Preparing Energy Providers' Knowledge Base for Going Digital

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Introduction of the EPOS procedure

Abstract. In this study, we develop a procedure for strategic knowledge management which focuses on small and medium energy providers in order to help them assemble and improve their organizational knowledge base for digital innovation. This tool called EPOS procedure is designed to fulfill nine functional requirements. These are drawn from literature, confirmed via empirical data and cross-checked in discussions with practitioners in order to ensure its usability and effectiveness. The procedure comprises four general phases in which knowledge needs are determined, deficiencies within the current knowledge base uncovered, action plans formulated and improvement measures implemented. By extending hitherto extisting approaches insofar as the multidimensional nature of knowledge and innovation, the importance of a certain amount of slack, a long-term strategic perspective and context specifics in the energy industry are concerned, the study provides substantial prescriptive suggestions for management in the energy sector.

Keywords: Innovation, strategic knowledge management, digitalization, smart technologies, municipal energy providers, action research

1 Introduction

> *In comparison to other industries, the energy sector is in dire need of innovation. Past business models and processes frequently cease to be functional and need to be adjusted, if not fully changed via new ideas. Due to their decentral orientation, municipal utilities are at a promising point of departure from which still unknown paths lead to future opportunities. In order to realize those, courage and professional preparation are necessary.* [4: 2]

As stated in the above quotation from Ernst & Young's 2015 annual *Stadtwerkestudie* (Engl. *Study on Municipal Utilities*), innovation represents a pressing issue in the energy sector. Especially in Germany, manifold external challenges like the planned closure of nuclear power plants, the transition in energy production towards renewables, the liberalization of the power supply market and the decentralization of power generation drive change in market actors' offerings, financial models, internal processes and business models [9]. Additional to such regulatory influence, the advent of digital technologies which is particularly evident in the advancement of the complex range intelligent decentral systems termed Smart-X serves as major trigger for disruption in the industry [21]. From the viewpoint of municipal utilities, the general tendency towards decentralization provides considerable business opportunities [5]. Still, proactiveness, entrepreneurial orientation and a professionalized and strategic approach towards innovation and innovation management are premise for harvesting opportunities and preventing bigger or more specialized market actors to from raiding own segments. Unfortunately, most utilities struggle to meet these requirements [4].

One core hurdle confronting small and medium-sized energy providers is the need to acquire and develop expertise and competencies which differ from those which were needed for the traditional business logic of the industry [19]. As resources for such expertise development are limited, a focused, effective and efficient approach to this end is indispensable [25]. Organizations must know in which fields of expertise to invest, which competences to acquire and how to manage a process of continual development, adjustment and improvement. Hence, the challenge of configuring one's organizational knowledge base to one's innovation goals represents a key strategic task with high potential for outpacing other actors in the market [6]. Against this background, it is surprising how little effort has been made to shed on this issue both in the context of the energy sector and also beyond [25]. There is a clear need for applicable management procedures, tools and techniques to support strategic executives and innovation managers.

In this paper, we describe the development of a procedure for analyzing, planning and developing firms' knowledge base configuration for addressing current and future changes in the energy sector, such as decentralization, digitalization and energy transition. We explicitly focus on municipal utilities with the goal to provide them with a methodology that eventually supports their efforts in process, product and administrative innovation by setting up the necessary base of expertise. Thereby, our work is rigorous both in respect of methodological approach – we follow systematic procedures of action design research [20] – and theoretical foundation – we base our considerations on the findings of previous research and integrate insight gained from our recent empirical investigations [17].

The final procedure aims to address three core issues in previous guidelines, frameworks or methodologies of knowledge management which compromise those approaches' value for handling the above mentioned issues: a) overly problemistic approaches and lack of long-term focus; b) insufficient differentiation between different types of knowledge; c) missing contextual focus. In the following, we will present our approach of tool development, before we explain and discuss the developed procedure.

2 Research Methodology

The research approach chosen is based on principles of action design research [20] which combines elements of design science and action research. Design science intends to create prescriptive design knowledge by building an artifact addressing a specific problem. By aiming to develop an applicable management tool which helps municipal utilities to configure their organizational knowledge base with the goal of fostering innovation, we follow this motivation. It is widely considered as useful to augment this artifact-focused research methodology with the principles of action research, namely the interaction between practice and research as well as the involvement of researchers in practical problem solving. Thus, in order to enhance the practical usefulness of the designed artifact, we strive for including practitioners' immediate challenges, suggestions and opinions throughout the whole design process. Thereby, in-depth knowledge of researchers' concerning the problem and its context and consequentially more valid management procedures and tools can be ensured [20].

