The starting point for the developed solutions is the daily routine of the company as well as the current decision-making patterns of the consumers and producers. The results of the research should now contribute to fully utilising the potentials of sustainable management in the

company, provide a new framework for economic research and initiate standardisation processes geared towards sustainable management.

In order to integrate the research and development tasks and moreover, enable the consideration of cross-project topics, cross-project working groups have to be organised. They represent an essential tool for effective interdisciplinary co-operation within the funding focus.

This publication summarises the results of both the “Material Flow Management and Recovery Systems” working group and the projects that were conducted. The focus of the “Material Flow Management and Recovery Systems” working group is at the core of the environmental problem: material flows and the resource consumption and emissions associated with them. The objective of the various practice-oriented projects is to reduce material related environmental pollution in conjunction with economic optimisation. To this end, new economically sound closed loop supply chain options should be taken into account for the purpose of promoting an utilisation of resources that is as intensive, sustainable and low-entropy as possible. Material flow management thus deals directly with the root of the problem, since material flows and their impact are direct causes of ecological problems. Accordingly, the reduction or substitution of material flows can directly contribute to a decrease in environmental pollution. Moreover, such changes usually result in a reduction of costs at the same time. The working group and the projects conducted concerned themselves with providing new impetuses and ideas to the dynamic structures between ecology and economy.

To present these results, this publication first describes a content-based framework on the topic of material flow management. The individual projects and their conclusions are introduced next. The conclusion then provides a comprehensive summary of the end results from the cross-project meetings as well as prospects for further possible activities.

Since the presentation of the results of the completed research projects is the main focus of this publication, a brief overview of the individual projects is provided here for informational purposes.

1.1 Brief Description of CARE Research Project

The BMBF-funded research project “CARE – Computer-Aided Resource Efficiency Accounting in Small and Medium Sized Enterprises” starts from the current state of (environmental) cost accounting and ecological information systems and takes it as a basis for developing an application method that expands the existing economic controlling systems of enterprises by adding ecological information and combines them into an

integrated information system. The Resource Efficiency Accounting (REA) system, a tool developed by the Wuppertal Institute (Wuppertal, Germany), serves as the methodical framework for this. Integrating the results of the REA into corporate controlling creates a decision-making basis for Management in regards to the economic and ecological assessment and optimisation of production processes and products.

The analysis and assessment of the resource efficiency of processes and products requires lifecycle-wide data and information. Such data is available from business information systems as well as external data sources. For this, data concerning internal material and energy flows are supplemented in the form of MI values by resource consumption data from upstream and, if applicable, downstream production steps and/or the utilisation phase.

To enable more efficient use of the data for analysing internal processes and products, a standard for exchanging data between business information systems (Enterprise Resource Planning systems, ERP) and Environmental Management Information Systems (EMIS) was developed in the course of the CARE project and published in the form of a Publicly Available Specification (PAS) in co-operation with the DIN institute. In the future, this data standard will facilitate the exchange of data between the different information systems and make the data available for the economic-ecological assessment of production processes and products.

The CARE project was able to demonstrate how the systematic collection and processing of data related to internal material and energy flows as well as costs associated with them can improve the quality of company and business decisions with respect to sustainable management. The results of the basic project were tested and implemented in practice at the corporate co-operation partners: Nolte Möbel, Toshiba Europe GmbH and Muckenhaupt & Nusselt.

1.2 Brief Description of EPM-Kompas Research Project

In conjunction with the Saxon industrial partners, and by commission of the BMBF, the Professorship of Business Administration, with a particular focus on Environmental Management, at the Technische Universität (TU) Dresden (*Dresden University of Technology, Germany*) has developed, in interdisciplinary co-operation with information scientists and mechanical engineers at the TU Dresden, a tool based on the approach of integrated management of environmental and risk aspects, which can be used as both a stepping stone for introducing an environmental management system (EMS) as well as a tool for the systematic further development of an

existing EMS. The free software developed in the scope of the project, EPM-KOMPAS, can be deployed for individually definable system borders (e.g. process, location, product, etc.) and supports companies in handling hazardous materials and waste, designing internal material and energy flows, setting environmental objectives, evaluating environmental protection measures and preparing reports for authorities. Along with the classic material flow analysis, also implemented are a “silent moderator” that guides users through the software as well the KOMPAS assessment (according to Günther/ Kaulich) for significant environmental aspects and ecological results breakdown.

The KOMPAS software joins the ranks of further research activities related to measuring the environmental performance of transport processes, products from the chemicals industry and products from the medical textiles sector, which are being conducted in the “Environmental Performance Measurement (EPM)” competence centre at the TU Dresden.

