

## Digitization of Decentralized Corporate Energy Systems: Supportive best-practiced methods for the energy domain

Christine Koppenhöfer<sup>1</sup>, Jan Fauser<sup>2</sup> and Dieter Hertweck<sup>3</sup>

**Abstract:** Digitization in the energy sector is a necessity to enable energy savings and energy efficiency potentials. Managing decentralized corporate energy systems is hindered by a non-existence. The required integration of energy objectives into business strategy creates difficulties resulting in inefficient decisions. To improve this, practice-proven methods such as Balanced Scorecard, Enterprise Architecture Management and the Value Network approach are transferred to the energy domain. The methods are evaluated based on a case study. Managing multi-dimensionality, high complexity and multiple actors are the main drivers for an effective and efficient energy management system. The underlying basis to gain the positive impacts of these methods on decentralized corporate energy systems is digitization of energy data and processes.

**Keywords:** Decentralized Corporate Energy System, Balanced Scorecard, Enterprise Architecture Management, Value Network

### 1 Introduction

To balance the increasing production of renewable energy sources and their consumption, digitization of the energy sector is necessary [Reht15]. Under focus are the stabilization of grids on a macro level, energy efficiency potentials on a micro level, and energy process optimization. Enterprises discovered decentralized energy generation for different reasons such as price advantages, planning stability, declining amortization time of power facilities, flexibility of energy demand and environment /resource protection [DiVe14], [Döri15]. Therefore the number of decentralized power generating sites has increased in recent years. Decentralized power generation is defined as a production close to the point of consumption and usually focuses on renewable energy [BrAl13]. Research done in recent years shows, that corporate energy management is seldom aligned with the overall corporate strategy ending in poor energy system decisions or in business decisions contrary to energy goals [MaPi13], [Posc11]. This leads to “accidental” energy architectures [Giro09] which result in inefficient energy savings or efficiency measures. The digital transformation in the energy sector is an opportunity, as well as a thread to overcome these barriers [Dole16].

---

<sup>1</sup> Reutlingen University, Faculty Informatics, Alteburgstr. 150, 72762 Reutlingen, Christine.Koppenhoefer@reutlingen-university.de

<sup>2</sup> Reutlingen University, Faculty Informatics, Alteburgstr. 150, 72762 Reutlingen, Jan.Fauser@reutlingen-university.de

<sup>3</sup> Reutlingen University, Faculty Informatics, Alteburgstr. 150, 72762 Reutlingen, Dieter.Hertweck@reutlingen-university.de

Our paper analyzes the challenges of a digitized decentralized corporate energy system. It researches the applicability of best-practice methods to support the digital transformation to decentralized corporate energy systems. Therefore, the following research questions have been formulated:

1. *What are the main challenges for a digitized 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 three widely used modelling methods like e3Value, Balanced Scorecard or Enterprise Architecture Management to identify transformation hurdles.

## 2 Research Context and Methodology

The aim of this research is to analyze, design, implement and evaluate a transformation path towards a digitized decentralized energy management system. A case study approach was selected to overcome the current actual gap in empirical research. Case studies are useful to research a new domain or phenomenon, providing initial hypotheses, which may be tested later systematically on a larger number of cases [Flyv06].

Our case is a 300 employee, medium-sized enterprise in the tourist sector that offers a unique botanical garden to its visitors. It has several decentralized renewable energy systems on its property and the ecological goals are clearly stated in its corporate strategy. When the enterprise started implementing an energy management system, various obstacles were detected.

Since the authors adopt an active role in the transformation process, our research activity conforms to the tenets of action research (AR). [Bask99] defines action research as an interactive 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 [ALMN99]. Three data collection methods were used during the case study: participating observation, semi-structured interviews and document analysis.

Conducted research is part of a public funded research program named ENsource ([www.ensource.de](http://www.ensource.de)) which focuses on decentralized, flexible solutions for future energy production and distribution. The Ministry of Science, Research and the Arts of the State of Baden-Wuerttemberg, Germany and the European Regional Development Fund (EFRE) fund this project.

### 3 Case Analysis

The implementation of renewable energy generators on 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 company built up several energy generation sites in the past years to achieve this corporate vision but also faces high energy demands due to green houses and several catering facilities. Since 2013, the company has started to build up an energy management system.

The scientific literature concerned with energy management systems (EnMS) is still limited and publications focus on practice-oriented books [Hubb16]. A report from Natural Resources Canada proposes a best practice framework based on results of thousands of trainings conducted with organizations in energy management [Natu15]. According to this guide, effective energy management requires a holistic approach that considers actions in eight categories: Commitment, Planning, Organization, Projects, Financing, Tracking, Communication, and Training. The performance in each category is rated on a Likert-scale of 1-5. Level 5 means the organization works in an optimal way, while level 1 means no action can be noted in this category. This framework can be used to set an energy policy or to check the state of an EnMS within an organization.

