Methods to Manage Information Sources for Software Product Managers in the Energy Market

A Reference Model Catalog for the Energy Market

The structural transition in the energy market presents new challenges to companies and their supporting information systems. Technological progress, changes in regulations, as well as new market players and process changes result in larger numbers of information sources. New concepts are necessary to make the requirements management of specific information systems for the energy business efficient. For this purpose the development of a reference model catalog and its formalization is suggested. The contribution presents existing approaches and requirements for structuring information sources in the energy business. Based on this, components and formalization of the catalog as well as methods for its construction, use, and maintenance are described. The article is focused on the description and evaluation of these methods.

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The Authors

Dipl.-Wirt.-Inf. José Manuel González Vázquez (✉)
Prof. Dr. Dr. h. c. Hans-Jürgen Appelrath
FuE Bereich Energie
OFFIS Institut für Informatik
Escherweg 2
26121 Oldenburg
Germany
jose.gonzalez@offis.de
appelrath@offis.de
url: http://www.offis.de

Apl. Prof. Dr.-Ing. Jürgen Sauer
Department für Informatik,
Abteilung Business Engineering
Carl von Ossietzky Universität Oldenburg
Ammerländer Heerstr. 114–118
26129 Oldenburg
Germany
juergen.sauer@uni-oldenburg.de
url: http://be.wi-ol.de

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1 Introduction

The energy market is currently in a fundamental structural change which will increase in the next years (Appelrath and Chamoni 2007, p. 329; Starace 2009, pp. 148–152). Causes are for one climate policies and regulations, e.g., through unbundling (separation of functions: production, transmission and distribution, trade and other activities of a utility) described in the German law "Energiewirtschaftsgesetz" (EnWG). Furthermore this change is enforced by technical developments, e.g., in decentralized generation.

Changes in the organization and technical improvements in the energy industry result in increasing competition, a growing number of actors and interfaces, changes in processes, and higher demands on communication.

Moreover, using the term "Smart Grid" technical solutions for the future electric network are being discussed, developed and tested in various national (like E-Energy) and international (like ETP Smart Grids) initiatives.

These changes result in various requirements for information systems such as additional supporting functions and IT-security requirements (Appelrath and Chamoni 2007, p. 329). This is demonstrated by the increasing number of heterogeneous information sources and documents which have to be considered for a requirements analysis. For this article the energy market is limited to the electricity and gas market in order to reduce complexity.

Software product managers in the energy industry are responsible for the functional development of information systems both in energy providing enterprises (user specific systems) and software vendors (products offered on the market). Their task lies in the procurement/offering, customization/development, and continuous enhancement of high quality software products at low costs and quick time-to-market for the operative (partly new) fields of business in the energy market. For this contribution we only look at systems specific to the energy industry (like energy management systems – EMS); industry-independent and technical application systems (like accounting or integrative solutions) are ignored.

Semantic technologies gain in importance and promise – besides the integration of heterogeneous information sources – higher flexibility for modeling and reasoning compared to, e.g., database supported solutions. A structured access to reference models is given with the generic solution provided by the reference model catalog by Fettke and Loos (2002).

This paper asks how suitable methods for the management of information sources for the support of software product managers in the energy industry have to be formulated based on the concept of a reference model catalog and with the aid of semantic technologies.

Methodically this article follows the principles of business and information systems engineering according to the established design science by Hevner et al. (2004) especially considering the seven rules of research (corresponding to the sections) and is structured as follows. Section 2 gives an overview of the current information sources for requirements analysis and the motivation for the necessity to establish a structured access to such sources (problem relevance). Section 3 lists requirements for such a system and analyzes existing approaches (problem relevance). Section 4 gives an introduction to the energy reference model catalog (Energy-RMC) and a description of the scenario with components and formalization (design as artifact). In the following, in Sect. 5 an integrated process model for the construction, use and maintenance plus the various phases of the model (design as artifact) is described. Section 6 is devoted to the process and the evaluation (design, process/evaluation, methodology, and communication) and provides references to related research publications. Finally the findings are summarized and an outlook is given in Sect. 7.

2 Information Sources for Requirements Analysis Within the Energy Market

The energy market offers a number of diverse information sources. Information sources (in the following just "sources") are all the documents which may or must be used in the development of energy market specific information systems, e.g., statutes, (reference) models, regulations, or IT-Standards. On the basis of desk research and expert interviews some 80 sources were identified (regulations, standards, and models) (González and Appelrath 2010, p. 321). These can (or, under regulatory demands, have to be) used or considered in the requirements analysis for further development of application systems.

Legislators and regulation offices issue laws, statutes, and regulations; associations have identified 14 laws and statutes as well as 9 regulations and directives as especially relevant, among others the EnWG and the rules for processes and data formats for data exchange between market participants (like energy supplier and transmission system operator) for the supply of clients with electricity (GPKE) and gas (GeLi Gas).

For the topic "Smart Grid" and the required integration and control of market participants, applications and hardware, the international standards of the International Electrotechnical Commission (IEC), especially those of the Technical Committee 57 (TC 57) "Power Systems management and associated information exchange", are relevant according to a recommendation of the "Deutsche Kommission Elektrotechnik Elektronik Informationstechnik" (DKE). All in all, 40 standards were identified, mostly published by IEC. Of special relevance are the standard families IEC 61970, 61968 which describe a data model for the integration of application systems of the energy industry.

Reference models are being developed in collaboration with research institutes, associations, software producers, and consulting firms; so far 11 reference models have been identified. Examples are the "functional reference model" of the KTH (Närman et al. 2006), the ENTSO-E "Harmonised Electricity Role Model", the "Utilities Business Maps" by SAP, and the "EVU-Referenzmodell" of IDS Scheer.

To sum up, there is a multitude of heterogeneous sources like (reference) models, regulations, specifications, and further IT-technical or professional descriptions. These address various views (such as data or functional view) and levels (requirements specification, design specification and implementation level). They differ strongly in terminology, coverage and details regarding the various areas of value creation in the energy industry. This results from differing objectives, target groups, and competencies of the sources producers. In addition, sources undergo continuous changes and new ones are frequently added.

A structured access to the information sources in the energy business for finding and managing relevant sources more easily is not available (González and Appelrath 2010, p. 322). Therefore, it is helpful to structure sources considering the different terminologies and their semantic integration.