In particular, we apply a recently developed framework for the creation of business tools and procedures published by the Institute for Manufacturing at the University of Cambridge [8]. Because of its explicit focus on management tools, its in-depth specifications as well as its application-oriented focus, there is an adequate fit of this framework to this paper's purpose. In all, the framework comprises five iterative phases which are described below: problem identification and tool definition, design, development, test and refinement, deployment (see also Table 1).

Problem identification and outcome definition (Stage 1). At the beginning, three factors must be described adequately in order to enable a problem-oriented and contextually focused development of business tools: the business purpose, the scope and the expected user [8]. In order to derive a thorough definition, we had several discussions and interviews with C-level executives of single utilities and industrial associations, with senior innovation managers at energy providers as well as with an interorganizational innovation circle. As a result, we define the intended outcome of this research as follows: "*We aim at developing a procedure that allows strategic level managers in municipal utilities to analyze the configuration of their current organizational knowledge base, assess its suitability for successful innovation, identify areas for improvement as well as plan and execute such improvements.*" Based on this definition, the specific problem context and prior theoretical and practical insight, concrete requirements were deduced (see chapter 3).

Design and development (Stages 2 and 3). Following this definition, the core development team consisting of two university-based researchers and one innovation manager based at one of the most prominent and largest German municipal energy providers developed the managerial tool. These efforts were supported by the intensive scanning of related research and practice literature concerning innovation, knowledge, and strategic knowledge management, by discussion and idea validation with practitioners and by empirical investigations on which knowledge base configurations benefit different types of innovation in the energy sector (results of this study are published in [17]).

Table 1. Application of the development framework (based on [8]; elements adapted from [20])

Stage	Jobs to be done	Execution
1. Problem identification and outcome definition	*Basic elements* ▪ Practice-inspired research ▪ Theoretical grounding ▪ Scope definition ▪ Requirements specification ▪ Identification of target users *Evaluation criteria* ▪ Relevant business need ▪ Gap in practice ▪ Well-defined requirements	*Method* ▪ Discussion with C-level and innovation managers at municipal utilities and industrial associations ▪ Literature review *Outcome* ▪ Mission statement ▪ Catalogue of requirements *Status* done (see chapter 3)
2. Design	*Basic elements* ▪ Definition of core elements and tool structure ▪ Determination of functional assumptions ▪ Dialogue between research and practice *Evaluation criteria* ▪ Fidelity with real world ▪ Completeness ▪ Appropriate level of detail	*Method* ▪ Workshops and informal meetings ▪ Empirical study (N=55) among German utilities *Outcome* Schematic structural sketch *Status* done (see chapter 4)
3. Development	*Basic elements* ▪ Detailed development of tool components ▪ Transformation of theoretical understanding into practice ▪ Involvement of practitioners *Evaluation criteria* ▪ Effectiveness ▪ Comprehensibility ▪ Applicability	*Method* ▪ Prototyping based on design principles ▪ Regular discussion with practitioners and reseach colleagues *Outcome* Prototypical management procedure (as presented below) *Status* done (see chapter 4)
4. Test and refinement	*Basic elements* ▪ Subjective assessment by experienced practitioners ▪ Validation in practice cases *Evaluation criteria* ▪ Robustness ▪ Maturity	*Method* ▪ Presentation in practitioner workshops with subsequent discussion ▪ Application in multiple practice cases in German utilities *Outcome* ▪ Implications for revision ▪ Ready-for-application tool *Status* ongoing

Stage	Jobs to be done	Execution
5. Deployment	*Basic elements* ▪ Communicating the tool to potential users ▪ Seeking feedback from users ▪ Long-term assessment of effectiveness *Evaluation criteria* ▪ Market acceptance ▪ Up-to-dateness	*Method* ▪ Review of use cases ▪ Release of updates ▪ Search for further fields of application *Outcome* ▪ Subsequent versions ▪ Overall package of the tool (e.g. manual, facilitation pack) *Status* planned in 2017 and beyond

Test and Refinement (Stage 4). In order to prove the developed tool's effectiveness and usability, cycles of test and refinement are indispensable. This stage is often the nucleus of both practical and theoretical knowledge creation as now, assumptions made in design and development are on trial [20]. The testing stage encompasses two compatible approaches: a) subjective assessment by experienced practitioners and b) application in a number of practical cases [8]. While practitioner assessment has been obtained from the innovation management unit at a large municipal utility and the innovation group within a network of energy providers, tests in practice are owing at this juncture, not to mention valid feedback on mid-term effects. We plan to start practice tests in cooperation with industry-wide innovation circles in early 2017.

