Integrated Value Engineering: Consideration of Total Cost of Ownership for Better Concept Decision

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***Abstract*--National and international competition demands companies to sell products with maximum value for the customer, which is reflected by high functionality for the customer for low costs within the company. Approaches in cost management support practitioners in developing valuable products and to reduce costs. The relatively new approach of integrated value engineering (IVE) uses matrices to combine target costing and value engineering in a structural model. The approach currently uses manufacturing costs to find optimization potentials in the product's value and to valuate different concepts of new products. However, the customer's utilization costs during the use phase of the product play an important role on the decision for buying a new product. The amount of these costs can be already influenced during the development of the product. Therefore this publication discusses an approach to extend the concept of IVE by utilization costs. Several concepts from the field of lifecycle costing and total cost of ownership are presented in a literature review. Main ideas are integrated in the structural model of the IVE approach to allow for a better decision on most valuable concepts for the customer. The benefits and limitations of the resulting approach are shown in a case study.**

I. INTRODUCTION

Innovations in product development and international competition demand companies to control their costs. Especially the creation of valuable products requires high functionality and quality for low costs (e.g. [1,2]) to compete in nowadays markets. According to [3] empirical studies show that 70% up to 85% of the total costs of a product are established in the development phase. In contrary, concrete costs emerge over the progress of the entire product lifecycle [4]. Exemplarily, buying a product with less energy consumption by the same functionality becomes more important for the customer with rising energy prices and might even allow for the acceptance of increasing purchasing prices.

Cost management approaches like value engineering (VE) and target costing (TC) as well as the relatively new approach of integrated value engineering (IVE) [5,6] support developers to meet cost targets and to create additional product value. However, these approaches hardly include cost considerations of the entire lifecycle of the product.

This publication aims to extend the IVE approach with the concept of lifecycle costing or total cost of ownership to allow for the possibility to perform cost analysis and optimization over the product's complete lifecycle. Therefore, approaches in the field of total cost of ownership should be analyzed and different cost levels defined to be integrated in the IVE approach. Finally, a possibility to combine IVE and total cost of ownership should be discussed. This supports to include costs occurring in later lifecycle stages, like operation costs, in cost optimization decisions. Altogether, a closer focus on the customer will be achieved.

To reach this aim the remainder of this article is organized as follows. Chapter 2 will introduce the state of the art for this article. This includes the presentation of different cost management approaches, especially the IVE approach, in chapter 2.1. Afterwards, the terms manufacturing costs and lifecycle costs are discussed in chapter 2.2 to facilitate the understanding of approaches like lifecycle costing or total cost of ownership in chapter 2.3. Chapter 2.4 concludes the state of the art and introduces as a first partially literature based result: The allocation of possible cost artifacts to the product lifecycle. Chapter 3 introduces a model to integrate lifecycle costs in the IVE approach. This model is briefly explained on an exemplarily use case to show its basic applicability. Finally, a short conclusion and outlook close this article.

II. STATE OF THE ART IN COST MANAGEMENT AND LIFECYCLE COSTING

A. Approaches in cost management

Two important approaches in cost management are target costing and value engineering [6]. Target costing (TC) plays an important role in product development to reflect the product's value on the market and directly set cost targets for engineering design. Focusing on the achievable product price on the market as a target for engineering design, TC allows for long term profitability of the company. Besides the market oriented planning of target costs it also aims to be aware of measures for influencing product's costs and determining a cost-oriented product development process [7]. To allow for the implementation of this process, first the target costs should be set. Reference [7] defines five categories to determine the target costs. The most important one is to set target costs based on the market (market into company). The achievable selling price on the market is reduced by the planned profit, what results in the target costs of the product. Further categories are "out of company" (determining target costs by assessment of the company's possibilities on the market), "into and out of company" (a mixture of the previous mentioned categories), "out of competitor" (deducing the target costs by benchmarking with competitors) and “out of standard costs” (setting target costs by fixed discounts on standard costs of existing products of the company). The deduced target costs of the product are now split on the components of the product. Finally, the achievement of the target costs should be supported. Reference [8] defines target costing as a “structured approach to determine lifecycle cost at which a proposed product with specific functionality and quality must be produced to generate the desired level of profitability over its life cycle when sold at its anticipated selling price.” Especially, in the context of this paper the inclusion of the profitability over the product’s lifecycle is important. Similarly, to [7], [8] starts the target costing process with market-driven costing by analyzing market conditions to deduce a target selling price, which is reduced by the target profit margin to receive the allowable costs of the product. First, target costing is performed on product level and then on component level. The target costing process covers, besides the product’s components, also the product’s functions.