3 Requirements and State of the Art

In order to enable a structured access to information sources to support software product managers in the energy business with requirements analyses, it is necessary to specify several requirements, as will be done in the following. These requirements have been discussed and validated with different software product managers in utilities and software producers in expert interviews and workshops. In addition, several surveys of the analyses in the energy market have confirmed these requirements (among others conducted with the EDNA-Initiative and the Gesellschaft für Informatik (GI) working group on energy information systems). All in all, more than 80 scientists and practitioners were interviewed.

Due to the amount of heterogeneous information sources in the energy market, there is a need to classify different types of sources (also called domain information). Here it makes sense to consider specific roles in the market (such as transmission system operator or energy supplier) to enable a search for information sources according to the need of the market roles. Furthermore it is necessary for the support of software product managers as to requirements analyses to refer to typical logical applications

Table 1 Overview of existing approaches

legend: ● covered, ○ not covered	domain information					organizational and IT-related aspects		support		
	(reference) models	IT standards	statutes/ regulations	additional sources	sources from utility industry	market roles	logic applications	process models for construction, use, and maintenance	IT tool	focus
reference model catalog (Fettke and Loos 2002, 2003)	●	○	○	○	independent from industry and application area ○			●	●	generic
reference model management system (Thomas 2006)	●	○	○	○	independent from industry and application area ○			●	●	tool
reference model overviews (Fettke 2006)	●	○	○	●	○	○	○	○	○	application specific
overviews of IT standards in the utility business, etc. (DKE 2010, pp. 68–69; Uslar et al. 2010; IEC 2011)	○	●	○	○	●	○	○	○	●	IT standards

for classic functions of utilities (like energy management (important) or billing systems). Descriptions of typical applications may be found in Appelrath and González (2010, pp. 2–13).

An operative adoption of such concepts and artifacts in order to structure information sources requires models for construction, implementation and maintenance, as well as adequate tool support.

Referring to these requirements, three general approaches from science and three from practice were identified and roughly compared (**Table 1**). These approaches will be described in the following. In doing so, those from practice will be dealt with collectively due to their similarity.

For the structuring of reference models, Fettke and Loos (2002) introduced the concept of a reference model catalog. This is defined as "a survey of reference models in table format put together methodically and structured in a complete and systematic way as far as possible within a given frame of reference" (Fettke and Loos 2002, p. 4). Typical for a reference model catalog according to Fettke and Loos (2002) is the division into the columns outline (structure), main part (sources), and access (attributes and classification of sources). A description of the classification and a rough model of implementation are found in Fettke and Loos (2003).The approach is quite generic and does not consider explicitly organizational and IT-related aspects of the energy industry. Moreover, only reference models are classified, tool support is rudimentary (http://rmk.iwi.uni-sb.de/).

Thomas (2006) describes a concept for the implementation of a tool for managing reference models and considers the life cycle management of reference models.

Fettke (2006, pp. 265–266) shows various application-specific reference model overviews which are analyzed in detail (pp. 44–46). The terms reference model catalog and overview of reference models are often used synonymously in literature. In the overviews of reference models dealt with here, not only the models but also additional approaches are classified (Fettke 2006, p. 266). This results mostly from a lack of focus as well as from the differing understanding of the term reference model (Thomas 2006, pp. 82–90).

Except for general scientific approaches there are currently several overviews of and recommendations for IT standards in the energy industry such as the German standardization roadmap with, among others, an overview of recommended IT standards (DKE 2010, pp. 68–69), an overview of IT standardization roadmaps (Uslar et al. 2010), or the IT standardization roadmap of IEC with recommendations for the implementation of IEC IT standards (IEC 2011). Moreover, first tools are being announced like the IEC "Smart Grid Mapping Tool" (IEC 2011) which is supposed to support the identification of IT standards in the energy industry through a website. Currently an Excel-based overview for the identification of IEC IT standards, structured according to functional areas like DER (Distributed Energy Resources) and "Home Automation" is available. Procedure models for the construction, use, and maintenance are currently not available.

Looking at **Tab. 1**, the absence of a holistic approach is obvious. Besides diverse domain information, this should also include (specific) organizational and IT aspects of the energy industry and present operational procedure models as well as tool support.

Semantic technologies gain importance in science and practice and find their way into modeling (Thomas and Fellmann 2009). Besides flexibility they promise advanced query and reasoning features for the deduction of new knowledge. This is the point where this article comes in and proposes a reference model catalog for the energy industry, based on semantic technologies.

4 The Energy RMC

Based on the requirements described before, a specific reference model catalog for the energy industry (energy RMC) is introduced. In method and structure it closely follows the concept of the reference model catalog by Fettke and Loos (2002), hence the name. For the purpose of this article we only roughly describe the RMC. Further details regarding the parts and the application scenario can be found in González and Appelrath (2010) and González and Uslar (2011).

4.1 Usage Scenario

Aim of the RMC is to structure the multitude of models and standards shown in Sect. 2 and to construct a suitable frame of reference. The energy RMC should provide software product managers with a structured access via a repository (knowledge base) and support the administration.

The reference model catalog should enable software product managers to identify relevant information sources for their specific models and to improve them individually. On the basis of linking their own models to the reference model catalog, functional coverage analyses can be carried out and ideas for supporting functionality can be gained. In addition, changes within the sources which affect own models can be identified.

In a potential usage scenario, various parts participate in the construction, maintenance, and usage of the energy RMC; they may belong to a single organization or to several (**Fig. 1**). Thus the following tasks and characteristics of potential actors can be derived for the use and maintenance of the energy RMC:

- *Software product managers* are responsible for specific functional improvement of software products respectively application systems.
- *Software product portfolio managers* are responsible for the advancement of a software product portfolio.
- *RMC developers* describe information sources and perform queries against the RMC knowledge base, collaborating with experts and users. Additionally, they take on the improvement and maintenance of the RMC.
- *RMC manager* coordinate the RMC model development and are to a large extent responsible for the consistency and quality of the model. They also coordinate basic changes with the users of the RMC. Each company using energy RMC should have an RMC manager.
- *RMC administrators* are responsible for the administrative functions of the energy RMC (e.g., access rights).
- *Experts* have experience and specific knowledge of the energy business. They are acquainted with information sources like statutes and regulations and their practical application.
- Commercial managers oversee the development of RMC from the financial side and provide a budget, keeping in sight costs, goals, and benefits for all stakeholders.

4.2 Components and Formalization

The energy RMC basically consists of four components (**Fig. 2**). The three most important parts of the catalog are the functional reference model (FRM), sources, and classification criteria. These correspond to the structure, main and access parts of the reference model catalog concept by Fettke and Loos (2002). For the structure part an FRM is used. An FRM is defined, according to Närman et al. (2006, p. 1), as a list of functions which describe a functional application area (in this case tasks of enterprises in the energy business). The concept of Fettke and Loos (2002) is extended by a query part consisting of core and additional elements.