Deployment (Stage 5). Without adequately high numbers of use cases, the effectiveness of a method can be assumed, however not empirically substantiated [8]. Hence, both for enlarging the academic knowledge base and providing valid solutions to practical problems, diffusion of the tool among practitioners is eligible. Achieving this is our long-term prospect, planned for 2017 and beyond.

3 Theoretical Background

Applying the approach explained above, we develop our procedure based on relevant, extant academic knowledge. These insights set the assumptions which underlie the functionality of the tool and thus determine the requirements it has to meet in order to prove effective. Thereby, we review literature on the nature of the core concepts demonstrated in the outcome definition: organizational knowledge as working point to be influenced by the procedure, innovation, in particular digital innovatioin, as organizational outcome of interest and municipal utilities as organizations with specific characteristics which operate in a specific industrial context. In the following, the paper gives a compact outline of each literature's key assumptions, extracts the relevant information needed to guide the design of management tool and proposes requirements for the tool.

3.1 Organizational Knowledge Base

Knowledge is one of the most important resources of companies, especially due to its immaterial nature [6]. Because knowledge is often implicit, procedural and embedded in an organization's members, structures, processes and artifacts [2] it is hard to replicate and thus a source of sustainable competitive advantage [6]. For a strategic approach to knowledge management these characteristic bear several implications. First, knowledge embedded in the organization must be mapped and assessed [23]; second, internal knowledge development takes considerable time and effort [2]; third, knowledge transfer is necessarily imperfect so that externally acquired knowledge possesses different value and limitations than internally developed knowledge [2]. These three assumptions combine to the following requirement:

R_1: Reflect the embedded nature of knowledge and consequential implications for its development and acquisition

The knowledge base of an organization encompasses more than only the intellectual capital in its direct possession. In fact, firms can draw on the expertise of other actors, such as consultants, business partners, customers, research institutes, legal advisors, universities, government agencies to name only a few [13]. While external knowledge has different characteristics than internal intellectual capital (as outlined above) [2], it is essentially to be included in our considerations. This is in line with the open innovation paradigm stating that the locus of innovation lies not within a single firm, but within a complex network of interdependent actors [16]. This notion must be captured by any management tool concerning strategic knowledge management.

R_2: Provide a boundary-spanning perspective on the organizational knowledge base

Knowledge is multi-dimensional [6]. Though most works utilizes single types of knowledge as research variables, there is a broad consensus in literature on the notion that different types of knowledge exist and that these types may differ in several aspects [18]. In particular, there are different domains of expertise such as technological, market- and customer-related or managerial knowledge [18]. Rather than perceiving knowledge as a unitary quantity, effective knowledge management acknowledges its nature as a complex configuration of multiple knowledge types.

R_3: Take the multi-dimensional nature of knowledge into account

3.2 Organizational Innovation

The configuration of an organization's knowledge base as a whole determines that particular organization's innovative output to a large degree. Knowledge represents the key input resource for innovation [6]. Hence, every innovative activity is linked to some set of intellectual capital, competences and expertise [25]. Concerning value creation via innovation, single new product, service or process concepts in isolation lack the ability to provide a basis for differentiation in the market [22]. Only the accumulation of these single innovative endeavors over time enables superior competitive performance. Consequentially, the task of configuring the organizational knowledge base is a long-term oriented, goal-focused, holistic, in short a highly strategic one [25]. A useful management tool must thus outreach the often IT-focused approach taken by many traditional methodologies of knowledge management and explicitly outline the content of an organization's knowledge as core strategic asset.

R_4: Explicate the strategic nature of the task of configuring one's organization's knowledge base

Corollary to this strategic perspective, our work aims to transcend a common, but in isolation rather ineffective approach that firm's take towards innovation: problemistic search [7]. Unfortunately, this approach is also reflected in most respective management tools. Problemistic search describes the tendency of firms to initiate the search and development of knowledge when facing problems which negatively impact or threaten the fulfillment of performance goals [7]. Transferred to our context, energy providers lacking expertise concerning for instance smart grid systems might actively search to acquire such competences. While such a rather reactive behavior is important for continuously readjusting a company's business model to fit its environment, firms which only approach innovation this way will unlikely be exceptionally successful. In fact, superior innovators draw on knowledge slack, "the pool of resources in a firm in excess of the minimum necessary to produce a given level of organizational output" [14: 1246]. To possess knowledge when it is not immediately needed may highly benefit innovative performance, as it frees innovator's attention from short term issues, enables creativity and promotes experimentation [14]. As a consequence, the innovating firm may pursue a more solution-push than need-pull approach that can yield advantages of pioneering. Our tool must hence both apply to the problemistic and the slack approach.