Value engineering (VE) is a scientific method to analyze a product or service [9]. VE does not only aim the identification of value improvement potentials it also focusses on the deduction of measures and their creative implementation to improve a product’s value [10]. Whereas TC aims the definition and achievement of target costs, VE supports the assessment of potentials and their implementation. Similarly to TC, VE can be performed over the entire product lifecycle. However, [9] suggests to apply VE early in the product lifecycle to facilitate highest cost reduction potentials. Reference [8] discusses three VE approaches depending on the design stages of the product from the earliest phase to introduce new functionalities to the last phase of product planning to improve the functionality of existing components. The improvement of the functionality for the customer with less costs for the company is the major aim of these approaches. These improvements are basically performed by improving the product’s components. Additionally, also functions are include in VE approaches to depict the value for the customer. According to [11] value engineering starts with listing the separate components and functions of a product. Then the customer value of the functions is determined and the components’ costs are calculated. A comparison of the value of the components’ functionality with its costs is used to identify improvement potentials. Afterwards, measures to improve the value of the product are searched, evaluated and finally implemented. A more detailed VE process is for example given by [1].

A combination of the approaches TC and VE is given by the approach of Integrated Value Engineering (IVE). The approach bases on a structural model, which includes the domains requirements, functions and components. A domain is a superordinate class of elements of the modeled product or more general system. The three mentioned domains represent the three main design stages of a product from the first customer input (requirements) over solution-neutral concepts (functions) to final technical concepts (components) [12,13]. The domains form a Multiple Domain Matrix (MDM), which generally structures several domains. Their subsets are Design Structure Matrixes (DSM) and Domain Mapping Matrixes (DMM). A DSM maps the relationships between elements of one single domain, whereas a DMM describes the relationships between the elements of two domains [14,15]. IVE uses two DMMs (DMM “component fulfills function” and DMM “function realizes requirement”) to map relationships between the three product domains. A table to display target and current costs of the product is added to the structural model. Fig. 1 illustrates this basic model on the right side.

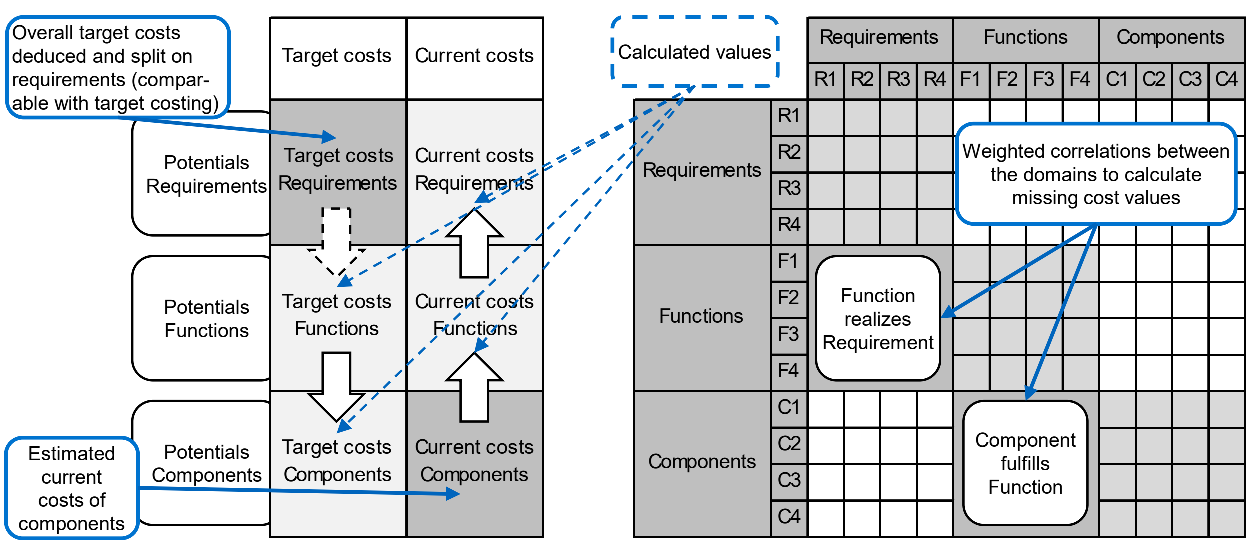

Figure 1.

Fig. 1: Basic model of the IVE approach with the three domains requirements, functions and components and two DMMs function realizes requirement and component fulfills function on the right. The cost table with target costs and current costs of each domain is shown on the left.

The target costs should be deduced from the market or from comparable sources as described in [7]. In contrary to some TC approaches the overall target costs in the IVE approach are split on the requirements (or on functions) as they display the customer's point of view. The current costs are estimated or calculated for the components. The two DMMs are now weighted and used to calculate the missing cost values. This can be done with two DMMs for each calculation direction (compare to Fig. 1), which requires four DMMs in total. Depending on the effort and accuracy of the model two DMMs are sufficient as the other ones can be deduced by standardizing the matrixes from lines to columns (see [5] for more information).

Therewith, a comparison of target and current costs is possible. As an extension to classical VE, the IVE approach allows for a comparison on all three product domains. Potentials in the components domain basically reveal possible cost reductions. Identified potentials in the functions domain offer more independence and creativity in their implementation. This supports value improvement in early stages, new innovative concepts and increased functionality for the customer. Finally, potentials in the requirements domain disclose for discrepancies between customer expectations and technical specifications [5,6].

