Managing and Controlling Decentralized Corporate Energy Systems
Transferring Best-practice Methods to the Energy Domain

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Abstract: Managing decentralized corporate energy systems is a challenging task for enterprises. However, the integration of energy objectives into business strategy creates difficulties resulting in inefficient decisions. To improve this, practice-proven methods such as the Balanced Scorecard and Enterprise Architecture Management are transferred to the energy domain. The methods are evaluated based on a case study. Managing multi-dimensionality and high complexity are the main drivers for an effective and efficient energy management system. Both methods show a positive impact on managing decentralized corporate energy systems and are adaptable to the energy domain.

1 INTRODUCTION

More and more decentralized power generating sites have evolved in recent years. Decentralized power (or energy) generation is defined as a production close to where it is used, which aims at self-consumption and usually focuses on renewable energy (Breyer et al. 2013). Enterprises in particular have changed the traditional energy supply chain from a 100% energy consuming to a prosumer role (combination of **pro**ducer and con**sumer**), building up their own power production sites. Several reasons for this are stated by the companies, such as the price advantage, energy price stability, acceptable amortization time of power facilities, flexibility of power demand and, of course, environment and resource protection (DIHK - Deutscher Industrie- und Handelskammertag & VEA - Bundesverband der Energie-Abnehmer e.V. 2014), (Döring 2015). The last argument is especially growing in importance due to changing cultural values, legal issues and environmental challenges. As a result, enterprises end up with a decentralized corporate energy system resolving corporate energy goals. Research done in the last years shows, that corporate energy management is seldom aligned with the overall corporate strategy ending in suboptimal energy system decisions or in business decisions contrary to energy goals (Manthey & Pietsch 2013), (Posch 2011) ending up in "accidental" energy architectures (Giroti 2009). Additionally, digital transformation changes the energy domain which causes serious challenges for managing energy systems (Doleski 2016).

This paper aims to analyze the challenges of managing decentralized corporate energy systems and to research the applicability of the best-practice methods to the energy domain. Therefore, the following research questions have been formulated:

1. *What are the main challenges for an effective corporate energy management system?*
2. *Which best-practice-proven methods address the identified challenges, and*
3. *What has to be taken into account by an application to the energy domain?*

The feasibility and benefit of the approach is demonstrated on a case study. Clustering findings along an energy management framework enables barriers to be detected. These results are combined with two widely used modelling methods, the Balanced Scorecard and Enterprise Architecture Management, which help to overcome the obstacles.

2 METHODOLOGY

Although the relationship between business strategy and smart grid design is stated in the Smart Grid Reference Architecture, there´s a lack of empirical research that shows the alignment between business strategy and decentralized corporate energy systems.

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The company which was studied in our research offers a unique botanical garden to its visitors and focuses on recreation and relaxation. With over 300 employees in summer and about 150 in winter, it is categorized as a medium-sized company. The company has several decentralized renewable energy generating sites on its property. Ecological goals are clearly stated in its corporate strategy. When the enterprise started implementing an energy management system, various obstacles were detected. Therefore, this case study, which was one of five in a bigger research initiative, focuses on energy efficiency topics, reflecting our research interest and goals and helping us to answer the previously introduced research questions.

Since the aim of this research is to analyze, design, implement and evaluate a new energy management solution, the authors adopt an active role in the development of corporate energy management. Hence, our research activity conforms to the tenets of action research (AR). Baskerville (1999) defines action research as an iterative process involving researchers and practitioners acting together on a particular cycle of activities, including problem diagnosis, action intervention, and reflective learning. AR is a widely discussed collaborative research approach and a significant amount of literature on this topic is available (Avison et al. 1999).

To increase construct validity and reliability (Yin 2009), three data collection methods were used during the case study: semi-structured interviews, participating observation and document analysis.