A short explanation of the single parts will follow. A more detailed description including the meta model can be found in González and Uslar (2011, pp. 19–23).

As the modeling of functions is an important aspect in the development of application systems (Myrach 2009), functions also play a central role in the energy RMC. The FRM forms the core consisting of the areas supply chain, activities, function groups, and functions (**Fig. 2**). The FRM describes specific supply chain areas and activities from the point of view of utility companies. **Figure 3** (center) shows the specific matrix of the FRM consisting of supply chain areas (vertical) and activities (horizontal). The FRM has to be seen as a functional hierarchy such as the table of contents of a book, containing links (here relations) to the additional components.

Information sources (main part) and their classification (access part) are an essential aspect of the energy RMC. Contrary to Fettke and Loos (2002), not only reference models but also other information sources (Sect. 2) are classified. Sources are linked with the FRM (**Fig. 2** relation "IsDescribedIn", arrows from left to right) and if necessary described within the catalog as a hierarchical structure consisting of function groups and functions (function groups may again contain function groups themselves). The detailed description of sources as a hierarchy is used here to identify relevant sources by means of the FRM or to compare the functional coverage of two sources. The suitable degree of details is chosen under economic points of view according to the relevance of the source for the catalog users. For the EnWG, the central law for the German energy market, **Fig. 2** for example shows a functional hierarchy linked to the FRM on the lowest level, whereas for the IEC 61850 (automation standard) there is a link only on a higher level.

Concerning classification, established criteria for reference models and standards are used by Schütte (1998, p. 71), vom Brocke (2003, p. 98), de Vries (2006, pp. 3–20), Braun and Esswein (2007, p. 404), and Fettke and Loos (2003, pp. 41–43). **Figure 3** shows the three essential attributes for the classification and possible effects: coverage – covered areas and views, type – origin and form of the source, and status – usage and status of development. **Figure 2** indicates that a classification is carried out for each source.

The query part consists of core and additional components. Market roles (such as distribution system operator – DSO) and logical applications (like distribution management systems – DMS) as core elements are in the focus of RMC and are therefore covered as completely as possible. In contrast, additional elements (products, processes, business objects, and definitions) enriching the RMC and functioning as optional elements are described only when needed (typically with name and description). The merely roughly described additional elements make it possible for quality assurance to ensure the covering of all relevant functions. In the same way that sources are linked depending on their relevance, core elements (relation "Executes" and "Supports") are positioned on the lowest level of FRM, and additional elements (relation "IsRelatedTo") on a higher level.

Semantic technologies support the search and integration of heterogeneous sources and thus are helpful in the formalization of the energy RMC. They permit greater flexibility in modeling (compared to, e.g., database approaches), allow for a technology-independent representation, and are readily available as a file. Furthermore, the deduction of new knowledge (reasoning) is made possible. Use cases for inferences and queries are, e.g., the identification of information sources and the disclosure of inconsistencies. By now a number of open source software products are available

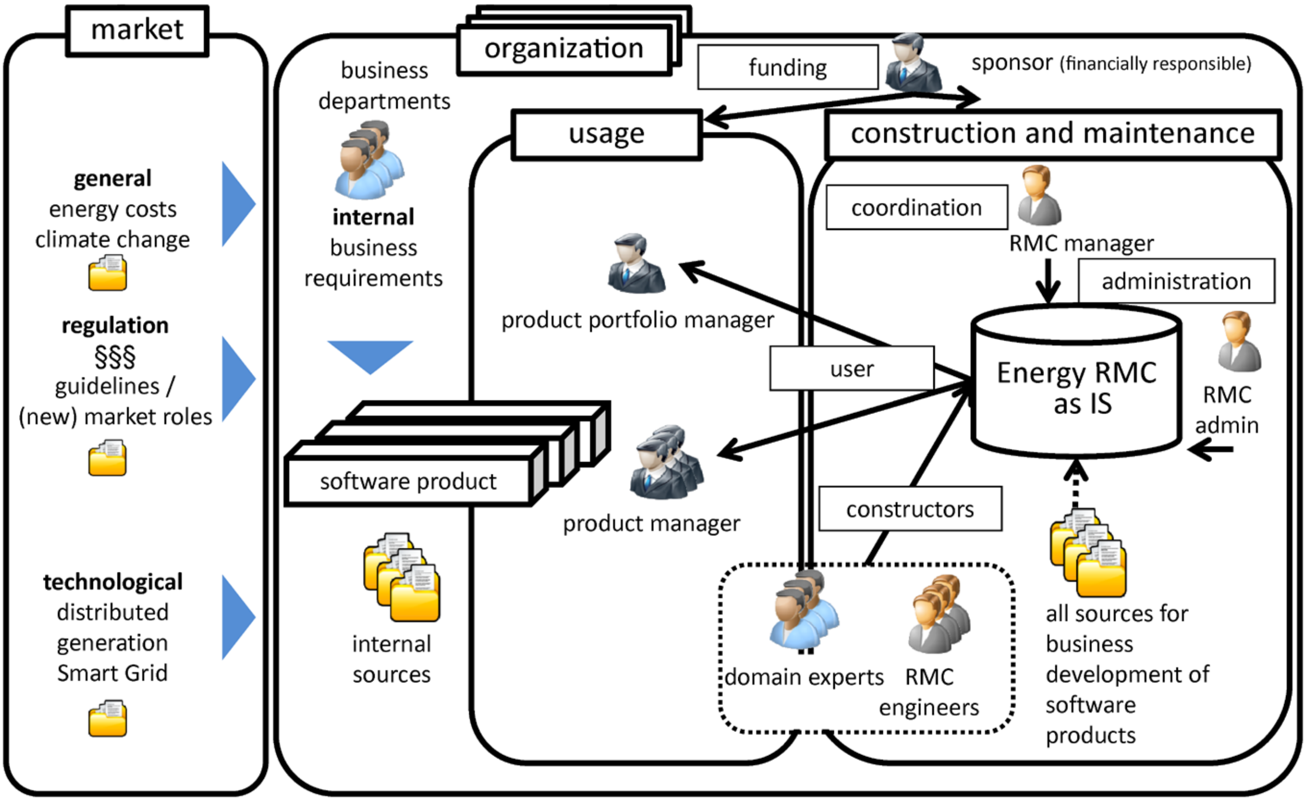


Fig. 1 Usage scenario of the energy RMC, based on González et al. (2011, p. 362)

