Extending Enterprise Management Systems - The Case of Energy Management

Completed Research Paper

Richard Roessler
Technische Universitaet Dresden
Richard.Roessler@tu-dresden.de

Hannes Schlieter
Technische Universitaet Dresden
Hannes.Schlieter@tu-dresden.de

Werner Esswein
Technische Universitaet Dresden
Werner.Esswein@tu-dresden.de

Abstract

The paper addresses the issue of an efficient implementation and utilization of new management system parts into an existing landscape of standardized management system on the example of the integration of an energy management system (ISO 50001) into a quality management system (ISO 9001) and an environmental management system (ISO 14001). Therefore we conduct a comparative analysis of the ISO 50001 requirements with the requirements of ISO 9001 and ISO 14001 and derive characteristic integration types: Identical, Integrable, Parallel and Different. To implement this integration types, we present integration patterns for extending an existing method for model-based energy management.

Keywords

Energy Management, Integrated Management Systems, Method Design, ISO 50001, ISO 14001, ISO 9001

Introduction

In recent years additionally to classical performance measures, such as sales and profit other target variables moved into the focus of companies. This development is largely driven by public, legislative and other stakeholders of companies (Fraser et al. 2006). The concept of sustainability is of particular importance in this context. It is one of the most influential terms by which the change of the target range of modern enterprises is described. To work sustainable means to match up the complete target system of a company and to be aware of the significance (meaning) and the consequences (impact) of business decisions for the entire environment.

From the perspective of a total economic sustainable industrial orientation, Germany and in particular the process of the energy turnaround have a special position within the most highly industrialized countries. For a sustainable reduction of fuel economy data and emission values the German federal government demands the reduction of the specific energy consumption in all social areas. To this end, a variety of measures was adopted by the government. Thus, the final phasing out of nuclear energy use was decided in 2011. At the same time, the expansion of facilities to use renewable energy sources is encouraged by massive funding support for small and medium enterprises and private households. Furthermore, in 2013 the German Federal Government adopted a regulation, so that all German companies have to introduce a systematic energy management (EnM) by 2015 (SpaEfV 2013).

Management system standards (MSS) provide general frameworks for the implementation of different aspects of enterprise management systems (MS) such as quality, risk, environment, energy, etc.. For example, the international standard ISO 50001 addresses the consideration of the aspect of energy. The standard proposes organizations to improve energy efficiency and to optimize the use of energy based on the specification of general requirements and guidelines for the implementation of an Energy Management System (EnMS) (ISO 2011). The requirements of the standard have to be adapted against the specific characteristics of the organization. EnM is a relatively new issue, which means that this adaptation process currently is less supported. For companies seeking the appropriate certification, this means high

effort. Against the background of the mandatory introduction of EnMS, the question arises how to build efficient and effective appropriate management structures. To this end Roessler et al. (2014) present a model-based method to configure and operate an EnMS based on conceptual models. However, the question of integration into already existing MS is not addressed in this article. According to López-Fresno (2010) the integration of MS can occur from the development of an IMS, which is an approach that seeks to take advantage from the synergies and elements common to all function specific MS.

Against this background, the present paper is an extension of the work of Roessler et al. (2014) and presents method fragments that assist in the development of a model-based method that supports the implementation and documentation of a holistic IMS. The paper addresses the issue of an efficient implementation and utilization of new MS parts into an existing landscape of standardized MS on the example of the integration of an EnMS into a quality management system (QMS) and a environmental management system (EMS). Therefore we conduct a comparative analysis of the ISO 50001 requirements with the requirements of ISO 9001 (QMS) and ISO 14001 (EMS) and derive characteristic integration types. These are incorporated into the design of the method. Implications for the model-based integration of MS are derived to discuss the further research direction.

Research Method

The present contribution is related to the design-oriented branch of information system research (Hevner et al. 2004). The core idea is to create an artifact for resolving an unsolved or an economical as well as a qualitative improvement of an existing solution. Design science research (DSR) is focused on the creation of useful artifacts in information system context (Offermann et al. 2011). This can be models, methods, implementation and their applications (Hevner et al. 2004). Conceptual models and model-based methods have been established instruments in information systems research for documentation, communication and improvement of information systems (Brinkkemper et al. 1998; Iivari et al. 2000).