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3 CASE ANALYSIS

Establishing decentralized renewable energy generators on the company´s territory is based on the corporate vision to create an economic and ecological balance. The company’s founder, who felt a high environmental responsibility, set this goal in place one generation ago. The corporate energy system mainly encompasses four photovoltaic sites, a gas block heat and power station, a wood distillation block heat and power station, a wood pellet power generation site and gas-fired boilers. A local energy provider supplies the additionally needed electrical power and gas. An additional biomass energy site is in discussion. The generating sites are owned and managed by several stakeholders. The traditional

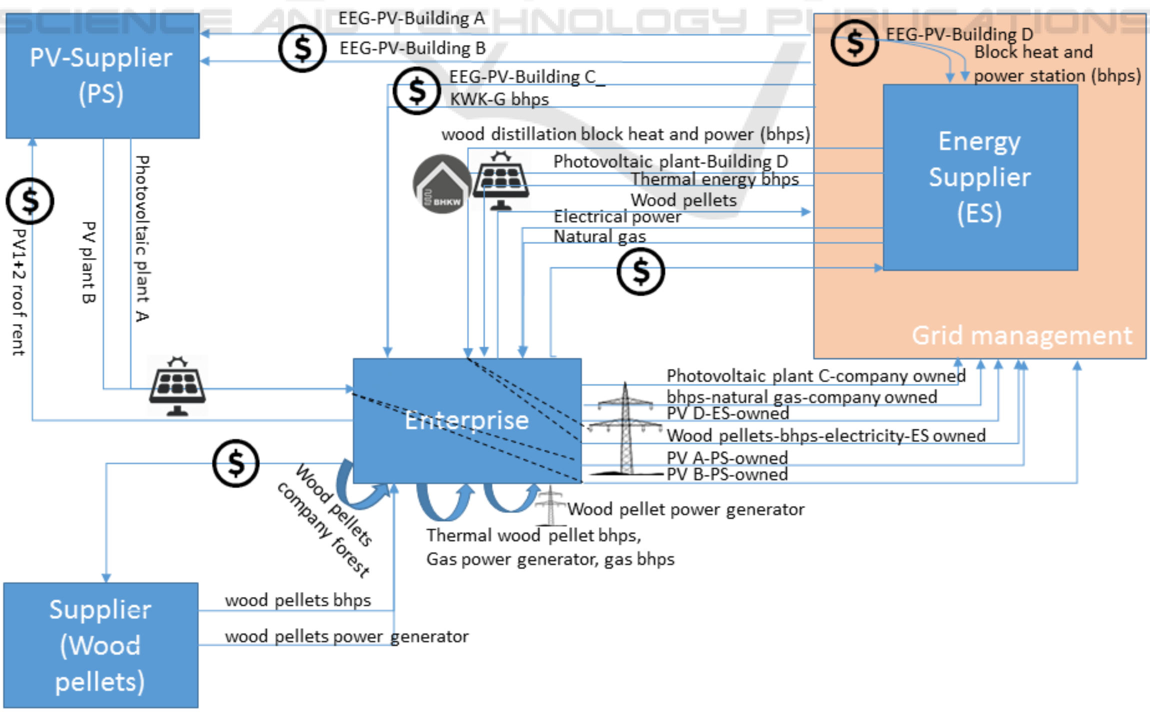

Figure 1: Energy Value Network (own illustration).

energy value chain (centralized power generation => transmission => distribution => Retail through an energy supplier) evolves thereby to an energy value network (Figure 1) where power generation, distribution and retail are combined transactions.
The value network demonstrates the multiplicity of actors and their complex relationships with each other which result in a highly complex and diverse system. Managing such a corporate energy system requires an efficient and effective management system to implement and support the corporate vision.

The scientific literature concerned with energy management systems (EnMS) is still limited and publications focus on practice-oriented books (Hubbuch 2016). A report from Natural Resources Canada proposes a best practice method for energy management and is based on results of training thousands of organizations in energy management (Natural Resources Canada 2015).

Figure 2: Energy management categories (Natural resources Canada, 2015).

According to this best practice guide, effective energy management requires a holistic approach that considers actions in eight categories, which are: Commitment, Planning, Organisation, Projects, Financing, Tracking, Communication, and Training (figure 2). The performance in each category is rated on a scale of 1-5. Level 5 means the organisations works in an optimal way, while level 1 means no action or successful activities can be noted in this category. This method can be used to set an energy policy or to check the state of an EnMS within an organisation.