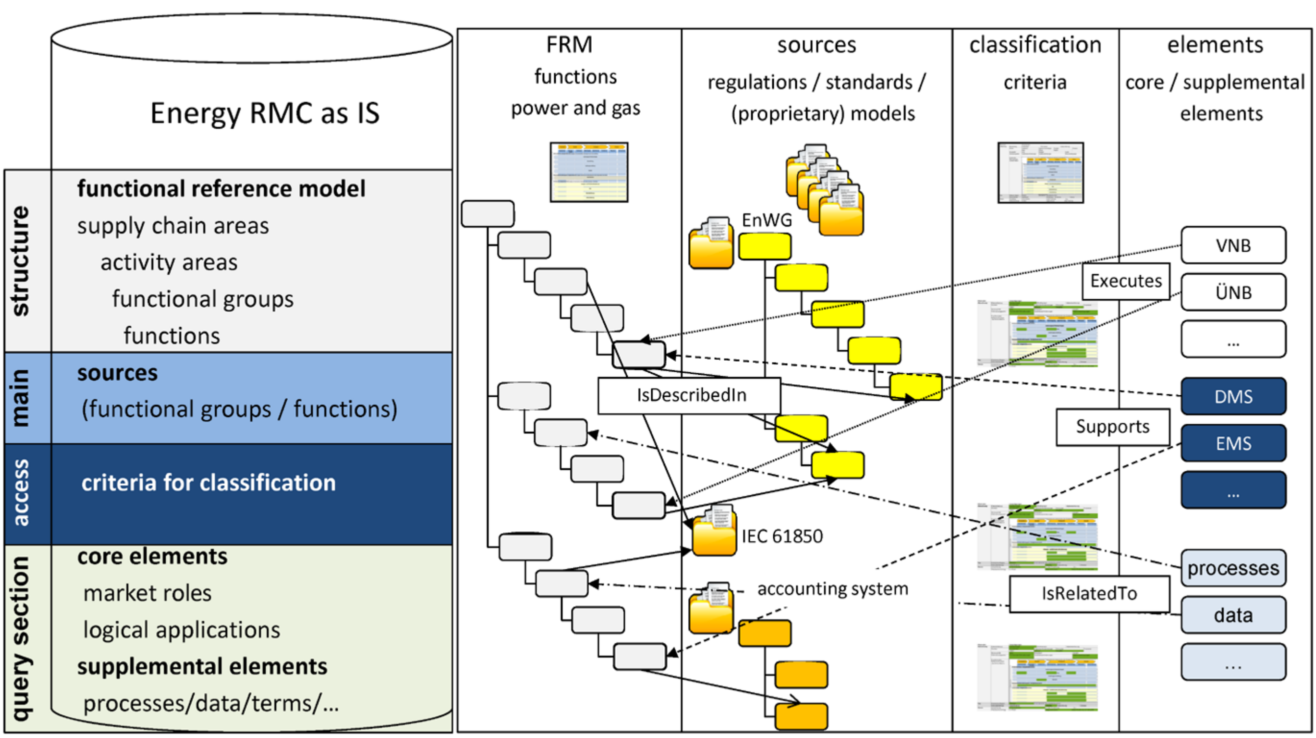


Fig. 2 Components of the energy RMC, based on González and Appelrath (2010, p. 323)

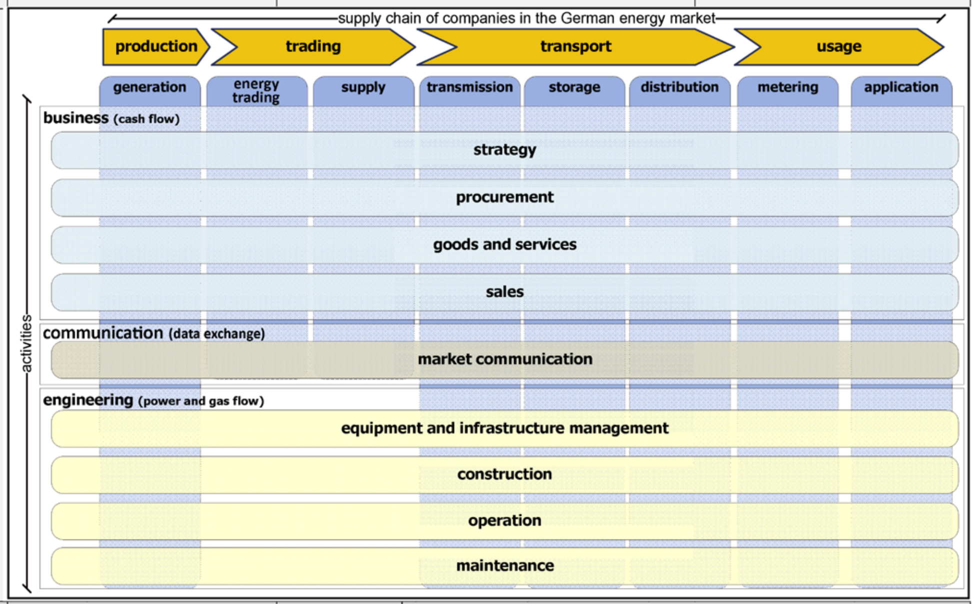
attributes		values			
coverage	layer addressed	requirements specification	design specification	implementation	
	viewpoints	functions	logical applications	products	processes
		data	actors	terms	
	granularity	rough	detail	case count	
	requirements type	functional requirements	quality requirements	general condition	
	functional reference model „business matrix“				
type	political region	Germany	international	European Union	
	document type	standard	recommendation	regulation	glossary
status	usage	in business	in research	n/a	
	development	under development	complete	last update:	

Fig. 3 Excerpt from the morphological box of the energy RMC's classification criteria, based on González and Appelrath (2010, p. 326)

to support management and querying of knowledge bases. The Web Ontology Language (OWL) is used as the modeling language because of its recommendation by the W3C and the existing tool support. The sub language OWL DL is preferred over OWL Lite due to its higher expressiveness by still keeping computational completeness and decidability. The energy RMC has been formalized using the open source ontology editor Protégé (versions 3.4.x) because of the multitude of available plug-ins. For this purpose, classes, individuals, data properties, object properties, and restrictions were defined. For the expansion of the functionality of the editor and for the prototypical support of the energy RMC's methods, a plug-in based on the Protégé OWL API was developed. The plug-in supports the import of information sources, offers evaluations for users in excel files and for quality analyses, and implements quality metrics.

5 Methods of Construction, Use, and Maintenance of the Energy RMC

In the following sections, the three-phased integrated process model for construction, use, and maintenance of the energy RMC is described. Subsequently the particular methods of the phases are shown.

