A Web Browser-Based Application for Processing and Analyzing Material Flow Models using the MFCA Methodology

Christian Kunisch, Volker Wohlgemuth

HTW Berlin - University of Applied Sciences, Faculty 2: School of Engineering, Technology and Life, Berlin, Germany
Christian.Kunisch@htw-berlin.de, Volker.Wohlgemuth@htw-berlin.de

Abstract. In the context of IT for Green, the potential of the Material Flow Cost Accounting (MFCA) method has not yet been fully unleashed. Using the advantages of mobile data acquisition for material and energy flows, for instance right at a production plant, makes it easier to identify optimization potentials in sustainability management. Tapping this potential, for example through continuous data acquisition of sensor data from sensors in a production plant, can also be made more convenient. Studies conducted that the introduction and application of MFCA has brought significant ecological and economic benefits. They also revealed that there is very little MFCA specialized software on the market. This paper describes the objective and concept of a web browser-based application for the processing and analysis of material flow models and their evaluation with the MFCA methodology.

Keywords: MFCA, IT for Green, Web browser-based application, Angular, Material flow model.

1 Introduction

Reducing energy consumption, waste emissions and the use of primary resources helps to achieve sustainable development [1], which is why resource efficiency is a recent issue on the EU's policy agenda [1]. In the political orientation of the Federal Republic of Germany (German Resource Efficiency Programme II), too, the goal of resource-saving production is anchored as a field of action in the coming years [2]. Particularly the industrial sector should focus its current path towards more sustainable development, such as resource efficiency and cleaner production.

One way to increase material efficiency, i.e. to reduce the sum of input compared to output, is, among others, to uncover the true monetary value of waste generated in production processes through the methodology of material flow cost accounting (MFCA) and thus encourage entrepreneurs to recycle it or sell it to other entrepreneurs. This paper first briefly describes the current scientific status of the MFCA concept and then gives a detailed insight into the structure of the web browser-based application.

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2 Material Flow Cost Accounting

In the late 1990s MFCA has been developed in Germany [3-5], starting with first approaches of flow cost accounting [6]. In the following decade the Japanese Ministry of Trade and Industry (METI) strongly popularized MFCA in Japan [4]. To date, more than 300 Japanese companies have integrated material flow cost accounting [4].
Meanwhile MFCA is ISO-standardized to 14051:2011 (General framework) and 14052:2017 (Guidance for practical implementation in a supply chain). Now ISO 14053 is under development addressing MFCA in small and medium sized enterprises.

MFCA quantifies "the flows and stocks of materials within an organization 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" [7].

The application of MFCA and the subsequent implementation of appropriate measures have shown that remarkable ecological and economic benefits can be achieved [4, 8]. A case study of an Argentinean sugar cane company proves that the use of MFCA and the resulting decision to acquire new facilities worth 350,000 US dollars saves 72,000 US dollars annually [9]. There is only a very limited number of software solutions specialized on MFCA, inter alia a desktop application „Umberto NXT MFCA" and "bw!MFCA" from the ifu Institut für Umweltinformatik Hamburg GmbH [10, 11] and the web application "Materialflusskostenrechner" of the VDI Zentrum Ressourceneffizienz GmbH [12].

Material flow cost accounting is to be promoted as a method because it optimally supports the combination of three perspectives. Firstly, the consideration of physical energy and material flows, secondly the monetary evaluation of savings potentials and thirdly the reduction potential of the climate impact. The material flow cost accounting method provides companies with information on waste and scrap losses. In particular, the true value of these losses is reported. This topic is therefore relevant for manufacturing SMEs, not least for reasons of increasing yields through increased resource efficiency. Based on achieved MFCA results, SMEs are enabled to optimize products and/or processes, to improve their business balance sheets and ultimately to contribute to securing Germany as a business location.

3 Web Browser-Based Application

Due to a lack of supporting software solutions for mobile data recording where the material and energy flows occur and for displaying the volume flows during tours of the production areas to support the development of process optimizations on site [13] the research project "MFCA mobile" was started in November 2017. The "Institut für Umweltinformatik Hamburg" (ifu) already developed a software for CO_2 balancing, material flow costing and visualization of material flows.

It also includes a material flow cost accounting component. But the software exists exclusively as a so-called desktop application for Microsoft Windows and can therefore

only be used locally. A decentralized (mobile) data acquisition or an efficient on-site presentation of the collected data and models in the production areas is therefore not supported [13].