The findings of the case study are examined and rated using this method to detect gaps in the company's decentralized corporate energy system and then to identify practice-proven methods aiming to close these gaps.

Commitment: The company's vision of an economic and ecological balance is clearly formulated and published. The management board has a high commitment towards this vision and the continuous improvement of the environment is a corporate goal. Three main energy goals (energy saving, energy efficiency and decentralized renewable power generation) were set up in 2013. However, none of these goals are connected with quantifiable numbers nor with a timeline. A tracking of target achievement is not possible. Therefore, the level is set at 4.

Planning: The enterprise started to establish an EnMS according to ISO 50001, a specification created by the International Organization for Standardization for an energy management system. Accordingly, the company established multiple detailed energy targets. But an outlined roadmap connecting measures to the top energy objectives or vice versa, measures derived from the objectives, is missing. The chosen targets seem unsystematic and have, yet again no quantification. As well, no deadlines are fixed. The published energy targets are either very detailed (e.g. changing a specific catering oven) or very broad (e.g. reconstruction of the green houses). A combining energy concept is missing. This criterion is rated at level 2, aiming to 3 only.

Organisation: There is one person working as an energy manager. His authority to give directions is limited and restricted to recommendations toward other business divisions. The rating of this criterion is 3.

Projects: The development of energy measures and projects are rather ad hoc and opportunity-driven and not systematically connected to the energy objectives. Several identified and published energy targets were not converted into projects due to economic reasons. Therefore, this criterion is rated at level 3 again.

Financing: The energy investments are based on short-term criteria and are, in the end, economically driven. No business case towards monetary effects through energy savings or efficiency has been conducted. The rating is 3 again.

Tracking: Momentarily one of the main tasks of the energy manager is collecting and organizing energy data. At present the available data and its quality is not sufficient for implementing the aspired goals. The unavailability is based upon three factors:

no data is measured at relevant local spots, energy data is not digitized and finally the data is not available in the needed aggregation level. For example, it is not possible to assign the energy consumption to the profit centers of the company. Therefore, this criterion is rated with 2.

Communication: Energy communication towards the public and the internal staff exists. On a yearly basis, the company publishes its sustainability report, which includes an overview about energy consumption, targets and projects. Via the company's intranet, energy information is supplied to the staff. The rating of this criterion is 3.

Training: Energy saving and efficiency trainings for staff members takes place. However, results are hardly seen. According to the energy manager a rejection of these topics even occurred due to too many ecological training measures. Taking the results into account, the rating of this criterion is split into 2 (training takes place) and 4 (poor results).

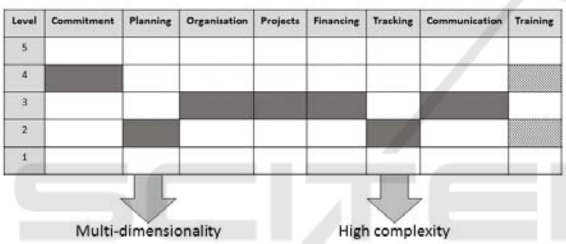

Figure 3: Overview of the ratings and resolving challenges (own illustration).

Figure 3 gives an overview of the case study ratings. The results show that the company and its management board have a high commitment towards energy objectives and have started energy transformation measures in different areas. Yet, further progress is hindered through two specific categories: planning and tracking. The corporate vision of a balanced economical-ecological strategy (criteria "Commitment") requires an alignment of economic and energy-related objectives and measures (criteria "Planning"). The implemented EnMS doesn´t support such functionality so far. Therefore, the needed energy reflection for corporate decisions has not been implemented and corporate decision making processes are mostly economically driven. To overcome this obstacle **multi-dimensional viewpoints** have to be included into the company's strategy.