5.1 Integrated Process Model

The integrated process model basically adopts the models described by Fettke and Loos (2002, pp. 6–7, and 2003, pp. 43–49) and goes into more detail. The model itself consists of three phases and four steps to be iterated (except for step 1, the starting point). Of central importance is phase III with step 4 focusing on the analysis and adaptation of the RMC, which should be performed in each phase (**Fig. 4**).

Methodically, this process model follows the established meta model for method construction according to Gutzwiller (1994, p. 12). Contrary to other approaches, the procedures for method construction according to Gutzwiller offer a broad understanding of methods, see for comparison Braun et al. (2005, p. 1297). According to this approach a method consists of activities, roles, results, a meta model, and techniques. In the following, steps (activities), techniques, artifacts (results and input sources), and participating roles will be roughly described for the individual methods of the energy RMC. The description of the roles in the following diagrams is limited to the more important ones and does not mean to exclude further roles.

Phase I – Construction: The first phase contains the development of an initial version of the energy RMC consisting of FRM, the classification of sources, the definition of a quality model, and the formalization of the catalog (step 1). Also in this phase the continuous iden-

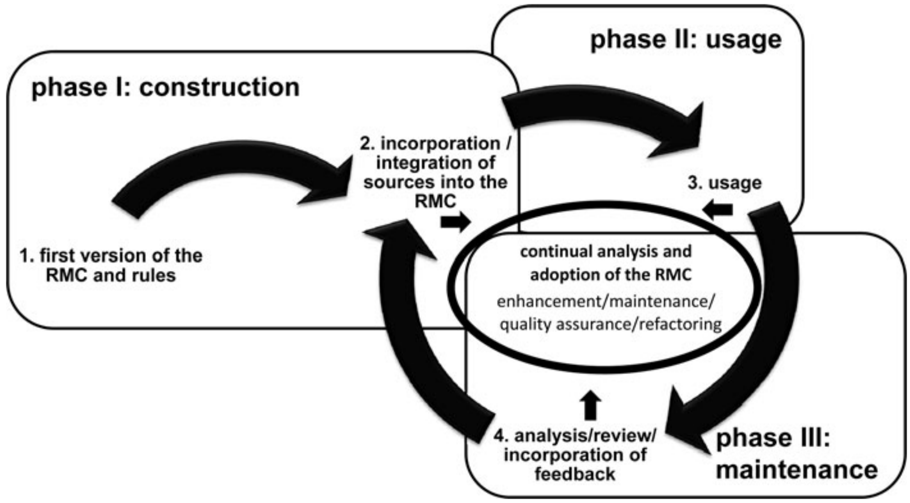


Fig. 4 Integrated process model for the construction, use, and maintenance, based on González and Uslar (2011, p. 23)

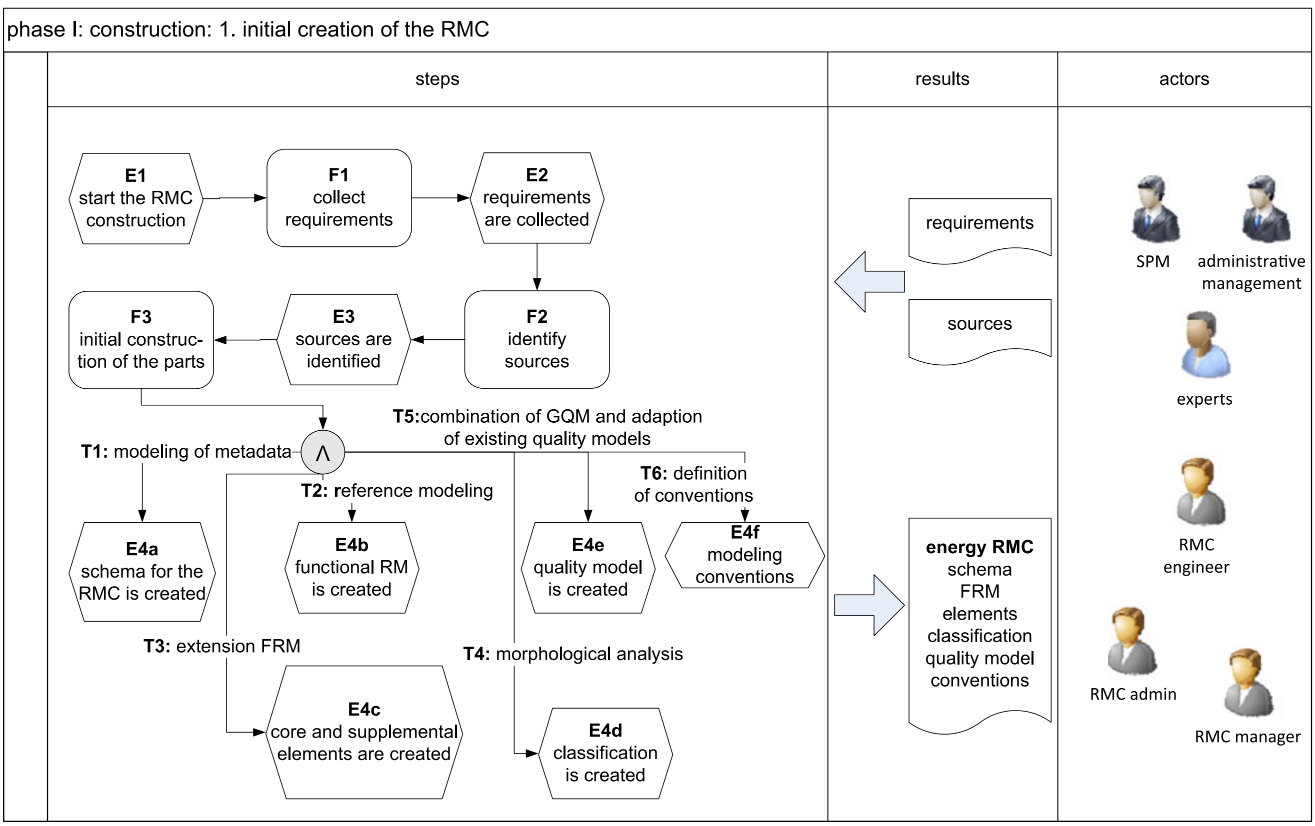


Fig. 5 Initial construction of the energy RMC

tification and integration of sources into the energy RMC is carried out (step 2). Hand in hand with the integration goes the continuous necessary enhancement of the energy RMC with additional versions.