R_5: Go beyond merely problemistic approaches towards knowledge development

Especially concerning digital and smart technologies, energy providers need to fundamentally reinvent their offerings, their business model as well as themselves [24]. This entails combining different single innovations to the big picture [22]. For instance, the business model of virtual power plants encompasses offering customers an electricity mix with high shares of renewables at high levels of reliability (product innovation), automated and intelligent load management (process innovation) and a decentralized network of energy producers that needs to be coordinated and governed (administrative innovation). In order to configure the organizational knowledge base for the challenges of digital innovation, an effective tool should accommodate the diversity of innovation types involved.

R_6: Reflect the complex nature of innovation in an era of digitalization

3.3 Characteristics of the Energy Sector and Municipal Energy Providers

Across different industrial sectors, the knowledge resources required for innovation can vary considerably. This is due to industrial ideosyncrasies concerning the technological, market, regulatory and competitive environment [15]. As a consequence, there is no global but rather a contextual value for different types of expertise based on industry characteristics. For instance, the energy market is highly regulated [12].

Therefore, knowledge on regulation, politic developments or legal issues might provide companies with valuable options for navigating resulting environmental opportunities and constraints and thus be more important than in other sectors. Similarly, the diversified technology base including ICT, storage and transmission technologies, or installation, among others, may account for specific knowledge configurations enabling innovation [21]. The intended procedure has to be based on empirical data revealing such ideosyncrasies and deduce reasonable implications.

R_7: Explicate industry-specific ideosyncrasies concerning knowledge and innovation

A large share of municipal utilities are small organizations lacking financial, material and personnel resources for strategic innovation management in comparison to large market players such as the Big 4 in Germany [4]. Knowledge as a scarce and valuable resource is costly to acquire and develop [6]. Most likely, utilities will lack capital and time for developing a knowledge base covering all potentially valuable fields of expertise. Hence, specialization on a focused set of internal intellectual capital enriched by carefully selected external acquisitions is a preferable approach towards knowledge base configuration. Utilities must thus know, which promising niche approaches exist and how they can adopt these.

R_8: Allow for niche approaches for small and medium-sized energy providers

Similarly, structural characteristics of municipal energy providers may set boundary conditions for their knowledge acquisition and development strategy. Two of the most important ones are local attachment and public ownership. Local attachment may for instance hinder the recruitment of skilled employees, one of the most impactful ways of knowledge acquisition [2]. Public ownership on the other hand can slow down the decision on as well as the implementation of strategic knowledge development plans [11]. Such potential issues must be identified by the tool and dealt with accordingly.

R_9: Take into account structural constraints of municipal utilities

4 A Management Tool for Analyzing, Planning and Developing Utilities' Knowledge Base Configuration

Within this section, we outline the developed four-phase management tool – the EPOS procedure. Thereby, the focus is on the distinguishing features of our tool which address the requirements R_1-R_9. We first describe general suggestions for application before we provide detailed explanation on each of the four phases (see Figure 1).

4.1 The EPOS Procedure – General Instructions for Application

The procedure is intended to support the creation and implementation of a companywide strategic plan for the improvement of the organization's knowledge base. As such, recommendations for successful strategic initiatives widely apply also here [3]. First, the tool is applied by an internal project team. The team should be composed in such a way that it has insight in all relevant areas of the utility and represent the organization as a whole [1]. Hence, the team should include employees and managers from different hierarchical and functional levels. The inclusion or at least support of the top management level is thereby indispensable.

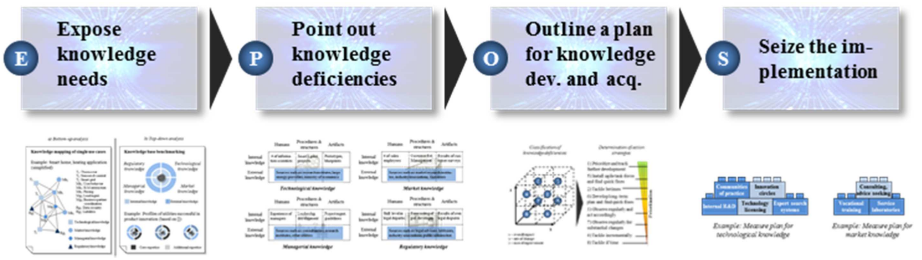

Fig. 1. Overview of the procedure

Second, our tool aims at actual improvement, so that project and progress management is highly important. We suppose using a dual structure between central workshops between which single focus groups perform tasks such as item specification, data collection, or championing the project to the rest of the organization. There should be at least six central meetings of the whole EPOS team including one kick-off, each one full-day workshop for all the four phases as well as one to several follow-up meetings to ensure the implementation of the project's results and its long time impact.