The findings of the case study are examined and rated using this framework 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 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 and defined detailed multiple 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 aren't quantified and seem to be unsystematic. 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 combined energy concept is missing. This criterion is rated at level 2, aiming to 3 only.

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

**Projects:** The development of energy measures and projects are ad hoc and event-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.

**Financing:** The energy investments are based on short-term returns on investments but no business case towards monetary effects through energy savings or efficiency has been conducted. The rating is 3 again.

**Tracking:** At present the available data and its quality is not sufficient for implementing and tracking the aspired goals. The lack of suitable data 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 at the needed aggregation level. For example, it is not possible to assign the energy consumption to business models or even profit centers of the company. Therefore, this criterion is rated with 2.

**Communication:** 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 training for staff members takes place but results are hardly seen. A rejection of these topics even occurred due to too many ecological training measures being currently operated. The rating of this criterion is split into 4 (training takes place) and 2 (poor results).

**Value Network Management: (customer-, partner-, supplier management):** The category Value Network Management has not yet been part of the best practice energy management framework (Natural resources Canada, 2015). Due to the case study findings and its discussed relevance in scientific literature [KaGT04], [Hert16], [DiVo15] the category "Value Network Management" is integrated into the energy management framework.

The corporate energy system encompasses four photovoltaic sites, a gas power station, a wood distillation block heat and power station, a wood pellet power generating site and gas-fired boilers. A local energy provider supplies additionally needed electrical power and gas. The generating sites are owned and managed by several stakeholders. The traditional energy value chain (centralized power generation => transmission => distribution => retail through an energy supplier) evolves to an energy value network where power generation, distribution and retail are combined transactions. For example, building roofs are rented to a supplier that delivers the photovoltaic generation sites and gets the governmental grant for renewable energy generation in return. In this way the company consumes renewable decentralized generated electricity while accomplishing its energy goals. The value network demonstrates the complexity of relationships between the actors and diverse systems. Yet, a planned approach to use and increase the advantages of the value network is missing. The rating of this category is 3.

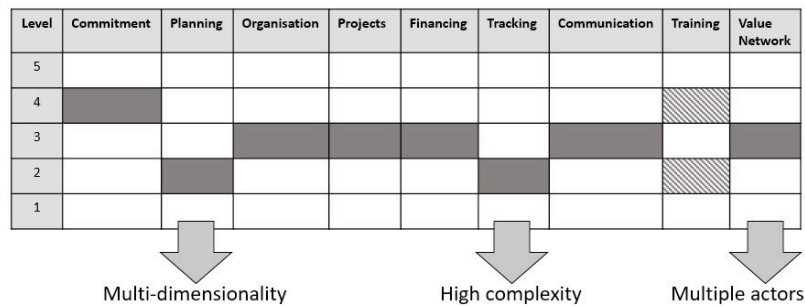


Fig. 1: Overview of the ratings and resulting resolving challenges

Figure 1 gives an overview of the final case study ratings. The results show that the company and its management board have a high commitment towards energy objectives. They have started energy transformation measures in different areas. Yet, further progress is hindered through two specific categories: planning and tracking. A third category “multiple actors” is of growing relevance since the achieving of the company’s energy goals relies on its value network.

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 hasn’t supported such functionality so far. Therefore, the reflection of energy items to corporate decisions has not been implemented. The corporate decision making processes are mostly economically driven. To overcome this obstacle **multi-dimensional viewpoints** have to be integrated into the company’s strategy.

Managing a decentralized corporate energy system is based on energy data. The category “Tracking” shows an essential gap in this area. Missing measurement spots, heterogeneous data formats and poor digitized processes are the main barriers. On top of that, the high diversity of power systems leads to **highly complexity**.

The case analysis also showed that decentralized corporate energy systems are not based on traditional supplier-buyer-value chains anymore, but encompass various actors that form an ecosystem of interdependent value-added services. This **multiple-actor-approach** is of specific means and has to be included in a management framework.

#### 4 Identification and transfer of practice-proven methods

Based on the case analysis three main challenges in managing an efficient decentralized corporate energy system are identified: Management of multi-dimensional target systems, of system’s complexity and of multiple actors in value networks.

Integrating different viewpoints into a company's strategy can be achieved by using the Balanced Scorecard Method (BSC). The BSC approach [KaNo92] addresses a combination of four business perspectives (financial, customer, internal business processes, and learning and growth) and offers the opportunity to integrate further strategic views [KaNo96]. The BSC is a global standard, widely used in private [GrSa01], [HuHu07] and public sectors [Usde17]. Objectives are linked to measures and quantified through key performance indicators (KPI). A constant controlling of improvements is possible. Such a holistic approach enables the integration of energy objectives into corporate strategy dimensions.