The central concept of the project is the combination of flexible data acquisition, validation and visualization on site with the opportunity of subsequent processing the data on the workstation computer using advanced tools that demonstrate optimization potential. One of the main objectives of the project is to implement a mobile variant to exchange data with the desktop version via a cloud service, creating new usage scenarios in the mobile context for material flow management and MFCA.

Through the mobile data acquisition and visualization and through the combination with an existing desktop application for MFCA, the application of the method for resource efficiency questions is significantly simplified. A further developed concept for data acquisition and representation of material flows will be developed and implemented. This should enable SMEs in the future to record their production processes in a structured way and thus implement operational material flow management. As an alternative to the autonomous approach, the efficient cooperation with experts/consultants will be optimally supported. Sankey diagrams are ideal for visualizing material and energy flows in production processes. They therefore also form a good basis for collecting material and energy flows as well as other data in production processes.

The interaction with a powerful desktop software should be used to intensify the cooperation between consultants and specialists in the company and to link the method of material flow cost accounting with an elegant data collection. The data collector in the company benefits from being able to check and modify the process modeling directly in the production environment on the tablet and to complete the model with data. The smooth and fast data exchange between consultant (desktop PC) and data supplier (tablet) in connection with the graphical representation of the production model leads to faster and better results. A special focus in the expansion of the concept will therefore be on the secure transmission of data by a cloud server including rights management. A commentary function for the work processes allows important work to be documented during the data acquisition tour in order to increase efficiency and to be noted for later implementation. The data to be entered i.e. can be:

- material and energy flows, the quantities of which are,
- Process specifications, their recipe factors, new inputs and outputs,
- Process parameters whose values are,
- Material properties, such as specific weight, price and more,
- Substance concentrations, substance properties and stocks.

The web browser-based application which is under development offers the following features:

- written in TypeScript with the frontend web application framework Angular,
- supports at least Chrome, Firefox and Edge,
- operable by mouse as well as by multitouch and
- is usable on smartphones, tablets and desktop.

The following Figure 1 shows an overview of the structure of the Web Browser-based application.

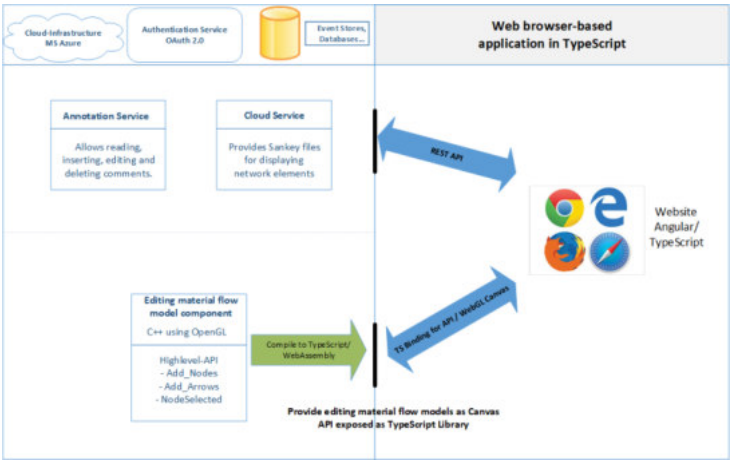

Figure 1. Overview of the structure of the web browser-based application

The Annotation-Service specifies metadata that is associated with web service implementations. It allows reading, inserting, editing and deleting of comments to the processes. The RESTful API is used for the communication between client and server [14]. Authentication and Authorization is implemented by the open protocol OAuth 2.0. It is the industry-standard protocol for authorization [15].

It allows secure authorization in a simple and standard method from web, mobile and desktop applications [16]. Other tools used in the infrastructure are GitLab Repositories [17], automated builds, deployment and test execution, a Build server at GitLab which consists of docker containers for building, deploying and testing and Microsoft Azure [18] for hosting the website whereat deployment can be started manually or automatically in GitLab.

4 Discussion and Outlook

The fact to gather data from mobile devices and push them into an existing material flow model offers the chance for an almost live calculation of the material flows and therefore the MFCA results too. This provides the opportunity to create a continuous and automated MFCA analysis. It is planned to have a mature prototype with these properties available in the first quarter of 2019. Completion is scheduled for January 2020. Currently we are implementing the authorization and authentication service for the web application. Further we are working on the routing and the router guards. With guards it is possible to add checks to restrict access to a user to certain pages [19].

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