1.3 Brief Description of INTUS Research Project

In the “INTUS – *Operationalisation of Environmental Accounting Instruments through the Effective Use of Environmental Management Information Systems*” research project, concepts were developed for facilitating the introduction of controlling tools into the internal environmental management systems of enterprises. The new concepts relate to the three key problems with which companies are faced when striving to optimise the internal provision of information in regards to environment-oriented management. Areas to be considered here include:

- the suitability of the various environmental accounting tools;
- the provision of the tools by way of information technology (IT); and
- the organisational implementation during the introductory phase and in long-term utilisation.

In co-operation with four companies, practical solutions for the IT-aided provision of environmental performance indicators and input-output balances as well as additional information for efficient and proactive environmental protection were developed. Amongst others, an environmental performance indicator system was created and realised within SAP R/3 at Germany-based glass manufacturer SCHOTT. Experience in the medium-sized enterprise sector was gained at the Göhring company, a manufacturer of wood furniture. At Göhring, a performance indicator system was developed, and moreover, the company can now access an input-output balance directly from the Navision Financials ERP system.

The research project also examined the suitability of special software programs for modelling and analysing internal material flows. In addition, a further focus was placed on organisational issues, since it was found that the deployment of IT solutions alone is not sufficient for the successful implementation of a controlling tool.

1.4 Brief Description of IC Research Project

The basis of this contribution is the BMBF sponsored project entitled “IC – Development of an Integrated Controlling Concept Based on a Process-oriented Costing System with Regard to Optimised Material and Energy Flows in Iron, Steel and Malleable Iron Foundries” (INPROCESS). The project is an interdisciplinary research project that aims at creating practically-oriented controlling tools in a sustainable development context.

The expansion of costing systems in regards to environmental protection represents an important basis for the development of an integrated controlling concept. The approaches presented in the literature were already analysed prior to the project; both differentiating and integrating approaches were found. Within the scope of the project, a non-monetary integrated environmental activity-based costing method was developed, which records material and energy flows as well as internalised environmental costs in an integrating system and allocates them to identical reference objects. A “controlling-friendly” cost management of both environmental costs and environmental impact is only made possible by an integrated assessment of the degree to which economic and ecological objectives are achieved.

In addition to laying the theoretical foundation, the methodological approach comprises case studies examining a total of nine companies, at which individual focal tasks of the project were put into practice. The main results of this project are:

- the development of a phase model for implementing integrated controlling in foundry companies;
- the development of a model foundry;
- the preparation of industry guidelines for distributing the results; and
- an IT-aided comparison of foundry-specific software.

1.5 Brief Description of StreaM Research Project

The BMBF funded project “StreaM – Material Flow Based Closed Loop Supply Chain Management in the Electro(nics) Industry for the Purpose of Closing Material Loops” was conducted from January 2001 to April 2004 at the Technical University of Braunschweig (TU Braunschweig) by the Institute of Business Administration, Department of Production Management, in co-operation with the Institute of Machine Tools and Production Technology, Department of Product and Life Cycle Management. The Agfa-Gevaert AG (Munich/ Germany) and Electrocyling GmbH (Goslar/ Germany) companies were brought into the project as industrial partners. In light of the fact that in the future, recycling companies should be integrated into the supply chains of product manufacturers, particularly due to the requirements for expanded product responsibility, the StreaM project aims to provide information technology tools as well as strategic and operative planning tools for integrated, material flow based, cross-company supply chain management in the electronics industry, for the purpose of facilitating companies in fully utilising the resultant ecological and economic optimisation potentials. For the development of the IT tool, the concept of the recycling passport used by Agfa-Gevaert AG was applied and an Internet-based communication was platform created, taking into account the information requirement(s) arising from the various recycling options; the platform interlinked the product development phase with the post-use phase. The concept was implemented in a prototype. The developed strategic tools primarily focus on the support of long-term cross-company planning in terms of the return and re-use of product components within the scope of spare parts management. In this context, a prototype software for a strategic planning tool was developed on the basis of the “systems dynamics” simulation method. These operative planning tools comprise two main tasks:

- the development of a concept for designing business processes related to the order processing for reusing products components in spare parts management, and
- the development of a production planning, control and management system for recycling companies based on the methods of activity-based analysis and operations research.

The developed tools were validated over the course of several comprehensive case studies. Corresponding recommendations for action for the companies and for general politics were then derived from the implementation and the experience gained from the case studies.