Managing and controlling a decentralized corporate energy system is based on energy data. However, the result in the category "Tracking" shows an essential gap in this area. Missing measurement spots, heterogeneous data formats and missing digitization processes are the main barriers. On top of that, the high diversity of decentralized power generation systems (figure 1) leads to a **highly complex system**.

4 IDENTIFICATION AND TRANSFER OF PRACTICE-PROVEN METHODS

Based on the case analysis two main challenges are identified: Management of multi-dimensionality and of complexity.

Integrating different viewpoints into a company´s strategy is the basis of the management and controlling method "Balanced Scorecard (BSC)". The BSC approach introduced by Kaplan & Norton in 1992 (Kaplan & Norton 1992) addresses a combination of four business perspectives (financial, customer, internal business processes, and learning and growth) and offers the possibility to integrate further strategic views (Kaplan & Norton 1996). Various new perspectives, for example an IT-perspective were implemented successfully in the last years (Huang & Hu 2007), (Van Grembergen & Saull 2001). The BSC is a global standard for managing complex systems and is in widespread use in private (Van Grembergen & Saull 2001), (Huang & Hu 2007) and public sectors (U.S. Departement of Energy 2017). Objectives are linked to measures and quantified through key performance indicators (KPI). Because of this a constant controlling of the improvements is possible. Such a holistic approach enables the integration of energy objectives into multiple corporate strategy dimensions. BSC information systems are widely used and numerous tools exist on the market. Therefore a quick initial implementation of an Energy Balanced Scorecard (EBSC) to improve decentralized corporate energy systems is possible and enables an evaluation of the method adoption.

The Enterprise Architecture Management (EAM) approach has been proven to be an efficient instrument to align business and IT from a holistic perspective and to control the complexity of IT landscapes (Hanschke 2012), (Hauder et al. 2014). EAM is used to model the as-is state landscape and to derive further on to the to-be state. The decentralized energy system reflects a complex energy landscape, which has to be aligned to the corporate objectives. Therefore EAM characteristics provide positive impact for establishing an effective EnMS.

EAM is an accepted methodology in practice and academia (Uslar et al. 2013). One of the most used EAM modelling languages is Archimate (The Open Group 2016). Archimate is hosted by The Open Group which also provides “The Open Group Architecture Framework” (TOGAF) (Haren 2011). TOGAF is a widespread and established enterprise architecture framework, which has been elaborated by several large industry actors as members of The Open Group.

4.1 Improving EnMS with the Balanced Scorecard Method

The BSC offers several advantages: First, with this method it is possible to monitor present performances as well as obtaining information about the future ability to perform. Second, it assists in translating an organization’s vision into actions through strategic objectives and a set of performance measures supported by specific targets and concrete initiatives. Third, using the BSC facilitates the identification of success drivers, allowing managers to focus on a small number of critical indicators, thereby avoiding information overload (Vieira et al. 2016). Several adoptions of the BSC towards sustainability addressing social and environmental dimensions have been implemented in the last years (Figge et al. 2002), (Arnold et al. 2003), (Sidiropoulos et al. 2004) and proved that integrating ecological perspectives is successful. However, the implementation of an energy viewpoint is hardly dealt with in scientific literature (Vieira et al. 2016) and seldom found in practice (Laue 2016).

Based on the results of the case analysis an Energy BSC was modelled using the software “ADOSCORE” from BOC. A typical corporate objective was selected to demonstrate the usefulness of managing multi-dimensional corporate goals with an inclusion of energy perspectives. “Increasing the number of park visitors (customers)” is a typical business goal and reflects the interdependencies between customer-, financial- and energy dimensions. The relations between these dimensions illustrates the impact of customer measures on financial and energy goals and vice versa. The energy BSC is illustrated in figure 4.