Third, the EPOS procedure represents a process of building meta-knowledge and thus organizational learning. Because it deals with complex knowledge, new insights, data, arguments, interpretations and ideas may emerge during its application [1]. The working culture should explicitly allow for this. For instance, discussion of new insights should be institutionalized, for instance via well-defined time slots at the beginning of each workshop. In general, open-mindedness and flexibility towards new ideas are essential success factors for EPOS.

4.2 E – Expose Knowledge Needs

In the first step, the company must know which types of expertise, information and competences it needs in order to innovate digitally. At the beginning of this, the project team should draw on existent innovation roadmaps or outline opportunities for digital innovation by itself. Thereby, explicating the own current business model and outlining how it might be change by the application of digital technologies is helpful. There are three broad possibilities for digitalizing the business model (complexity of change in ascending order): optimizing existent business models (e.g. using software for complaint management), enriching existent business models (e.g. smart metering app for electricity customers), and extending the current business model (e.g. municipal e-car sharing). It is important to mention, that the feasibility of such digitalization opportunities depends heavily on general strategic constraints such as served business segments and regionalism and must thus be assessed against this background. Resulting digital innovations are combinations of a certain set of product, process and administrative innovations [24]. Hence, after prioritizing digital opportunities, these should be broken down to the different types of innovations involved.