As an artifact, we present design recommendations in terms of method fragments that represent the basis for the design of a more complex method. The basis for this is the work of Roessler et al. (2014), which deals with the design of a method for model-based EnM. In the DSR Knowledge Contribution Framework of Gregor and Hevner (2013) the present work is thus classified as "Improvement". According to Gregor and Hevner (2013) and due to the medium degree of abstraction of the method the artifact is classified as a Design Science Research Contribution Type of Level 2. The evaluation of the artifact takes place through instantiation using a concrete example. To this end, we aim for the application of the final method using a detailed case study, which results from an integration project in an industrial company. We present the results of the evaluation in a subsequent article. We use the procedure model of Peffers et al. (2007) as research framework. In the first step, we give a short insight in the problem field and relevant literature and introduce the method of Roessler et al. (2014). In the second step we build integration scenarios and analyze the possibilities of integrating a new MS into an existing MS landscape. Therefore we derive integration types and design integration patterns for a meta-model-based link of the different MS.

To answer the research question of how the integration of MS can be methodically supported using models, the contribution provides as a result the design of an artifact that supports in the efficient implementation of an EnMS based on the four different integration types.

Literature Review

Implementation of Energy Management Systems

To assist in the tasks of systematic EnM various approaches exist already. These can be divided into the categories: *Energy Controlling Tools, EnMS-oriented Maturity Models and Guidelines*. For the evaluation of these existing approaches, we derived criteria from a user perspective. Therefore, first is to clarify what are the use-creating criteria for the user. On the one hand, these criteria relate to the consideration of the standard requirements (ISO 50001). Reason for this is that an appropriate system can only be successfully certified, if all requirements are adequately implemented (Evaluation Criteria: *Full Consideration of Standard Requirements*). On the other hand, we evaluate the extent to which the approaches support in the task of MS-documentation (Evaluation Criteria: *Documentation of the Management System*). This is of particular importance as the standards prescribe the mandatory

documentation. In addition, we examine how these approaches allow for a maturity assessment of the MS (Evaluation Criteria: *Maturity-Check of Implementation*). Similar to the process of continuous improvement, the implementation and subsequent evaluation is a necessary condition for the effectiveness of the MS. The last criterion checks to what extent the possibility to integrate further MS is given (Evaluation Criteria: *Integration of Aspects from other Management Systems*). This is particularly important because in today's corporate environment hardly any company exists, which has no defined existing management structures. The results of the comparison under the mentioned criteria are presented in table 1.

The EnMS market survey, developed by the Energy Agency.NRW (2013a), shows that there are currently no comprehensive methods based on a holistic view of an EnMS, but only partial aspects of an EnMS such as the issues of energy measurement and energy data management are addressed. The tools listed by Energy Agency.NRW (2013a) are rather solutions for energy controlling and analysis that support in data collection at the machine and measuring point level. The research project "ReMo Green" (Meyer 2013) has similar objectives and aims to develop an industry-specific and process-oriented energy efficiency software. For this purpose reference modeling should be applied. In addition to functions for monitoring, controlling, reporting and benchmarking, it also offers the functionality for simulation. Organizational aspects, such as the documentation of an energy policy and the identification of objectives for implementing this policy are not considered in this approach.

On the other hand, there are various guidelines of certification companies (e.g. GUTcert 2013) and public bodies (e.g. Kahlenborn 2012) for standard implementation of an EnMS. These are recommendations, which are strongly based on the requirements of the ISO 50001 standard. They are partly supplemented by document templates. The aspects of the integration into an existing MS-landscape are, if at all, considered as cross-references to the requirements of other MSS. However, the application of these guidelines still requires a company-specific interpretation. A similar approach is followed by the project mod.EEM (EnergyAgency.NRW 2013b) whose central idea is to check the progress on implementation of an EnMS through an online checklist. It also offers the possibility to formulate recommendations for action or to refer to legal provisions. Although not described as such, mod.EEM has similar aims as a maturity model. It defines different levels of maturity of an EnMS, which can be described using the checklist. Supportive document templates are provided as well. Both mod.EEM and existing guidelines help to interpret the standard, but give no documentation tool at hand. Thus, it depends on the capabilities of the company if a consistent information management is implemented. Schlieter et al. (2010) propose a model-based approach to EnM, however, aim for the reuse of models in the context of the efficient creation of EnM processes and not for a holistic model-based approach. Independently from EnM research, in the areas of process and quality management, model-based solutions are pursued already. However, owing to the specificity of EnMS these approaches are not transferable to the domain of EnM.