B. Manufacturing and lifecycle costs of products

The basic IVE model covers manufacturing costs of a product. Since TC and VE literature suggests to extend cost management on the lifecycle of a product (see chapter 2.1) this chapter aims to clarify the terms manufacturing and lifecycle costs.

Basic lifecycle stages are exemplarily proposed in [16]: First stage is the concept stage, followed by development, production, utilization, support and finally retirement. Another product lifecycle is presented by [17] and contains the steps requirements definition, product planning, development, process planning, production, operation and recycling. Reference [18] mentions product planning; development and design; manufacturing, assembly, testing and logistics; distribution; commissioning; use, maintenance and modification; decommissioning; and finally disposal and recycling. All three product lifecycles combine product development with production, utilization and decomposition. They discuss the product from its first innovative idea till its final disappearance. This includes the internal processes like development and manufacturing, which allow for a detailed cost calculation. Processes after selling the product to the customer also occur, depending on the product, and can be also important for cost calculations.

The company internal processes are often mentioned under the term manufacturing costs. Reference [19] discusses manufacturing costs as the combination of components costs, assembly costs and overhead costs. Components costs may occur in buying standard parts or in manufacturing or processing of customized parts. Assembly costs covers labor costs of assembling these parts. Overhead costs include all other costs, for example shipping, facilities, etc. Life cycle costs are discussed as company or social costs, which are not accounted as manufacturing costs occurring during the product's lifecycle (e.g. for disposal, etc.). Reference [13] defines manufacturing costs as the total of the costs for material and production including additional costs such as for production tooling and fixtures, and for design, development, models and tests as far as they relate to a specific product. Additionally, indirect administration costs and indirect sales costs, which cannot directly be allocated to a specific product must be charged. Reference [4] combines material costs, production costs and costs for outside assembly to manufacturing costs. The term manufacturing costs therewith conforms to other definitions. However, [4] further detail the overhead costs or indirect costs. They mention development and design costs, special sales direct costs and administration & sales overhead costs, which are combined with the manufacturing costs to total costs. A profit or loss added to the total costs comes to the calculated selling price.

C. Approaches of lifecycle costing

Reference [20] defines Total Costs of Ownership (TCO) as a purchasing tool and philosophy aiming to understand the true costs of buying a product. To assess an investment decision, TCO takes not only the purchasing costs (direct costs) but also the consequential costs over the whole lifecycle (indirect costs) into account. The method is often used in the strategic cost management to exploit great potentials in the selection of suppliers and award decisions. A structured analysis of the TCO includes a project analysis and the calculation of the direct and indirect costs [21]. According to [3] the term Life Cycle Costing (LCC) is used similarly to TCO. A slight differentiation between both terms is given by [22]. They differentiate both terms by transaction costs. TCO and LCC contain development costs and the consequential costs for operation, maintenance and disposal over the whole product lifecycle. Transaction costs in purchasing and other transaction costs are only respected by the TCO model. So the TCO model corresponds to the LCC model with the addition of the transaction costs.

Reference [23] mentions for LCC, that the costs of operation may exceed the purchasing costs, depending on the product. Mentioned examples are military hardware and construction of state buildings. They also highlight the importance of the considered time horizon after purchasing the product. Another important aspect of LCC is the perspective of the practitioner. The operator or customer of a product is concerned to make a selection from different offers, whereas the manufacturer has to place competitive and profitable products on the market. For LCC both, customer and manufacturer should jointly apply methods to consider costs and performance or benefits for the whole lifecycle [3].

Additionally, standardized procedures for LCC analysis are hardly available [23]. LCC is more a combination of different cost estimation methods and should support decision making as well as reveal cost drivers for future cost optimization [24].

In summary according to [22], both TCO and LCC are models for a precise and complete assessment of all costs that are connected to an investment and corporate guidelines for the implementation of TCO or LCC are not available. Additionally, this publication differentiates TCO and LCC by the mentioned transaction costs and focusses on the cost analysis of the whole product lifecycle. However, further approaches for the monetary assessment of products (or projects) are mentioned in literature. These approaches are briefly presented in the following sections.

The approach Total Benefit of Ownership (TBO) is considered as an opponent method to the TCO. Considering that the TCO deals with costs only, it is rarely easy to take the optimal investment decisions. To conduct the TBO, it is required to differentiate the project from its environment. It follows an identification and assessment of all positive effects of the investment decision during the lifecycle (use, advantages and cost savings). The result is a complete collection of the benefits from an investment decision throughout its lifecycle [21].

Similar to the TBO approach, the Total Value of Ownership (TVO) takes a benefit-oriented view when assessing investment decisions. The TVO calculates an explicit monetary declaration of a project or an investment decision [25]. The basis of the TVO is a TCO calculation that is enlarged through a direct and indirect benefit assessment [26]. A challenge is the monetary definition of the direct and indirect values. The TVO analysis also impacts the business relations between two parties from cost focused to driving value [27].