Pyramids with connected KPIs to enable an ongoing controlling process, symbolize objectives in each perspective. Red or green dots signal a positive or negative development according to pre-quantified goals. An aspired increase of visitors (green dot) leads in the financial perspective to a revenue increase and higher profits which results in a rise of the equity ratio. Simultaneously on the energy perspective due to higher power demands through e.g. higher catering

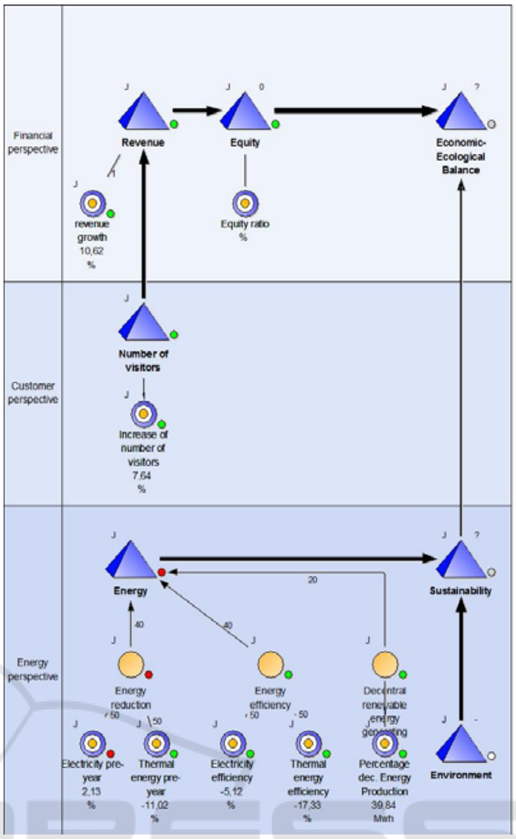

Figure 4: Energy BSC (own illustration).

activities, the KPI for decentralized renewable power generation is turning negative as well as the energy objective “Energy savings”. The Energy BSC signals the energy manager, and respectively the board of management, when there is a need for adjustments.

The implementation of an Energy BSC showed that the method provides corporate management with a transparent controlling process integrating energy goals into corporate strategy. Taking the studied case, the model indicates direct negative consequences on the energy goals through increasing visitor numbers. Identifying such goal conflicts between strategic dimensions enables the management to set up compensating energy measures or to adjust customer goals.

For an effective EnMS an on-going controlling and decision making process with up-to–date information is necessary. A data-warehouse-based BSC standard software like ADOSCORE offers the possibility to integrate energy data via Excel or SQL-database-statements enabling a continuous digital data integration. However, the analysis of the studied case expresses a gap regarding data tracking, grounded on the heterogeneous database and the non-existing digital energy data flow that significantly hinders the multi-dimensional controlling process.

Managing and controlling energy goals in a corporate strategy with BSC has been applied positively. The BSC offers the possibility to manage the multi-dimensionality of a corporate energy system. Therefore, transferring the BSC method onto the energy domain is possible and results in a positive impact. Yet, the analyzed BSC approach focused test wise on one business goal only. An expansion of the BSC combing all relevant corporate perspectives has not been conducted yet. Further, the BSC method is only as good as the selected measures and KPIs.

Finally, the findings of the case study indicate clearly that a fully digital energy data process is the foundation of an effective and efficient usage of the BSC.

4.2 Modelling Corporate Energy Systems with Enterprise Architecture Management

An enterprise is a complex and highly integrated system consisting of processes, organizations, information and technologies, with interrelationships and dependencies in order to reach common goals (Razavi et al. 2011). A common problem of many medium-sized enterprises is the diverse IT-landscape. A mostly unsystematic growth of applications in enterprises over time results in “accidental architectures” (Giroti 2009). The corporate energy system with its high diversity and its unsystematic growth leads to a similar development with similar difficulties like in the area of IT. Taking the case study results (criteria “Tracking”), data heterogeneity and non-existent digital energy data processes resemble the IT-domain. In order to solve these problems enterprises need to be aware of their relations among strategy, business processes, applications, information infrastructures and roles.

Enterprise Architecture Management (EAM) contributes to solve these problems. It is a holistic approach providing methods and tools to establish a complete perspective on enterprises (Lankhorst 2013). Architecture is thereby defined as a fundamental concept of a system in its environment, embodied in its elements, relationships, and in the principles of its design and evolution (International Organization Of Standardization 2011). According to (Lankhorst 2013), EAM can be defined as “a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise’s organizational structure, business processes, information systems, and infrastructure”. In this context, EAM provides an approach for a systematic development of the organization in accordance with its strategic goals (Ahlemann et al. 2012). Thus, EAM evolves as a best-practice method that positively assists an EnMS.