In summary it can be stated that currently there is no comprehensive method, which supports all relevant aspects for an effective implementation and operation of an EnMS. Each of these approaches has its strengths in a specific partial function of an EnMS. A holistic model-based method, as presented in Roessler et al. (2014), helps to overcome the weaknesses of the existing approaches. Based on a detailed requirements analysis of the standard the method supports both in the documentation of the EnMS as well as in the practical implementation of EnM by analyzing and controlling relevant aspects of the EnMS from an energy policy right up to measures on the shop floor level. In addition, on the adjustment of the generic modifiable meta-model, other subsystems, such as a energy controlling system, can be integrated into the EnMS. Therefore, the model-based method can be understood as an integration framework for other dedicated subsystems as well.

EnMS-Tool	Evaluation Criteria: Full Consideraion of Standard (ISO 50001) Requirements	Documentation of the Management System	Consistency of Documentation	Maturity-Check of Implementation	Possibility for further Analyses	Integration of Aspects from other Management Systems	Explanation / Assessment
Energy Controlling Tools (cf. EnergyAgency.NRW, 2013a)	-	o	-	-	o	-	typically technically oriented data collection, analysis and documentation on machines and measuring point level
EnMS-oriented Maturity Model (cf. EnergyAgency.NRW, 2013b)	x	o	-	x	o	-	strongly standard-oriented and document-driven documentation of EnMS, maturity check through checklist
Guideline (cf. Kahlenborn et al., 2012)	x	o	o	x	x	o	strongly standard- and implementation-oriented recommendations, maturity check through checklist, documentation as requirement for implementation of EnMS, recommendation for integration typically through references
Model-based Method (cf. Rößler et al., 2014)	x	x	x	o	x	x	strongly standard-oriented, holistic and consistent documentation of the EnMS with a variety of analysis and control possibilities, real integration of aspects from other management systems
Legend: "-" not fulfilled, "o" partly fulfilled, "x" completely fulfilled							

Table 1. Evaluation of EnMS-Tools

Integration of Management Systems

With the introduction of an EnMS a company is faced with the decision whether this MS should be kept isolated or if it should be integrated into an existing corporate MS. In literature there are numerous references to synergies that may be raised by the integration of MS. These include:

- Utilization of common management principles (process-based approach, continuous improvement, etc.)
- Similar structures of the underlying standards on the basis of the continuous improvement cycle
- Similar standards requirements (sometimes identical requirements) that can be simultaneously satisfied (Bernardo and Simon 2012).

Karapetrovic (2008) states that the integration becomes a necessity due to the increasing variety of standardized MS. In recent years an intensive discussion of various aspects of the integration of MS took place. This discussion focused primarily on the strategies, methods and levels of integration and the integration of audits. Bernardo and Simon (2012) conduct a comprehensive literature review on these issues. Among others they conclude that MS-integration means additional efforts for companies. This implies the need for organizations to take action for sharing tools, methodologies, and systematic management of different areas, and to comply with the different standards or models governing the MS.

Perspectively, the developed method for EnMS should not only meet the requirements of ISO 50001. Rather, it should be applicable to various MS and should, in particular, support for the integration within an established environment of MS. To demonstrate this purpose, in the following course of the paper, the two standards with the highest certification numbers worldwide (ISO 2012) are considered:

- ISO 9001 for QMS: A MS that ensures that the products manufactured / services provided consistently meet the requirements of customers and that quality is continuously improved.
- ISO 14001 for EMS: A MS that assures the company's management, employees and external stakeholders that the impact on environment is measured and continuously improved.

MS according to the ISO standards 9001, 14001 and 50001 have similarities in content and structure. In the following we will analyze intersections of these standards and derive implications for a model-based integration of MS. As a starting point the requirements of the related standards were compared. As a

result of the comparison we found that, for a variety of requirements, similar provisions have to be made and similar data has to be raised. However, there are also requirements that are unique to the individual standards. Based on the content and structure analysis, we can distinguish four different integration types: *identical, integrable, parallel and different* (see table 2).