Phase II – Use: The second phase is dedicated to the use of the catalog (step 3). Queries are adequately put in order to identify information sources, to compare models, or to analyze impact analyses of model changes.

Phase III – Maintenance: The last phase is directed to the improvement of the catalog on the basis of analyses, feedback and user reviews. This phase should be performed parallel to phase II, as users are most likely disposed to pass on feedback and reviews during use. It is also advisable to conduct regular analyses and review processes on core aspects here to enhance the quality and acceptance of the catalog. The development of the energy RMC is a continuous task; of highest importance is the iteration of the three phases with focus on permanent quality assurance (phase III).

5.2 Construction

To start with, the first phase requires the initial construction of the energy RMC and after that the continuous integration of information sources.

The process of initial construction is roughly described in **Fig.** 5. Starting

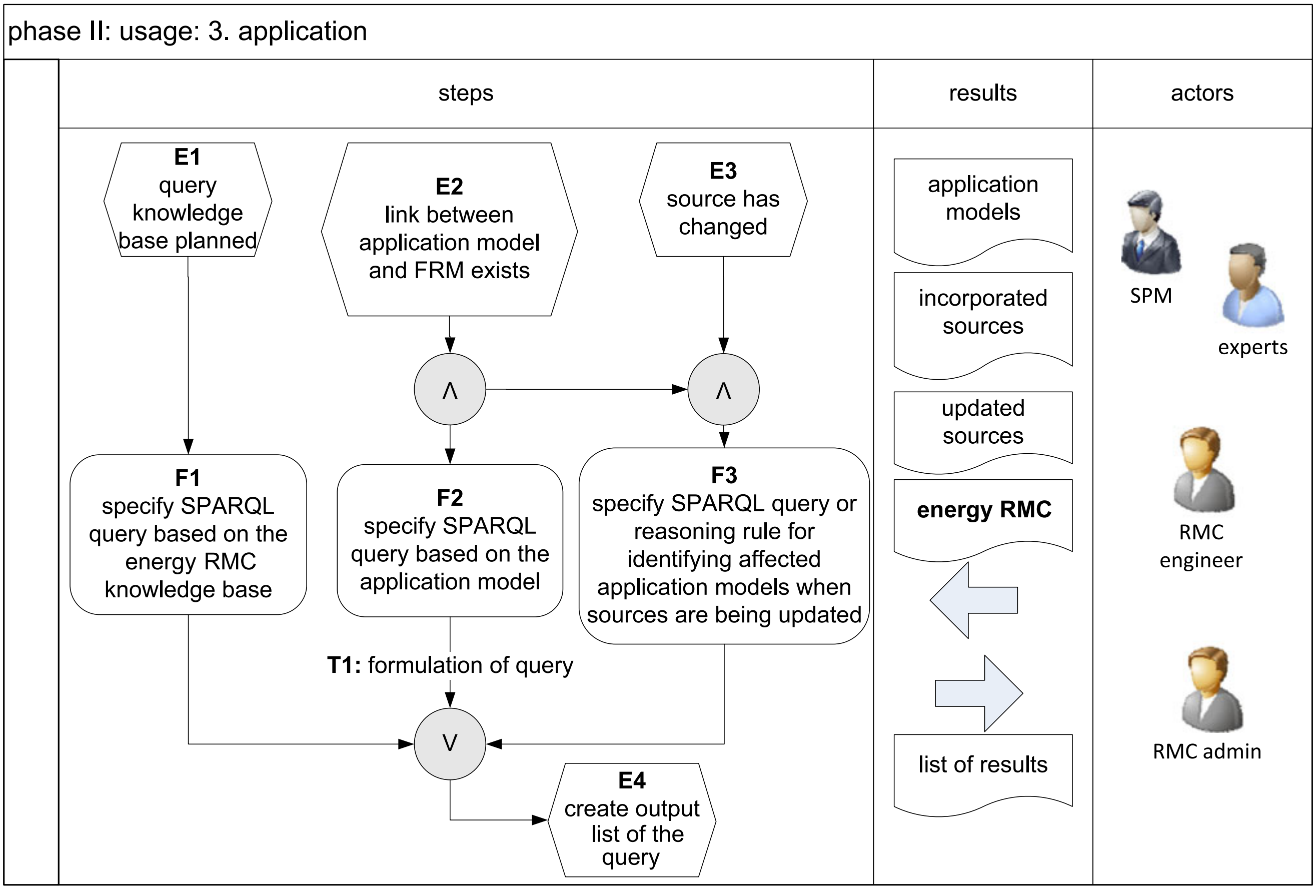


Fig. 6 Use of the energy RMC

points were workshops with software product managers, domain experts, and further participants for the definition and identification of information sources (see path E1–3 and employed techniques T1–6). On this basis, an initial version of the energy RMC including a meta model and components (FRM, classification, core and additional elements) was developed (E4a–d). In addition a quality model (E4e) (details in Sect. 5.4 and in González et al. 2011) and modeling conventions (E4f) were developed.

Beginning with the initial version of the energy RMC, additional information sources and updates have to be integrated continuously. The integration of information sources mainly consists of two steps, formalization of the source as ontology and extraction of information as well as the linking of FRM and source. While integrating information sources, first their contents and relevance have to be checked. Based on this analysis, information is extracted and, depending on the result, the information source is modeled in a detailed or cursory way. The distinction of modeling into detailed and cursory is an example, further nuances are possible. In González and Uslar (2011, pp. 30–32), integration is described in more detail with the help of an example.