The Total Economic Impact method (TEI) monetarily quantifies project investment decisions in a customer specific manner. It focusses on integrating the corporate enterprise strategy into its considerations [28]. Similar to the TVO approach, the TEI recognizes direct and indirect costs and benefits. Furthermore, the TEI assesses dynamic and risk parameters for a project. Another difference is that the observation period is flexible and does not need to include the whole lifecycle [28,29].

The Total Value of Opportunity (TVOpp) is a comprehensive tool for the evaluation of planned investments. It uses well established models to produce reliable results. Nevertheless, high efforts are sometimes required to produce the needed input factors. The TVOpp is tailored to evaluate the business value of IT systems. The analysis procedure is very similar to the one of the TEI but the analysis of potentials and risks is more accurate [28,30].

With the key figures that the method Rapid Economic Justification (REJ) produces, investment projects get comparable. Critical success factors, key performance indicators and financial metrics are among them. The REJ is a very precise and reliable framework to analyze and optimize economic performance of investment with focus on business priorities [28]. The REJ procedure consists of diverse approaches for the cost and value assessment and it outputs cost estimations, risk analyses, an organizational analysis and statements about the Return-on-Investment (ROI).

Combining the approaches of TCO, TBO and Total Risk of Ownership (TRO), the Economic Value Creation (EVC) aims to create an economic figure to undertake economical assessments of IT and communication investments [31]. One advantageous feature of ECV is that costs and value can be controlled during the project. The modular structure of EVC that consists of the three named methods empowers a high flexibility as each of the integrated methods provides a different angle of view. Furthermore, the TRO provides a "what-if" analysis to test and control the effects of diverse influences.

D. Conclusions for the applicability of LCC and TCO

Chapter 2.1 introduced the two cost management approaches TC and VE. Within both approaches authors state that the consideration of the product lifecycle for cost management is promising. The approach of IVE combines ideas of TC and VE in a structural model. A consideration of costs among the product lifecycle hasn't been implemented in the IVE approach so far. It currently focusses on manufacturing costs. This term was specified and differentiated from the term lifecycle costs in chapter 2.2.

Chapter 2.3 introduces different approaches in lifecycle costing to allow for a selection of some of these approaches for the integration in the IVE approach. The most promising approach is the TCO (respectively LCC) approach. Comparable with the IVE approach it focusses on the assessment of a product and its costs. The other approaches have a slightly different focus as they consider prices or benefits of an investment decision. An application of these approaches within the IVE approach seems basically possible, but need a changed scope of the IVE application from product or engineering cost management to project management and economically investment decisions.

Remarkable are the mentioned statements considering the missing standardized procedures for the application of TCO in cost management. We assume that changing product and company properties hinder the definition of a standardized process for TCO in cost management. Therefore, as a first result of this state of the art, an overview over possible product artifacts and issues is compared with the different cost levels and a product lifecycle. Fig. 2 illustrates a typical product lifecycle, artifacts and issues affecting costs during this lifecycle and allocates corresponding terms from cost management. The content bases on [32-34] and has been extended and discussed among the authors. The collection should basically support practitioners in the identification of