Type		**Identical**		**Integrable**		**Parallel**		**Different**	
Characteristics		Identical requirement in various standards (structure and content identical)		Structurally similar requirements, which can be grouped (structurally identical, different in content, content can be integrated)		Structurally similar requirements, which can not be grouped (structurally identical, different in content, content can not be integrated)		Requirements with no similarities with requirements of other standards (structure and content different)	
Example	**Standard**	Section	Description	Section	Description	Section	Description	Section	Description
	ISO 50001	4.5.3.2	Control of documents	4.3	Energy policy	4.2.2	Management representative	4.4.4	Energy baseline
	ISO 9001	4.2.3	Control of documents	5.3	Quality policy	5.5.2	Management representative	-	-
	ISO 14001	4.4.5	Control of documents	4.2	Environmental policy	4.4.1	Resources, roles, responsibility and authority	-	-

Table 2. Integration Types

Case Scenario

On the occasion of the 30 pilot networks initiative, which is part of the Climate Initiative of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, energy efficiency networks were developed throughout Germany. In each of the networks ten to fifteen companies affiliate for the project period of three years to collectively address the problem of rising energy costs. Core components of the networks are regular exchange of experiences at so-called energy efficiency tables (Goellinger 2012) and a company-specific energy advice in which the measures for energy savings are presented. These measures form the benchmark for the assessment of energy savings in subsequent years. During the project, each company is thus asked to implement efficiency measures and to take organizational measures to implement a continuous EnM. As part of the "Energy Efficiency Network Saxony" (EENS), which is one of the 30 pilot networks, parties were asked to what extent an EMS is already in place and whether certification is planned or has already been completed. 5 of the 15 companies currently have a ISO 50001-certified EnMS and one company is in the process of certification. In general, the EnMS was not the first standardized MS, which has been implemented in the companies. All companies that have already completed the ISO 50001 certification were previously certified to ISO 9001. Some of the companies also had certifications to ISO 14001 or certifications in accordance with other systems.

In discussions with the managers in charge of the MS we could find that each company was faced with the question whether the EnMS should be implemented separately from the existing MS structures, or if an integrative approach should be followed. In all companies the decision was made for the benefit of the integrated approach. Similar to the results of Karapetrovic (2008), the decision was always justified with expected gains in efficiency in the MS documentation, mainly resulting from contextual and structural similarities of the existing MS. The entire MS documentation is limited in all companies to standard office tools such as Word and Excel.

To demonstrate an extended version of the method presented by Roessler et al. (2014), the example of a company participating in the EENS is used. The company is active in the field of plastics processing and has already completed the ISO 50001-certification process. In addition to ISO 50001, the company also has certifications according to ISO 9001 and 14001. The company thus has a typical integration scenario for the EENS. We accompanied the certification process and identified interfaces for the integration of MS. The interviews with the managers in charge of the MS revealed that changes and additions to the existing documentation of the company increasingly complicate the work of managers due to the large number of individual documents and mostly unstructured collected data. This is especially true if modification anomalies because of renamed roles, changed laws or renamed process steps must be avoided.

Method Design

Model-based Energy Management

Roessler et al. (2014) present a model-based method for documenting and maintaining an EnMS compliant with ISO 50001. In the context of a standard-based requirements analysis, four different sets of requirements were identified: *General Requirements, Management Responsibility, Energy Planning* and *EnM-Processes*. Based on this requirements analysis and using a multi-perspective modeling approach (Ferstl and Sinz 2008) the necessary concepts for the adequate representation of the requirements for the different presentation types were defined. Subsequently an appropriate allocation to the model views has been made. By a set of views, all business-related EnM-information are comprised and their network of relations is maintained. For implementation the meta-CASE tool named Cubetto Toolset was used, which is a generic tool for the definition of (individual) modeling grammars. The views of the model-based EnM method are derived in accordance with the main aspects of ISO 50001: *strategy, EnM-processes, energy analysis and documentation* and *organization*. Table 3 gives an overview of these views, their associated presentation types, their purpose, and the underlying requirements.

As presented in Roessler et al. (2014) figure 1 shows an excerpt of the meta-model as UML class diagram. It defines the abstract syntax of the modeling language by describing the model views (e.g. *Strategy View*), their specific presentation types (e.g. *Target plan, Action plan,*), concepts (e.g. *EnergyPolicy, EnergyTarget*) and their relationship types. In *Strategy view*, concepts for modeling energy targets, related measures and programs are shown. Using these concepts a stepwise operationalization of the energy policy of the company through the definition of energy targets and derivation of programs of measures. In figure 1, the concepts of the presentation types *Target plan* and *Action plan* are illustrated. Within the presentation type *Target plan EnergyTargets* can be assigned to an *EnergyPolicy* by a structural relationship. These targets can be assigned indicators (e.g. *KPI* or *EnPI*). Within the presentation type *Action plan* at least one program of measures (*EnergyProgramme*) can be assigned to an *EnergyTarget*. Each program in turn is assigned to at least one *EnergyTarget*.