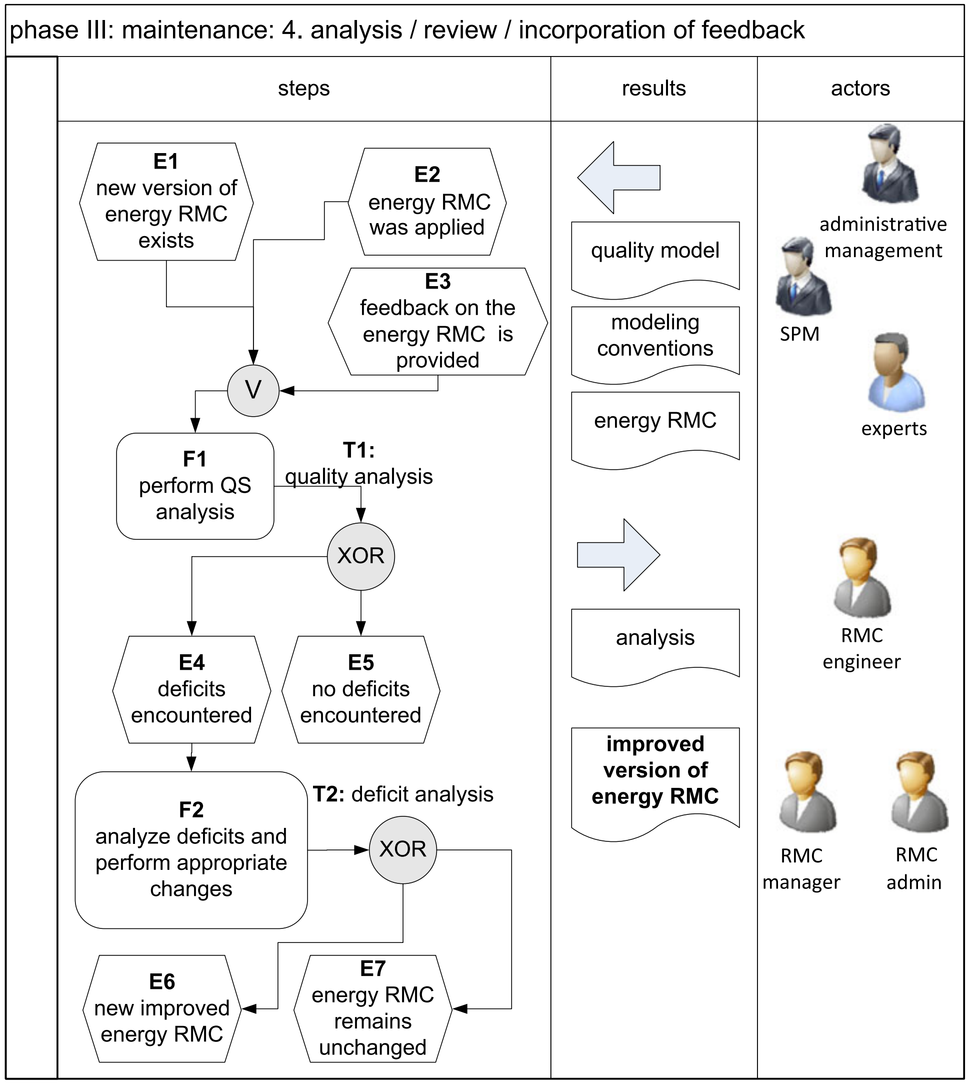
5.3 Use

Three scenarios (F1–3) are supported when using the energy RMC, all requiring the formulation of queries (T1) (**Fig. 6**). First, the use of energy RMC as a knowledge base by formulation and evaluation of queries (F1). Second, the linkage of company-specific models with the FRM of the energy RMC for the identification of relevant sources for specific models (F2). Third and as an enhancement of the second case, the analysis of affected areas of company-specific models when changes occur in the integrated sources (F3). The linkage of FRM and company-specific models is required for the last two scenarios.

When using the catalog as a basis of knowledge, e.g., to identify relevant information sources or to compare different sources, suitable queries have to be defined. Here the use of the vocabulary and elements of the catalog is necessary (FRM, classification criteria, core and additional elements). For formulating a query, we suggest the SPARQL Query Language for RDF. After the execution of the query results can be analyzed further. Depending on the catalog's degree of detail it may be necessary to incorporate certain sources in more detail or to refine the catalog to obtain more significant results. In generic cases such as the one shown, a multitude of queries is possible.

In the case of linking the catalog to company-specific models, for example to carry out impact analyses or queries based on company-specific vocabulary, these models first have to be formalized as ontology in OWL. Then FRM and the specific model have to be linked in the same way as in the integration of information sources (Sect. 5.2). Thus queries can be defined based on the vocabulary and the structure of company-specific models. Potentially relevant information sources can be identified using the self defined models.

Fig. 7 Maintenance of the energy RMC



Through the modeling of additional sources, the third scenario (F3) enables impact analyses referring to the models used in the company, e.g., when changes in legal regulations occur. This implies that the sources and company-specific models to be examined are described at a certain level of detail and are linked (E2 and E3) in order to obtain significant information.

As a result of F1–3 lists are produced according to the scenarios. An example is in the case of F2 a list of functions of a company-specific model with potentially relevant sources classified in the energy RMC.

5.4 Maintenance

Maintenance of the energy RMC is of central importance in the procedure model. **Figure** 7 roughly describes the energy RMC's flow of the analyzing and customizing processes. Based on the goal-question-metric quality model by Basili et al. (1994), a continuous analysis and enhancement of the energy RMC should be achieved. By using the quality model, analyses and identifications of deficits should be carried out when a new model version is introduced (E1), the energy RMC is used (E2), or other feedbacks to the energy RMC are received (E3). In coordination with all parties, the energy RMC is improved and/or enhanced if necessary. At the moment the quality model includes 34 requirements. It includes different approaches from modeling (such as the principles of proper modeling; GoM, Schütte 1998), from reference model evaluation (such as the analysis of ontological deficits; Fettke 2006, pp. 60–67), from software engineering (such as software product quality requirements; ISO and IEC 2001), and from ontology engineering (such as OntoClean; Guarino and Welty 2004). Overall, 24 metrics could be implemented, and measures for the improvement of quality for the remaining requirements could be developed. The metrics allow for a simple calculation of quality indicators for the continuous analysis of the energy RMC.

A detailed description of the quality model and operating experiences can be found in González and Uslar (2011, pp. 363–369).

6 Procedure and Evaluation

Using the design science approach according to Hevner (2004) and following the consortium research as described in Österle and Otto (2010), the methods shown above and the energy RMC are being developed in a research cooperation with 32 employees of a regional utility company (5 of them in the core project team) since mid-2008. In addition there was the (less intensive) exchange with 31 external experts from science (11) and practice (20). Construction, use, and maintenance of the catalog is done iteratively (20 versions so far) by action research. Currently the catalog comprises more than 26,000 elements.

In this context the energy RMC is used and evaluated iteratively together with potential users of the industrial partner. Furthermore, an evaluation of methods and energy RMC for a complete view following the perspectives described by Frank (2007, pp. 132–137) has been initiated. In addition, the use of analytical and empirical evaluation methods such as attribute based comparison and action research to compensate for the weaknesses of individual methods has started. In the following, results are described exemplarily according to the different perspectives.

Economic perspective: According to recent checks, the criteria posed by Frank (2007, pp. 124–130) are met to the greatest possible extent, assuming that maintenance and usage of the catalog take place in various departments or companies respectively and the cost/benefit characteristics of the FRM and the integration of sources are given. However, this perspective should still be considered more closely.