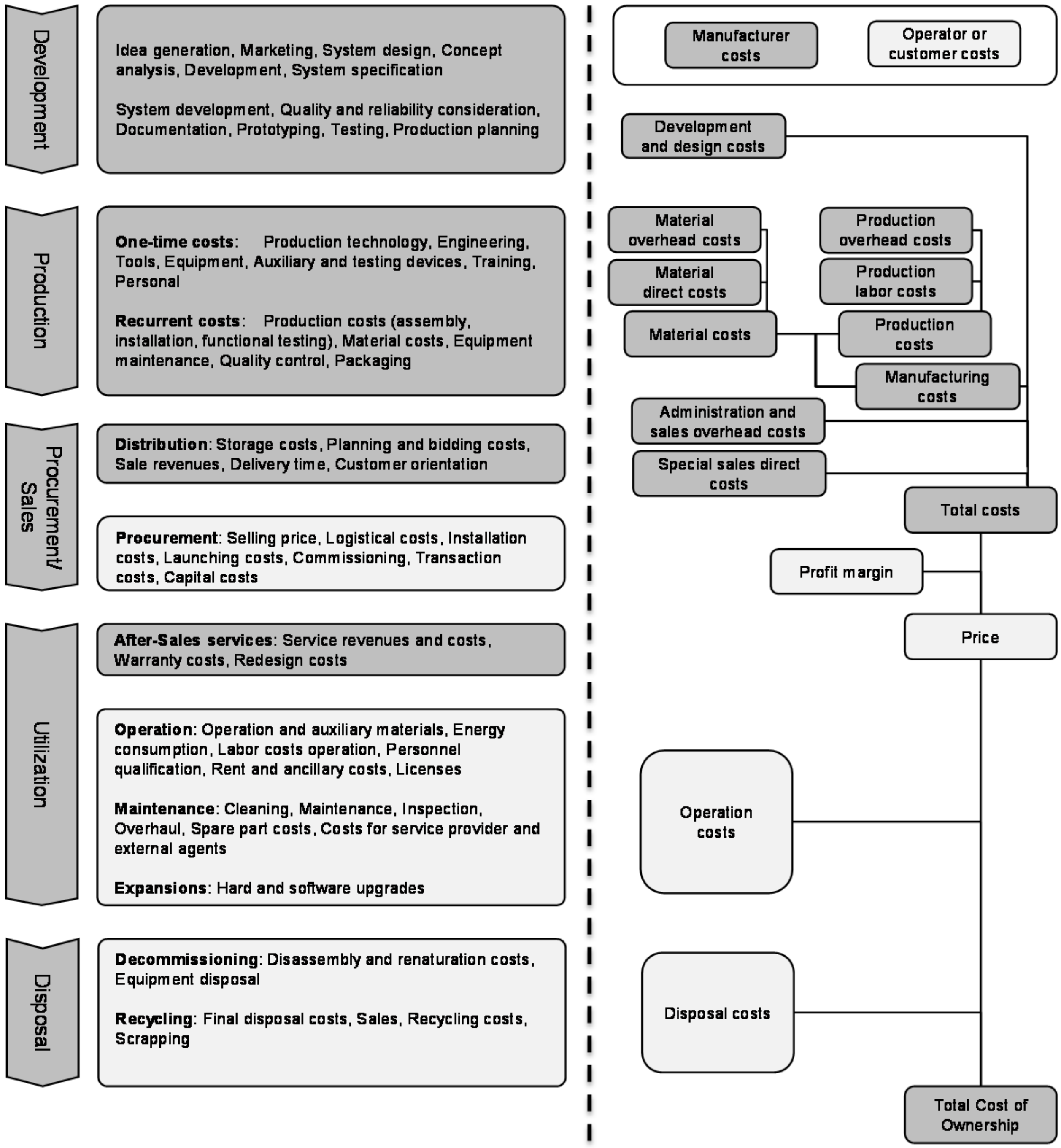

Figure 2

relevant costs for the calculation of manufacturing, total or lifecycle costs. As the literature in chapter 2.3 also highlighted the differentiation between the perspective of the manufacturer and the operator or customer we tried to differentiate between these two perspectives. However, the differentiation is highly influenced by the considered product and customer. For example a product-service system can easily change these perspectives, and Fig. 2 is therewith only one possible illustration of these correlations.

Fig. 2: Overview of different cost artifacts allocated to steps of an abstract product lifecycle (left side). The right side of the figure illustrates different cost levels and their correlation to the cost artifacts and the product lifecycle.

Based on this result, chapter 2 intended to clarify possibilities and limitations of a combination of IVE and TCO. Based on these findings, chapter 3 discusses the concrete combination of these two approaches.

III. MODELING AND ANALYSIS OF PRODUCTS ON DIFFERENT COST LEVELS

The IVE approach basically considers the level of manufacturing costs of a product. These costs are defined as current costs and compared with target costs of the product. The target costs should be deduced from the market or comparable sources. The comparison of both cost values reflects the comparison of costs for the product for the company with the demand and expectations on the customer side. Setting the target costs requires asking the customer for his desired product price, the target price, which is reduced by the profit margin to gain the product's overall target costs. Additionally, overheads (respectively indirect costs) have to be removed.

It is important to only consider the same cost level within the current and target costs to allow for an adequate comparison between these two values for the product. As a cost level we define the consideration of a specific combination of cost relevant artifacts during the product's lifecycle for a certain product. Exemplarily, all artifacts from the production process (meaning all material costs and production costs with its direct and indirect artifacts) of a certain product result in a current cost value in the manufacturing cost level. To reach the same manufacturing cost level within the target costs, the market price has to be reduced by the profit margin, target development and design costs, target administration and sales overhead costs and target special sales direct costs. This context is illustrated in Fig. 3. Each dotted line illustrates a possible cost level. The target costs mainly start on the price cost level, whereas the current costs of a product are mainly known on manufacturing cost level. Please note, that the for example the current price of a product is only known if a predecessor is available. Meaning that for innovative and new products manufacturing costs can be estimated within the concept stage of product development, what allows for calculating current costs. A target price is given by market and customer analysis (for example by surveys or conjoint analysis).

According to the results from chapter 2.4 manufacturing costs, total costs, the product's price on the market and the total cost of ownership for the operator or customer are suggested as cost levels (dark grey elements in Fig. 3). Especially, for early stages and the calculation of assembly groups or components of a product a detailed consideration of material costs and production costs can be promising as well. Therefore, an assembly group or component might be split in materials, which are processed by production processes and purchased parts from external suppliers. Processed parts and purchased parts are combined by assembly processes and overhead costs can be added to the different parts whenever they occur. This represents a detailed consideration of assembly groups or components (left box in Fig. 3). An example of a comparable model is given in [6].

For the integration of the proposed concept of cost levels in the IVE approach the basic IVE model can be regularly modeled (compare to chapter 2.1). Before the setting of the current costs for the components and the overall target costs of the requirements, a cost level should be defined, depending on the product and the desired customer. Therewith, the overall current cost and target cost values should be converted to the same cost level. Fig. 4 illustrates this procedure for the adaption of the current cost values.