Model View	Presentation Types	Purpose
Strategy & energy policy	Target plan	Presentation of energy policy as well as hierarchic mapping of strategic and operational energy goals and their major attributes including the allocation of key performance indicators (KPI) and energy performance indicators (EnPI)
	Action plan	Allocation of energy programmes with the relevant activities as well as their particular core features to the energy goals and allocation of underlying documents
	Internal programme view	Chronological presentation of activities of an energy programme
	External view of activities	Mapping of an activity including resources and goals which are pursued by the activity
	Internal view of activities	Presentation of the main subtasks and milestones of an energy activity
Energy manage-ment processes	Process chart	Presentation of important, basic approaches and processes of the organisation in the context of EM usage of actions, states, decisions, junctions, roles and sequential relations
Energetic analysis & document-tation	Energetic evaluation – process orientation	Mapping of key business processes of the company under the assignment of measuring points to sub-processes and the representation of energetic parameters of a sub-process with appropriate priority
	Energetic evaluation – structure orientation	Mapping of the organisational unit structure by hierarchical breakdown of energy consumers and associated measuring points under allocation of prioritized energy variables
	Measuring plan	Listing of measuring points of certain corporate divisions, its components and assignment of measured values and measurement times

	Requirements	Listing of commitments undertaken due to EM and associated characteristics and documents
Organi-sation	Organisational structure	Mapping of hierarchic organisation structure by means of divisions, positions, roles and teams
	Job description	Description of single positions and roles with needed skills and given authorisations

Table 3. Architecture of the Method for Model-based EM (Roessler et al. 2014)

Based on the presentation type *Target plan* and *Action Plan* the integrative modeling approach is demonstrated. In the small dashed box the concepts of the presentation type *Target plan* are shown, whilst in the large dashed box the concepts of the presentation type *Action plan* are shown. The object *EnergyTarget* is used in both presentation types. In case of modeling, an *EneryTarget* has to be modeled only once for this and referenced in each presentation. Graphical representations of these concepts are shown in figures 2 and 3. Based on this method design, we will now make an extension for the integration of MS.