In the findings of the case analysis, several characteristics were identified indicating EAM solution potential: First, the complex, unsystematic development of corporate energy architecture; second the multiple energy consumers (e.g. catering facilities, greenhouses, administration, event facilities), third the heterogeneous energy data landscape resulting in missing data recording spots, only analog data existence at various metering spots and rough data. And finally the incoherent energy data process.

For modelling the Enterprise Architecture, the ArchiMate 3.0 (The Open Group 2016) modeling language was selected because the entity “physical elements” enables the modeling of power generation sites. For modeling the Archimate models, we used the modelling tool Signavio. The modelled Energy Enterprise Architecture (figure 4 and 5) shows a simplified representation of the energy system in our case study. The model enables the visualization of the current energy data process, the identification of digital gaps, and the planning of a roadmap towards a better fitting, future Energy Enterprise Architecture.

Figure 5 shows the energy data process on a high granular level. The business process consists of three steps (entity “Business process”): capturing electricity energy production, capturing electricity energy consumption and balancing production and consumption data. The process is connected (entity “Realization”) with two separate Excel-files (entity “Application component”). For reasons of better demonstration, just the electrical power grid is modelled. The model points out the existence of side-by-side energy Excel sheets.

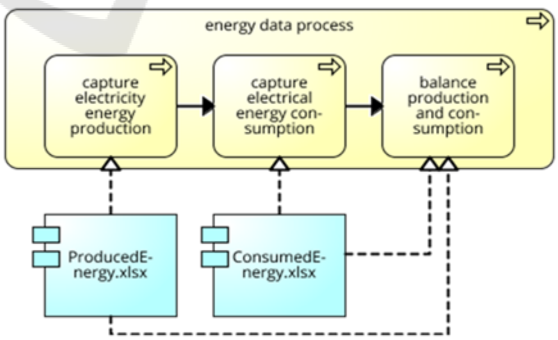

Figure 5: Energy Data Process (own illustration).

The Energy Enterprise Architecture (figure 6) reflects the business process “increasing park visitors” and its resolution in higher energy demand in catering facilities (chapter 4.1).