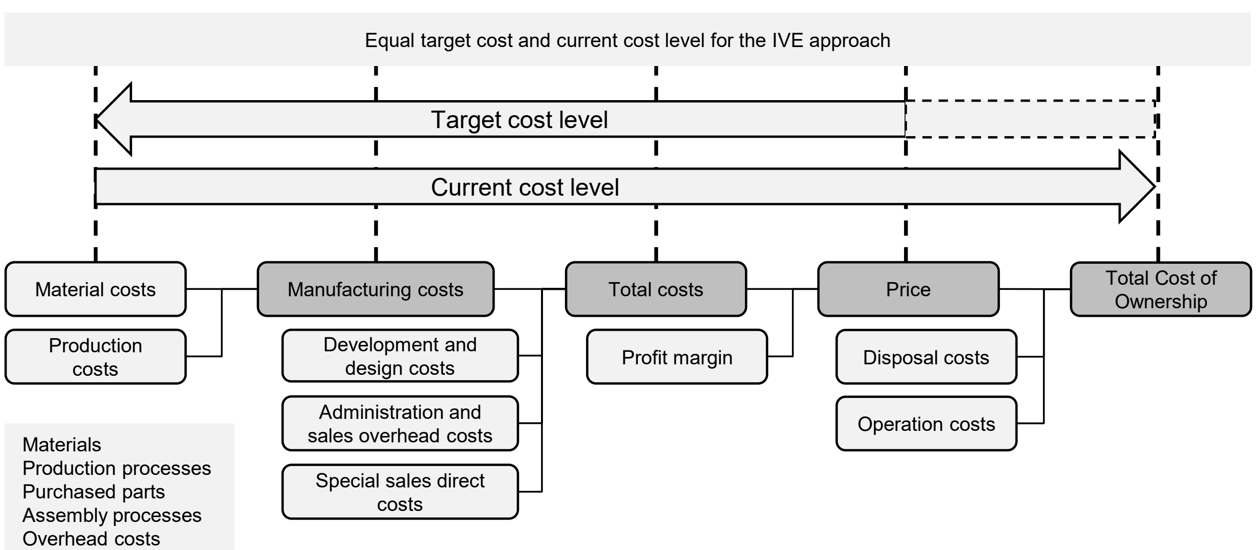

Fig. 3: Four defined cost levels (light grey) and their influence on the deduction of overall target and current costs of a product.