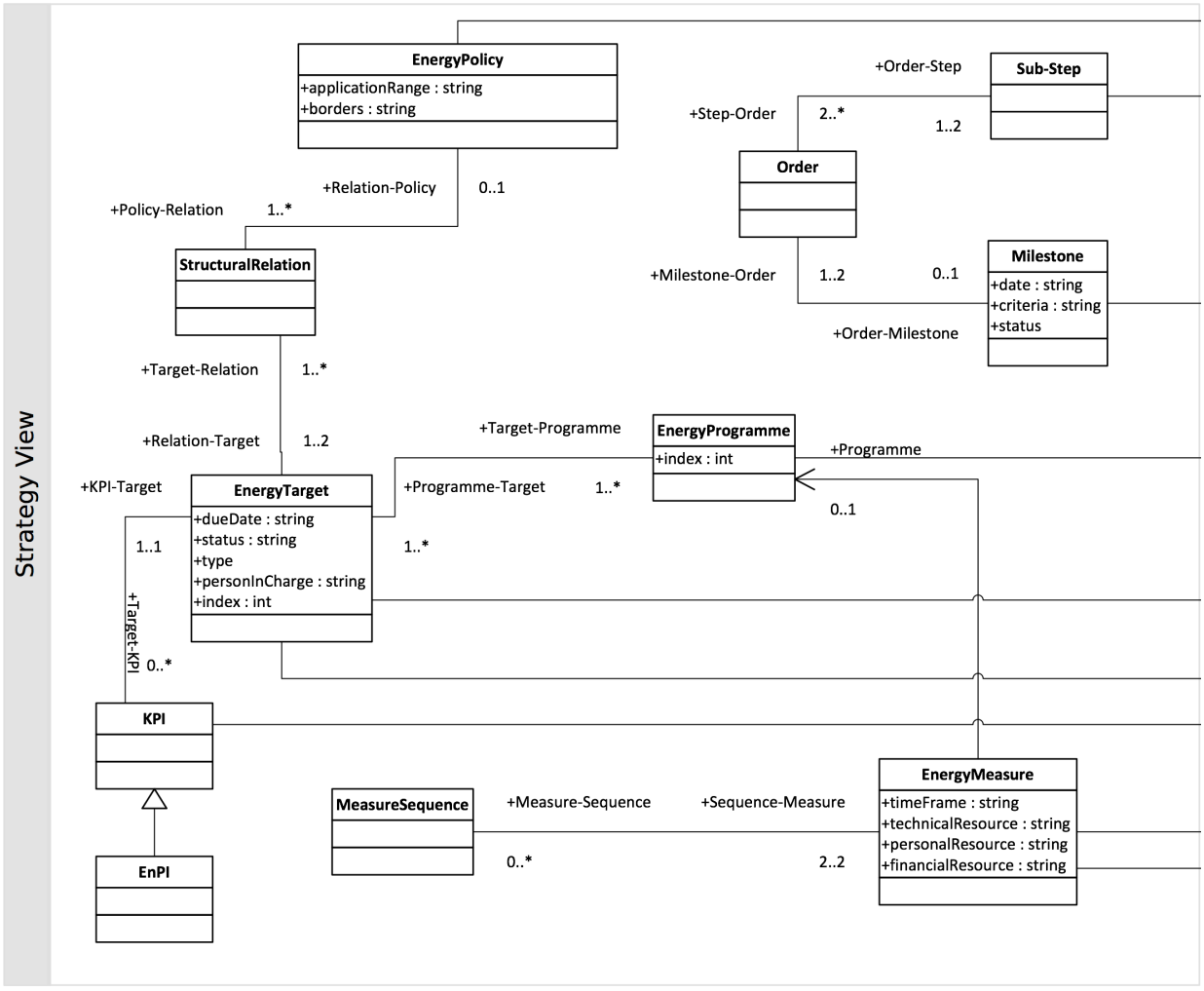

Figure 1. Excerpt of the Meta-Model (Roessler et al. 2014)

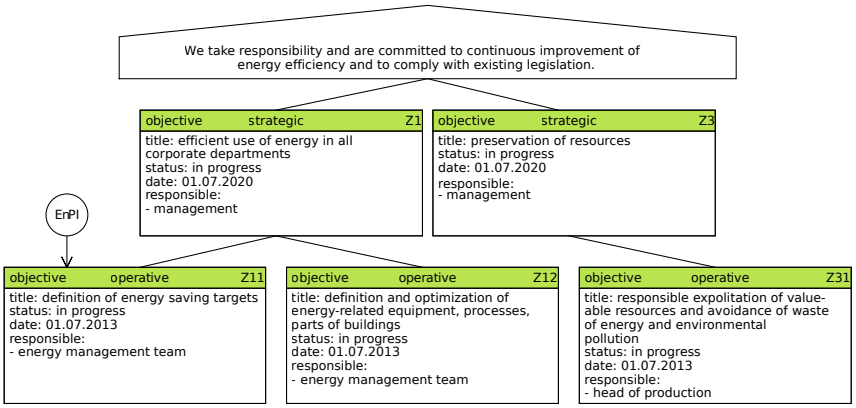

Figure 2. Target plan (excerpt)

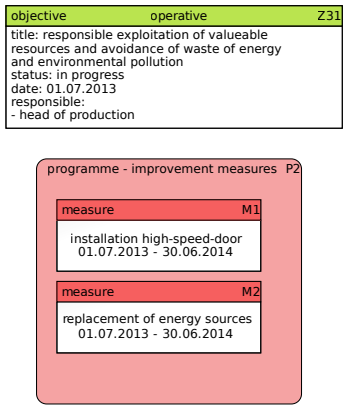

Figure 3. Action plan (excerpt)

Model-based Integration of Management Systems

Based on our experiences from the case scenario on the implementation of the EnMS and its integration into the existing MS landscape, the applicability of the model-based method for this integration scenario is demonstrated. We found that a generalized view concept with the four views: *Strategy, Analysis and Documentation, Management Processes* and *Organization* is applicable and sufficient for a complete consideration of all standard requirements in the integration scenario of ISO 9001, 14001 and 50001. Based on the identified integration types we describe their implementation within the meta-model below.

First, there are requirements that are *identical* in all three standards. They do not have any subject-specific differences, they are *identical* in both structure and content. This applies, for example, for the provisions relating to the control of documents. Within an integrated MS the corresponding process description has to be created only once and can, if necessary, be supplemented by references. This means that enterprise-wide and functional unspecific a uniform approach is defined for document control. If necessary, specific functional sub-systems, such as the EnM refer to this procedure description (see figure 4). For the design of the model-based method, this means that the corresponding processes and objects have to be created only once.