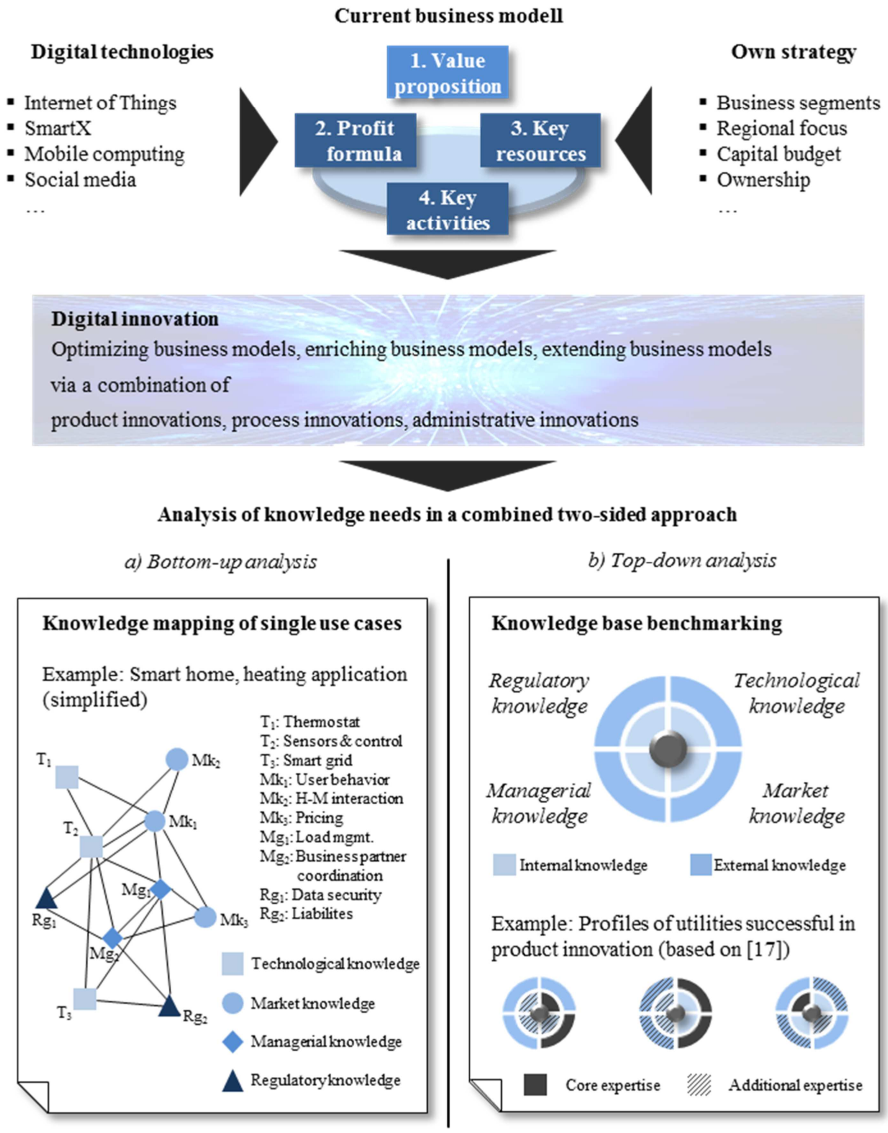

Fig. 2. Analysis steps for exposing knowledge needs

Based on such a set of aspired innovations, the knowledge needs of the firm can be determined. Due to the assumptions leading to R_5, a two-sided analysis approach is advisable. On the one hand, the bottom-up approach aims at outlining specific knowledge needs by examining concrete use cases respectively innovations.

Knowledge mapping methodologies [23] are helpful here as they allow for examining systematic interdependencies of knowledge elements. On the other hand, the top-down approach rather aims at providing the firm with an eligible base of expertise for various tasks concerning digital innovation by taking a more general, slack-based perpective on the knowledge needs. In an empirical study in the energy industry [17], we extracted the knowledge base profiles of successful innovators. Our findings yielded between 2 and 4 profiles for each product, process and administrative innovators. Based on the combination of intended innovations, one or two of these profiles should be selected as benchmarks for the own company's knowledge.