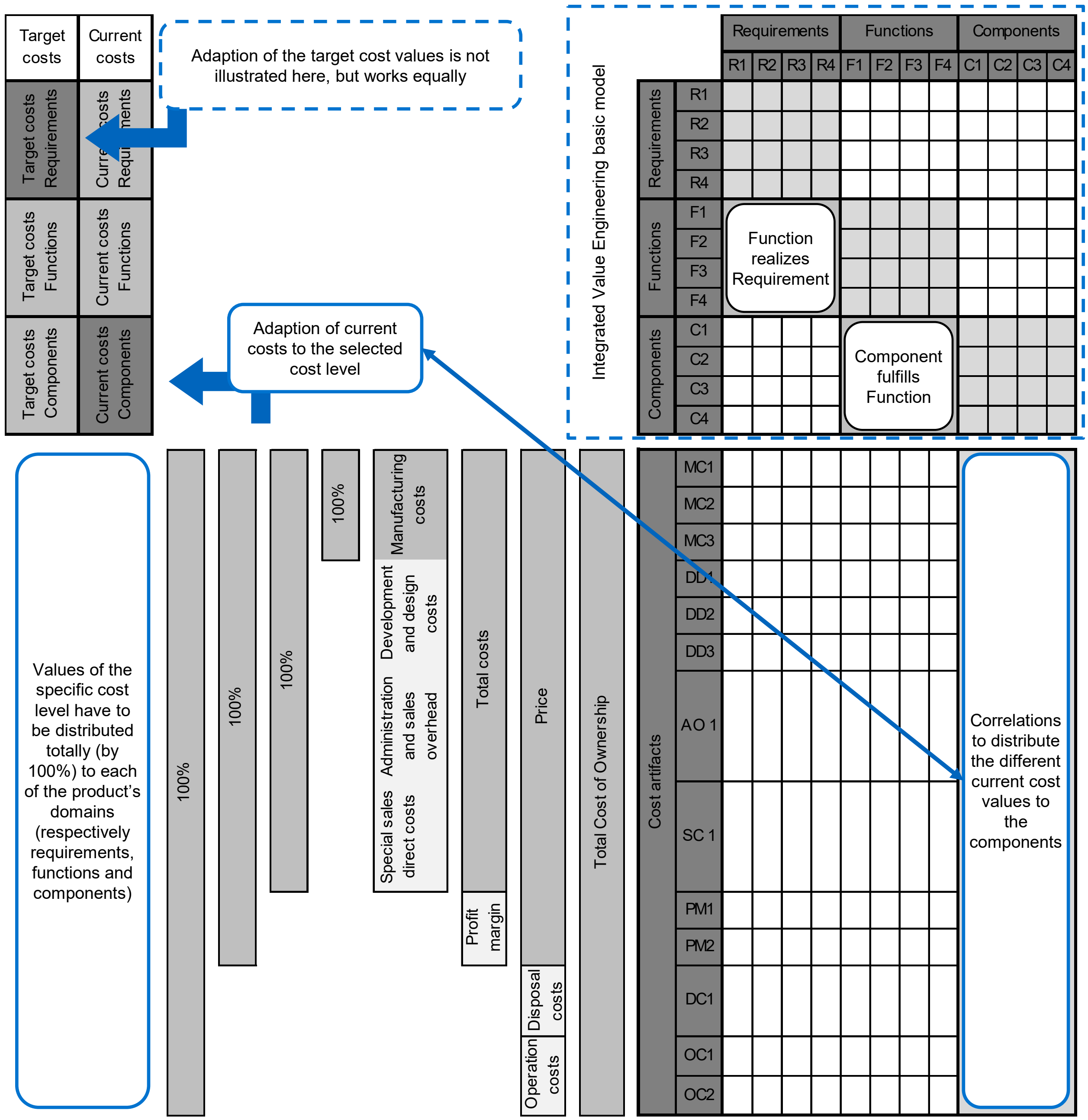

Fig. 4: Model to integrate different cost levels in the IVE approach (only current costs).

In Fig. 4 the four cost levels are illustrated. Depending on the product and customer different cost levels require the distribution of different cost artifacts on the components. The DMM with the correlations between cost artifacts and components is used to distribute different current cost values to the components (right bottom of Fig. 4). Exemplarily, for the total costs cost level, manufacturing cost 1 (MC1) represents the processing costs and MC 2 the material costs for the four components C1, C2, C3 and C4. MC3 is a special cost artefact considering an extra material treatment for the components C1 and C3. DD1 is the development and design overhead for these two components, whereas DD2 and DD3 are the overheads for the other two components C2 and C4. The administration and sales overhead AO1 is distributed on all four components and the special sales direct costs are an additional packaging for C1.

The components current costs on the specific cost level can be now split on the functions and requirements as generally suggested for the IVE approach in chapter 2.1. The distribution of the target cost values works equally, the correlations can be modeled on the other side of the diagonal of the IVE matrix. The target costs distribution basically proceeds the other way round, as, target cost values are basically on the market price level, whereas current cost values are best set on the manufacturing level (compare to Fig. 3).

IV. DIFFERENT COST LEVELS WITHIN THE IVE MODEL OF A HAIRDRYER

The differentiation between different cost levels is now shown within an academic use case of an already existing IVE model of a hairdryer. The reason for this selection is that a hairdryer is a relatively simple product.

The information for the IVE model was acquired by using reverse engineering, which means to systematically decompose a product in its merest parts. For the creation of an IVE model the component domain as well as requirements and functions have to be considered. The elements of the components domain could be easily set by decomposing the physical hairdryer in its smallest elements. Functions have been modeled in using different types of functional models. A final hierarchical functional model was deduced in discussions with several engineering students and engineers. This hierarchical model allowed a proper selection of functions for the IVE model. The requirements have been deduced from the data sheet of the hairdryer and revised in several experiments and discussions. Finally, 21 requirements, 24 functions and 38 components have been selected. The current cost values of the components have been determined by searching similar components in spare parts catalogues and in the internet. If no similar components were found the current cost values have been estimated by consideration of the manufacturing effort for this component. Economics of scale have been discussed and also estimated. For target cost values a fixed cost reduction percentage has been considered (compare to [35]).

In addition to the requirements, functions and components twelve cost artifacts are added to represent the total cost of ownership. Fig. 5 illustrates the new IVE model for the total cost of ownership consideration. The twelve cost artifacts and some of their correlations to components are shown in Fig. 6. Some of the values for the cost artifacts can be easily calculated. Exemplarily, the energy consumption is calculated over a period of one year, assuming six operation days per week and a duration of ten minutes per day. This results in 52 operation hours per year. With a power of approximately 2000W and an energy price of 0.22 €/kWh cost for power consumption are 22.88€. Other values like the costs for recycling are estimated. All together total current costs of 72.72€ occur in comparison to a target of 51.15€. On cost level of total costs the current costs account 35.00€, whereas the target is 32.51€.

A cost comparison of the target costs and the current costs can be performed in the next step. Exemplarily this shows that the component heating element (C28) with the highest energy consumption has only a minor deviation between current and target costs when analyzing on the three levels manufacturing costs, total costs and selling price. But on the total cost of ownership level the high energy consumption determine a high cost deviation for this component. This exemplarily shows the importance of the consideration of cost artifacts over the entire lifecycle for correctly deducing measures for cost optimization.