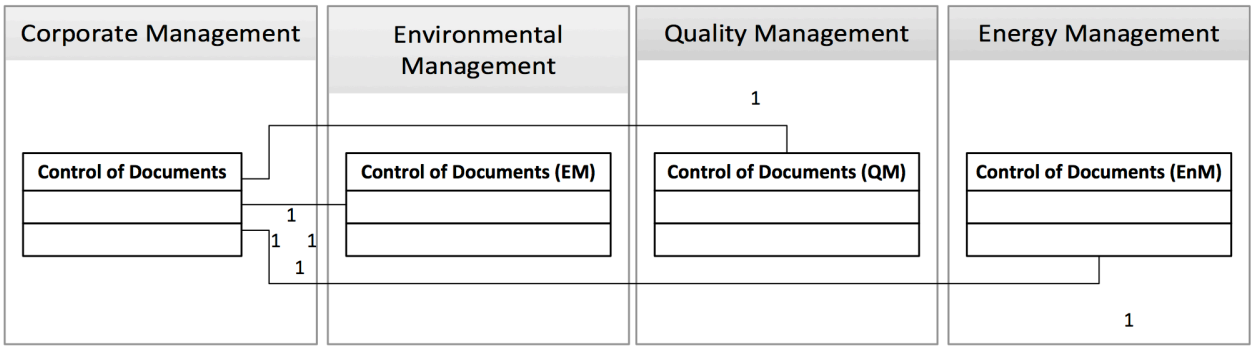

Figure 4. Integration Type - Identical

Second, there are requirements that are similar in structure, but differ in content. If the contents of these requirements can be reasonably summarized in an integrated system, they are *integrable*. An example of this is the combination of the energy, environmental and quality policy of a company in a uniform corporate policy. As shown in figure 5, the contents of the function-specific commitments will be linked on the basis of an aggregation relationship with the company policy. In addition to company-specific strategic commitments corporate policy thus includes all strategic aspects of function-specific sub-systems.

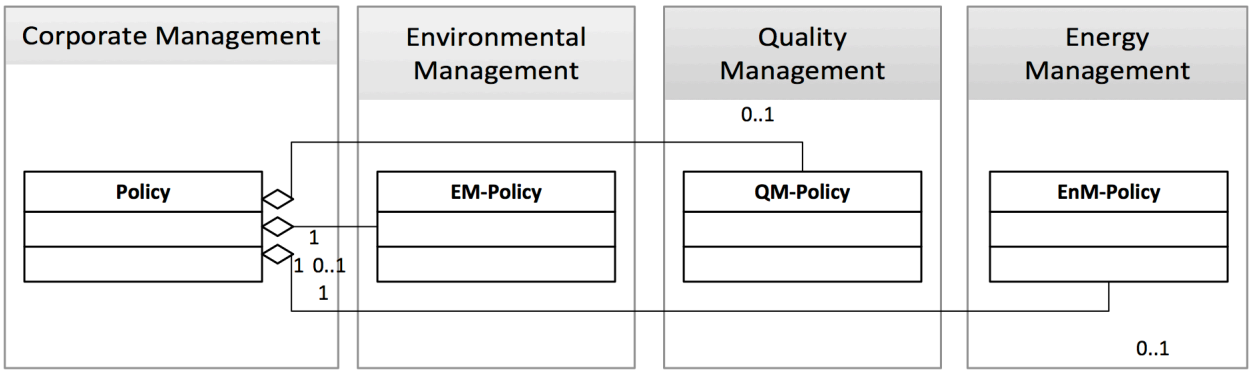

Figure 5. Integration Type - Integrable

Third, there are requirements that are similar in structure, differ in content, but cannot be combined reasonably. These requirements must be treated in *parallel*. In figure 6 this is illustrated using the example of the different targets. Due to the strong diversity with regard to contents of the targets an aggregation is not meaningful. However, for each objective a minimum set on criteria, which are generally applicable to any goals can be defined. These include the appointment of a supervisor or a time deadline. Based on the inheritance relationship as shown in figure 6 we show how this minimum set of criteria can be set using the abstract supertype *target*. In contrast to the *policy*, which is instantiated in the model as a separate element, the target merely serves as a template for the definition of function-specific targets. In the event that a target addresses aspects of EM and EnM, it is conceivable to integrate these objectives by means of an analogous procedure as in the case of the integration type *integrable*.