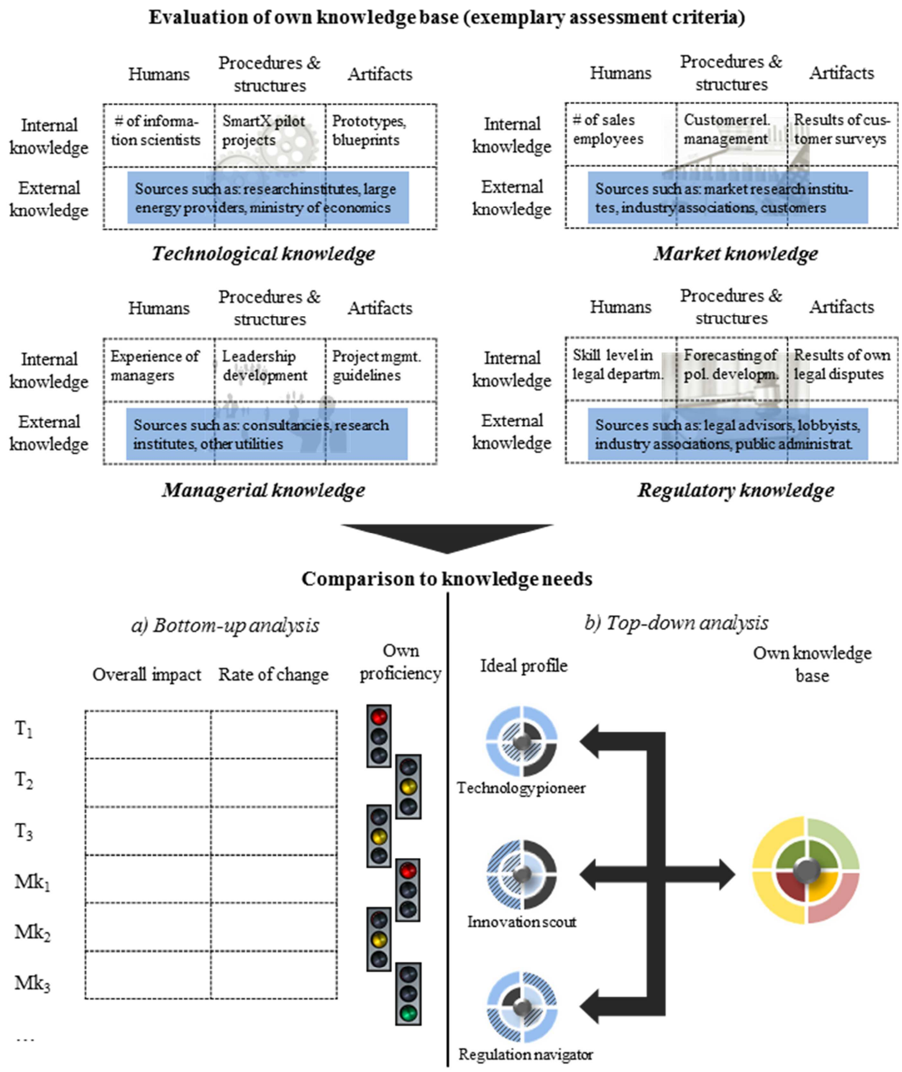

Fig. 3. Comparison of target and actual organizational knowledge

4.3 P – Point Out Knowledge Deficiencies

In the second phase, the current organizational knowledge base must be compared to the needs identified in phase 1 (see Figure 3). In order to achieve this, an in-depth assessment of the firm's knowledge is necessary. Here, the *Wissensbilanz* (Engl. intellectual capital statement) developed by the German Fraunhofer Institute proposes an item and indicator-based evaluation of the quantity, quality as well as systematic treatment of important knowledge factors [1]. Our method widely adopts this approach, but also acknowledges that in order to be managed subsequently, a more finegrained differentiation of knowledge types is necessary. First, we argue that the knowledge domain should be differentiated as previous research showed differences in the effects, development and acquisition of these different domain types [18]. Thereby, our approach focuses on knowledge contents especially important for innovation, namely technological, market, managerial and regulatorys knowledge. Second, knowledge is embedded in different ways within the organization, in its members, procedures and structures or in tangible artifacts [2]. All these loci of knowledge interact multiplicatively, so that it is necessary for firms to manage all three. Finally, firms may draw on knowledge within the own organization or acquire it from diverse external sources. Based on the resulting 24 (4x3x2) general knowledge types to be assessed, our method takes a holistic but differentiated approach and includes various specific items and indicators for each of these types. After this, firms can compare theit knowledge base to the knowledge needs elicited from the bottom-up and top-down analysis. Particular attention should be turned on pressing knowledge needs, i.e. knowledge elements which have many linkages to others, change frequently or are shown to be causally important for innovation in the ideal profiles.

4.4 O – Outline a Plan for Knowledge Development and Acquisition

In the next step, the EPOS team must decide which deficiencies to prioritize and when and how to deal with them (see Figure 4). The summary of knowledge deficiencies from phase 2 serve as input for this step. First, the team should here assess overlaps between the concrete knowledge elements determined from bottom-up analysis with the general knowledge needs from top-down analysis. As the concrete elements also represent building blocks for the general organizational domain knowledge, these will also serve as starting points for general development. Second, deficiencies must be classified in order to determine appropriate action plans. Our method utilizes three factors for doing so: impact, rate of change and ease of improvement. Impact describes the degree to which the knowledge deficiency is seen to influence the firm's innovation performance, rate of change describes the volatility concerning the knowledge gap (e.g. because of technological progress) while ease of improvement describes how long and costly improvement efforts may be. Action strategies are based on these criteria and aim to allow for a focused and resource-efficient but still effective improvement via reasonable prioritization.

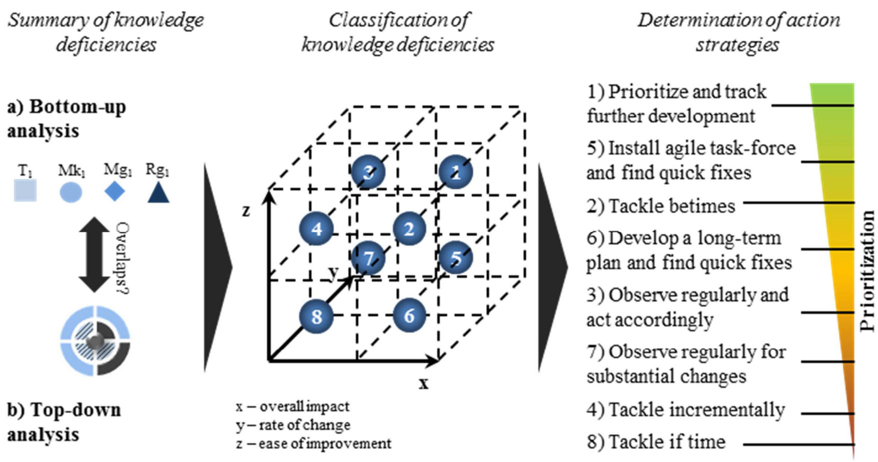

Fig. 4. Outlining the action plan

4.5 S – Seize the Implementation

In this final phase, the project team must select concrete measures for achieving the knowledge improvements (see Figure 5). Our tool comprises various concrete measures describing their value, limits and their range of application concerning the different knowledge domains (technological, market, managerial, regulatory) and loci of embeddedness (human, procedures/structures, artifacts). These should be compiled respective to the specific situation. Especially for highly relevant, somewhat volatile knowledge elements, a general recommendation is to configure internal and external means of knowledge development and acquisition in order to ensure uniqueness and thoroughness of knowledge on the one hand as well as flexibility and diversity on the other hand [2]. Additionally, the measure descriptions discuss the impact of resource or structural constraints specific to the context of utilities. This supports careful selection of methods as well as putting particular attention towards potential obstacles emerging in application.