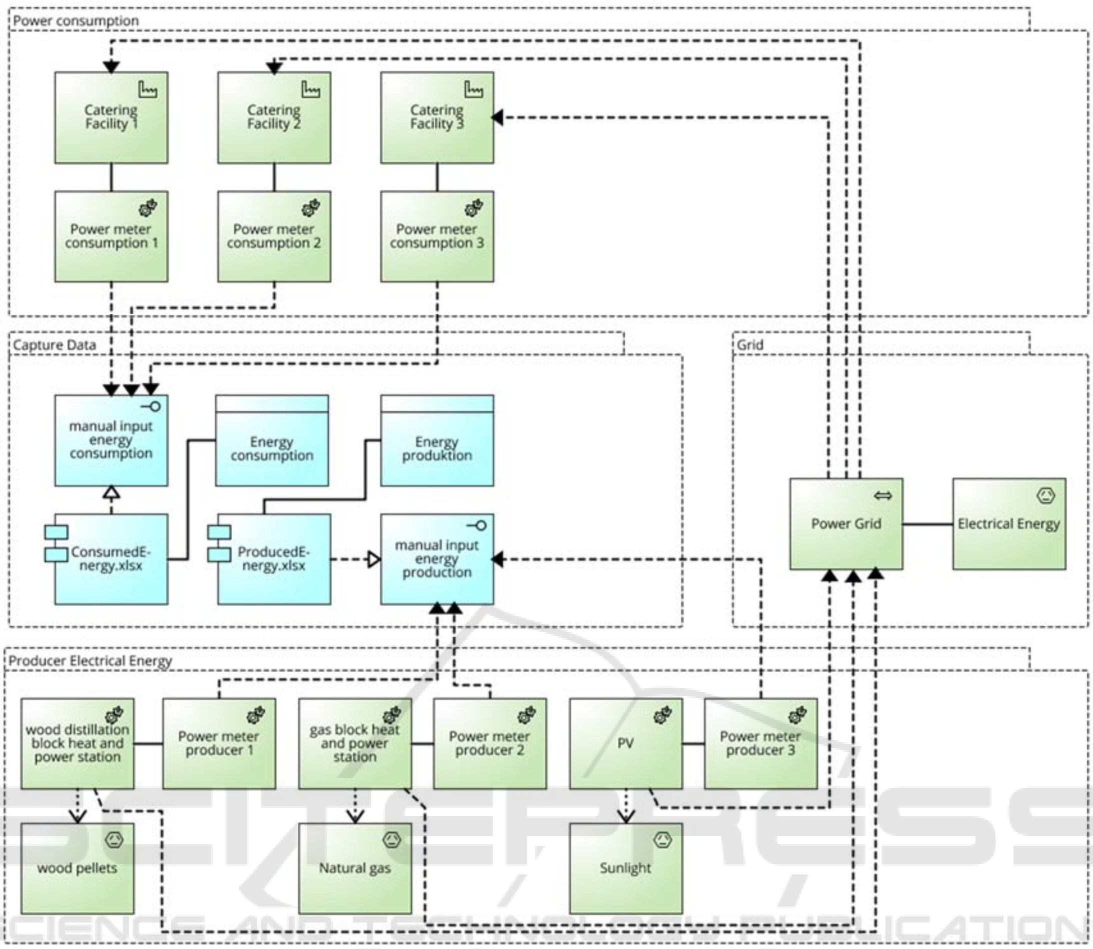

Figure 6: Energy Enterprise Architecture (own illustration).

It describes the data sources for generated and consumed electrical power linked to the above mentioned Excel-files. Today, the energy data recording process is carried out manually. Data from electric meters is manually written into an Excel file The Energy EA displays the decentralized power generation system with its generation material as well as the catering electricity consumers. Producer and consumers are connected via the power grid.

The Energy EA reflects the as-is state of the decentralized energy system and enables the energy manager to identify data gaps, existing data flows, the quality of data (analog-to-digital), data sources etc. This information is the baseline for planning the to-be-model based on a corresponding roadmap.

Modelling an Energy EA provides a positive impact for an effective energy management system and is therefore a useful method for managing the energy domain in a digital, data driven process. By now the modelling approach is simplified and represents only a small part of the decentralized energy system. Different viewpoints have to be integrated as well. Still, designing an Energy EA and the development of an EA-roadmap is the basis for the implementation of an effective Energy Scorecard and an enterprise wide, multidimensional Controlling System.

5 CONCLUSION

Decentralized corporate energy systems have evolved constantly in recent years, changing the role of enterprises to energy prosumers. Companies are motivated to build up their own power production sites due to price advantages, energy price stability, power demand flexibility, environmental protection and legal obligations. However, establishing an effective EnMS relies on challenges in eight different categories. Applying these to the conducted case, our study identified two main obstacles: Managing Multi-dimensional target systems and enterprise complexity.

Two practice-methods that address these challenges, the Balanced Scorecard and Enterprise Architecture Management were identified and evaluated in this paper. The Balanced Scorecard enables enterprises to manage complex and link multi-dimensional strategies. However, the current energy EA can´t deliver the energy data necessary for proper system management. EA Modelling enables the visualization of the energy enterprise architecture to identify gaps in data flow and digital processes. These gaps define the roadmap towards a future Energy Enterprise Architecture that copes with the planned future development.

The transfer and partial integration of BSC and EAM to the energy domain seems to offer a promising impact for managing corporate energy systems. Yet, further research is needed in respect of method integration, to find standardized interfaces between business demand and operational energy system data sources. Future research on conceptual models and their validation by empirical use cases will elaborate the data driven management of decentralized energy systems.

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