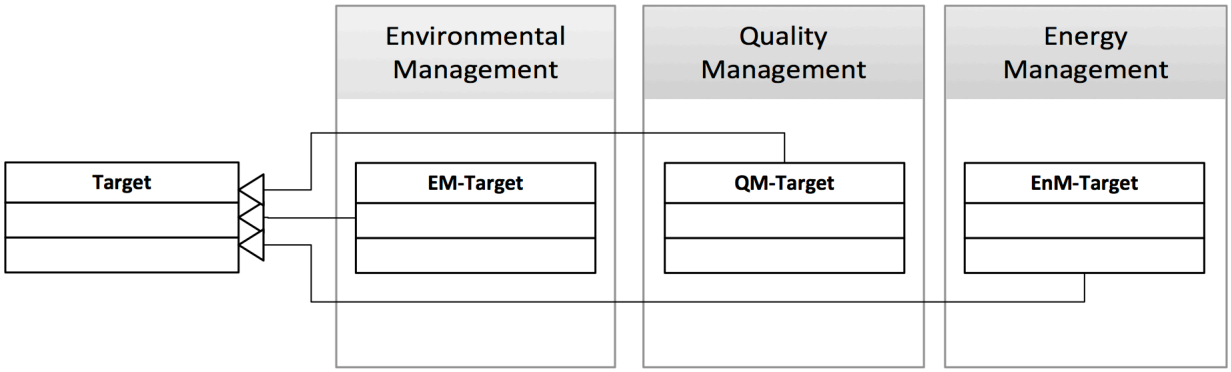

Figure 6. Integration Type - Parallel

Fourth, there are requirements that are unique in the relevant standards and have neither content nor structural similarities with requirements of other standards, they are completely *different*. For example, ISO 50001 requests the definition of energy related key performance indicators (EnPI). None of the other two standards requests for something similar. In this case, the meta-model needs to be added to function-specific concepts. The example of the EnPI is shown in the meta-model in figure 1 down left side. As a special case of a performance indicator it can be defined using an inheritance relationship.

Conclusion & Outlook

In literature currently a lively discussion on the topic of IMS takes place. Previous works strongly focus possible strategies for integrating MS, maturity levels of IMS and the impact on the audit of IMS etc. (Bernado and Simon 2012). Our own analyzes come to the conclusion that all previous works have in common that they contribute to the development of a theory-based foundation for the integration of MS, but hardly provide methodological support for the actual practical implementation of an IMS.

In this paper we address this gap and contribute to the development of a model-based method, which assists in the operational implementation of an IMS. Based on the results of Roessler et al. (2014) introducing a model-based method for implementing and maintaining an EnMS, we present an extension

of this method. The necessity of this extension is given from the experiences from the project work within the EENS. Within this network, we supported companies in the implementation of EnMS. We found that only in very few companies the EnMS was the first certifiable MS. Rather, the question arises how to embed the new requirements in the existing MS-landscape as efficiently as possible. So that duplicate and unnecessary operations due to similar standards requirements can be avoided.

Against this background and based on a typical integration scenario, we have exemplary compared the requirements of ISO 50001 with the requirements of ISO 9001 and ISO 14001. On this basis, we worked out fragments to extend the method of Roessler et al. (2014). This work thus fits into the successive expansion of the presented method. In the further course of research, we will present a comprehensive standards-based requirement comparison. This will take into account in addition to the initial findings in the area of EnMS, EMS and QMS also the requirements of a safety management system according to OHSAS 18001. Perspectively, the model-based method should represent a framework for the documentation and maintenance of an IMS. On the basis of norm-specific concepts and the configurable meta-model the method should be able to map all relevant aspects of an enterprise-MS and provide support as necessary for the implementation of standard-specific requirements (for example, with regard to the certification of function-specific systems). Thus, we try to solve the problems of the integration of MS on a conceptual level.

We suspect, that in addition to the efficiency gain in the documentation and the avoidance of redundant data storage, the consistent use of models for documentation also increases the ease of use and allows even novice users easier access to the domain of IMS. It is expected that accompanied with new certification-demanding legislative initiatives and the further spread of ISO 50001, the subject of model-based integration of MS experiences an increased importance in the corporate landscape. Finally with the increasing use of standardized MS the option of an empirical analysis of the method opens up.

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