5 Conclusion

Within this paper, we describe the development of the EPOS procedure, a management tool set allowing municipal energy providers to analyze, plan and develop their knowledge base configuration for addressing innovation in the energy sector, particularly with regard to digital innovation. The final tool thereby advances previous methodologies of strategic knowledge management and includes several distinguishing features which address core requirements drawn from previous research and practical experience. In particular, these features are reflected in the following phases and elements of the EPOS procedure: a) differentiated analysis of knowledge types in order to ensure a comprehensive understanding of knowledge needs and gaps as well as to determine adequate measures for improvement (R_1, R_2, R_3, R_6); b) the two-sided analysis approach which enriches purely problem-driven knowledge search with a strategic plan for the general set-up of the organizational knowledge base (R_4, R_5); c) blueprints for niche strategies as well as a prioritization scheme which allows firms to develop a focused and efficient improvement plan (R_8); d) industry-tailored catalogues of concrete indicators for each type of knowledge and concrete measures including information on their value and applicability for small and medium energy providers (R_1, R_2, R_3, R_7, R_9).

While first discussions with practitioners confirmed the usefulness of these distinctive features, we just started the validation process encompassing iterative assessment and refinement. As the EPOS procedure addresses an intangible, inherently complex but acutely crucial topic, these further refinements will largely address the trade-off between the level of functional detail in the tool and its ease of use. We hope that in the course of this paper, we were able to provide insight to our development procedure, highlight the theoretical assumptions which should shape tools for strategic knowledge management, outline the specific features of the prototypical EPOS procedure and hence stimulate considerations and discussions among managers and researchers in the energy sector.

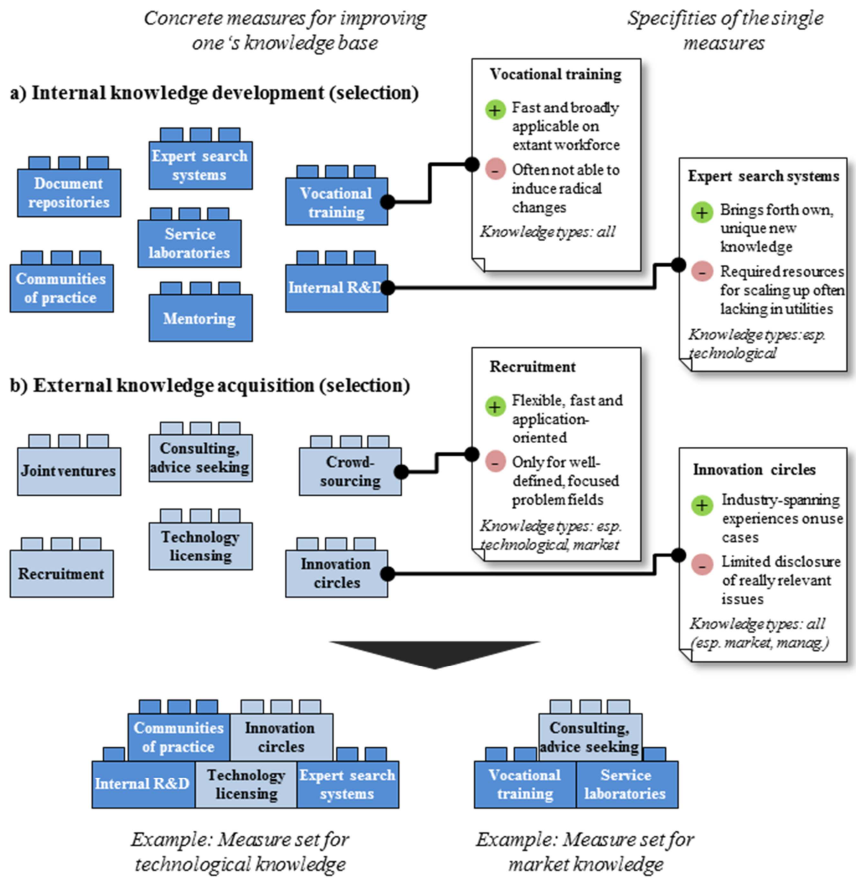

Fig. 5. Choosing concrete measures for implementation

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