User perspective: The industrial partner uses the energy RMC in the context of analyzing the current application landscape and its domain specific functional development in the future. In an open interview, two IT employees considered the energy RMC's FRM quite helpful, especially to obtain an overview of functions of the energy industry and of corresponding application systems. Furthermore, domain specific models could be integrated in four user scenarios with the identification of potentially relevant information sources. The mappings derived were considered useful by all four users (in open interviews, one user pro scenario).

In the context of the information sources integration (Sect. 5.2), the linkage of sources and FRM proved to be time consuming and error prone. A future task is to analyze whether semi-automatic mappings can be used intelligently for the linkage of sources and FRM especially for subsequent controls.

When using the open source tool Protégé for the construction and maintenance of the ontology, its use for the RMC engineers became apparent. However the tool appeared too complex for inexperienced users and for the presentation of the contents of the ontology in workshops with potential model developers. The Protégé plug-in (Sect. 4.2), especially the import/export routines and metrics, proved to be useful for accelerating the integration of sources by the authors compared to manual handling. Nonetheless improvements seem to be necessary in regard to performance concerning the calculation of metrics and the execution of queries (in cases up to 10 minutes for particular queries).

As demanded by design science, research results were communicated in the form of excerpts of the energy RMC and the underlying methodical concepts. These were discussed with experts from science and practice. Lectures and workshops took place with employees of research institutes, energy suppliers, and software vendors (some within associations (EDNA-Initiative) and standardization organizations (VDE, DKE, and CIMug)). Here parts of the energy RMC concept were presented and discussed (González 2010a, 2010b). All in all, parts of the energy RMC were presented in lectures and personal discussions to more than 63 experts from science and practice (31 outside of the research project). The approach to integrate sources by means of semantic technologies was appreciated by all. Some parts of the catalog such as classification criteria and the domain matrix could be used in similar contexts like the classification of standards and use cases (e.g., the German standardization road map for Smart Grids (DKE 2010, pp. 68–69)). The feedback gathered here will in future help to enhance the energy RMC.

Engineering perspective: Besides the criteria according to Frank (2007, pp. 131–133), requirements regarding models (GoM by Schütte 1998) and methods (Greiffenberg 2003, p. 142) as well as own requirements (Sect. 3) in the context of an attribute based comparison of alternative methods and energy RMC were used. Due to the iterative development the criteria can be seen as mostly met.

In this context, the application of conventions and the implementation of continuous quality analyses based on the metrics of the quality model were carried out by the authors. The continuous calculation of the metrics proved to be quite useful to enhance quality. Besides established metrics (such as number of unattended attributes or model elements), additional metrics for the identification of ontological deficits between models (like incompleteness, excess, overload, and redundancy) according to Fettke (2006, p. 61) were employed. The alignment between information sources modeled as functional hierarchy and the FRM was checked (González et al. 2011, pp. 363–368). Thus similarities between regulations of the areas of electricity and gas could be identified, and errors in the attribution of sources were detected.

Furthermore several online surveys regarding requirements analysis in the energy industry as well as expert talks on the validation of requirements of the energy RMC and its components were conducted (Sect. 3).

Epistemological perspective: This article takes up several topics from the areas of reference modeling and reference model catalog construction, requirements management, and ontology design.

In regard to the construction of a reference model catalog, the energy RMC largely uses the model and concepts of reference model catalogs by Fettke and Loos, enhances and refines these (Sects. 4.2 and 5). For the classification of sources for the RMC, established classification schemes were adopted and combined (Sect. 4.2). Hierarchical structuring of artifacts and the subsequent formalization as ontology as suggested here is also proposed in other approaches, e.g., by Thomas and Fellmann (2009).

From the domains of reference modeling (RM) and ontology design (OD), process steps were derived for the integrated procedure model. Sources here were overviews of procedure models as described in vom Brocke (2003, pp. 134–142), Thomas (2006, pp. 229–243) (RM), and Gómez-Pérez et al. (2004, pp. 109–196) (OD).

Lastly this article is based on a number of own studies describing the construction of the energy RMC, its components and its use (e.g., González and Appelrath 2010; González and Uslar 2011, and González et al. 2011).

7 Summary and Outlook

In the context of this article an integrated procedure model for the construction, usage, and maintenance of an industry-specific reference model catalog for the energy industry and the energy RMC itself was introduced.

The approach comprises an operational structured procedure for requirement analyses to support software product managers in the energy industry. Identification, analysis, and change management of information sources are considered. The described method for engineering supports the modeling of information sources on various levels of detail and allows, under economic points of view, to configure the costs of modeling depending on the relevance of the user's source.

To completely exploit the possibilities of the energy RMC, know-how regarding ontology engineering, the formulation of queries, and reasoning is indispensable. For the integration of sources into the catalog, support by experts with practical experience in quality assurance is advised. The tools in ontology design are often prototypical implementations of a lower maturity level (e.g., regarding performance) compared to classical database technologies. However, experiences in the construction of energy RMC with the combination of established methods and rather young semantic technologies seem promising.

A transfer of the integrated procedure model and domain-independent classification criteria also to the design of different domain reference model catalogs seems conceivable. The feasibility in other domains has yet to be proven. Classification criteria and methods for related tasks in the energy industry, e.g., for the classification of use cases not only cases and IT standards for Smart Grids, have already been used successfully.

The described energy RMC and the relevant methods are in constant enhancement. The next projects will concentrate on the prototypical support of model engineers and users, besides further evaluations especially with regard to the economic perspective and a detailed analysis of related works (among others using the approach for the comparison of methods by Greiffenberg 2003, pp. 144–150).

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Abstract

José Manuel González Vázquez,
Jürgen Sauer, Hans-Jürgen Appelrath

Methods to Manage Information Sources for Software Product Managers in the Energy Market

A Reference Model Catalog for the Energy Market

The German energy market is facing several challenges due to changes in regulation, technical advancements as well as increasing energy costs and climate achievements like CO_2 reduction. This results in changing requirements for companies in the energy market and thus business information systems, which support their core tasks and processes. Software product managers in energy and software developing companies in charge of driving the functional development of information systems have to deal with these challenges and need to develop new information systems or enhance existing ones. Conceptual models proved helpful to design and implement information systems within several industries. However, identification and management of models as well as impact analysis of model changes results difficult. This contribution describes methods to construct, use and maintain a domain specific reference model catalogue to support requirements analysis for software product manager in the German electricity and gas market.

Keywords: Reference models, Reference model catalog, Ontology engineering, Information sources, Requirements engineering

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