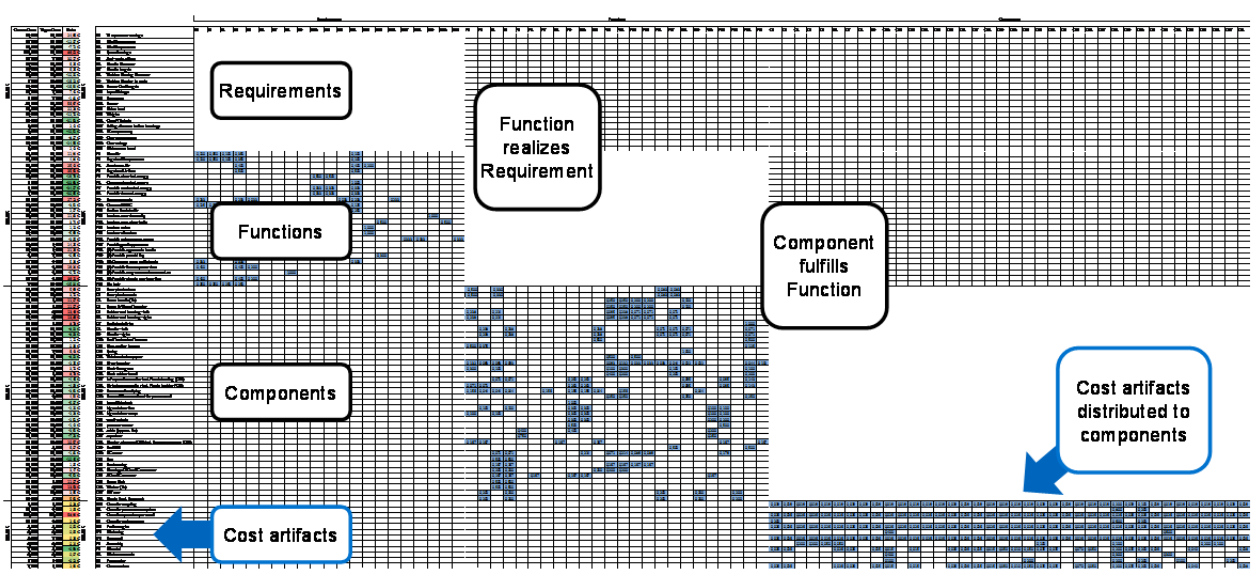

Fig. 5: Illustration of the complete hairdryer IVE model with the cost artifacts and their allocation to components.

		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
DC1	Costs for recycling	0,019	0,019	0,019	0,019	0,019	0,019	0,019	0,019	0,019	0,019	0,019	0,019	0,019
OC1	Costs for power consumption													
OC2	Costs for operation personell	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026
OC3	Costs for maintenance	0,200												
PM1	Profit margin	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026
AO1	Marketing										0,400			
MC1	Personell	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026	0,026
MC2	Assembly			0,200	0,200	0,050	0,050							
MC3	Material	0,026	0,026				0,026	0,026		0,015	0,015		0,015	
DD1	Market research										0,400			
DD2	Prototyping										0,100			
DD3	Construction	0,026	0,026				0,026	0,026		0,015	0,015		0,015	

Fig. 6: Extract of the hairdryer IVE model to show the twelve cost artifacts and their allocation to components.

V. CONCLUSION AND OUTLOOK

The previous chapters present the objective of integrating lifecycle considerations in the approach of IVE. Therefore, the IVE approach is briefly introduced and a differentiation between manufacturing and lifecycle costs is presented. Additionally, different approaches for lifecycle costing of products and projects are discussed. As the focus is on engineering and product optimization the total cost of ownership (respectively lifecycle costing) approach is selected for further consideration. Based on this clarification of the mentioned objective four different cost levels are defined and cost artifacts over the entire product lifecycle are allocated. Influences of changing cost levels on the product's target and current costs are discussed to support the integration of total cost of ownership in the IVE approach. A model to allow for this integration and switching between the four cost levels is presented. Finally, a brief use case of the application of this model on a hairdryer is shown.

To conclude the presented model basically allows for the integration of different cost levels in the IVE approach. Limitations occur especially in the acquisition of the required information. It seems very difficult to calculate the values for the different cost artifacts in the use case. Additionally, also the allocation of cost artifacts on the components results in additional effort. As shown in Fig. 6 some artifacts are allocated equally to components, which is not perfectly accurate (exemplarily costs for recycling highly depend on the amount and material type).

Nevertheless, the approach is beneficial to include lifecycle considerations in the IVE approach, which allows for more detailed cost optimization decisions. Especially products with high operation costs lead to a different cost optimization focus depending on considering manufacturing costs, total costs, selling price or the total cost of ownership.

For future research we suggest to apply the model to a product with higher operation costs and a long lifecycle to clarify the impacts of different cost levels on the assessment of cost optimization potentials or even different concepts. According to literature, the deduction of a procedural model for lifecycle costing will be promising. Especially, if the mentioned limitations in the definition of cost values for the cost artifacts are supported by methods or tools and these tools are combined to a procedural model. Additionally, the applicability on projects and investments, based on the other lifecycle costing approaches, should be tested to apply the presented ideas in other contexts and research fields beside product cost management and engineering design.

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