The Enterprise Architecture Management (EAM) approach has been proven to be an efficient instrument to align business and IT and to control the complexity of IT landscapes [Hans12], [HRSM14]. EAM is used to model the as-is landscape and to derive from there the to-be state. The decentralized energy system reflects a complex energy architecture, which has to be aligned to the IS and enterprise architecture. Therefore, EAM methods provide a positive impact for establishing an effective EnMS. They have been accepted in academia and practice [USDT13] for years. One of the most used EAM modeling languages is Archimate [Open16].

Today enterprises can seldom be viewed as isolated entities. Usually they are connected in an enterprise network forming an ecosystem [Krcm11]. Because enterprise energy systems are operated by different actors, the ecosystem approach seems to be appropriate [ChRo95]. Many enterprises have established energy value networks with cooperating partners. Therefore, it is necessary to model and integrate the value flow into the EnMS of each partner. Modeling value networks is a relatively new field in IS research. The most common modelling language is e3-Value (e3v). The focus of e3v is on identifying and analyzing how value is created, exchanged and consumed within a multi-actor-network in both qualitative and quantitative ways [GoAk01], [AkGo03].

#### **4.1 Improving EnMS with the Balanced Scorecard Method**

The BSC method offers several advantages: (i), it enables the monitoring of present performances as well as obtaining information about the future ability to perform. (ii), 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. (iii), using the BSC facilitates the identification of success drivers, allowing managers to focus on a small number of critical indicators, thereby avoiding information overload [ViOS16]. Several adoptions of the BSC towards sustainability addressing social and ecological dimensions have been successfully implemented in recent years [FHSW02], [ArFK03]. However, the implementation of an energy viewpoint is hardly dealt with in scientific literature [ViOS16] or in practice [Laue16].

Based on the results of the case analysis an Energy BSC was modeled using the software "ADOSCORE" from BOC. A typical corporate objective was selected to demonstrate the usefulness of managing multi-dimensional corporate goals including 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 2.

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 result in a rise of the equity ratio. Simultaneously on the energy perspective due to higher power demands through e.g. higher catering 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.

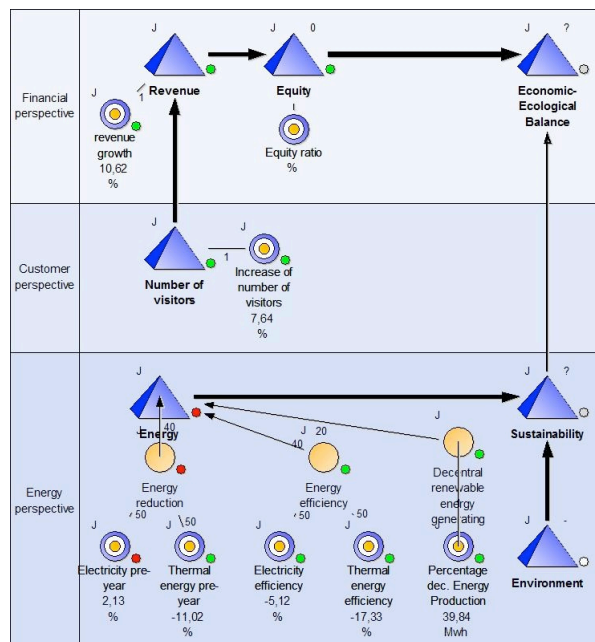


Fig. 2: Energy BSC

The implementation of an Energy BSC showed that the method provides corporate management with a transparent controlling process integrating energy goals into corporate strategy. Our case 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 opportunity to integrate energy data via Excel or SQL-database-statements. However, the studied case expresses a gap regarding data tracking, based on heterogeneous data formats, and non-existing digital data flows that significantly hinder the multi-dimensional controlling process.

The BSC offers the possibility to manage the multi-dimensionality of a corporate energy system. The transfer to the energy domain is possible and results in a positive impact. But the BSC method is only as good as the selected measures and KPIs.

The findings of the case study indicate clearly that a fully digital energy data process is the necessary starting point of effective and efficient BSC usage.

#### **4.2 Modelling Decentralized 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 [RaAB11]. 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” [Giro09]. The corporate energy system, with its high diversity and its unsystematic growth, leads to a similar development with similar difficulties. Taking the case study results (criteria “Tracking”), data heterogeneity and non-existing energy data processes resemble the IT-domain. Therefore 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 for enterprises [Lank13]. According to [Lank13], 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 organizations in accordance with its strategic goals [ASML12]. Thus, EAM has evolved as a best-practice method that positively assists an EnMS. Additionally Appelrath et al.[ApTW12] emphasized that changes of the energy system require an analysis of the corporate information systems as well.

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 different energy consumer units (e.g. catering facilities,



greenhouses, administration, event facilities), and third the heterogeneous energy data landscape (missing data recording spots, analog data only, highly aggregated, useless data, various metering spots without an interconnected digital data workflow).

For modelling the Enterprise Architecture, the ArchiMate 3.0 [Open16] modeling language was selected because the entity “physical elements” enables the modeling of power generation sites. For modeling the ArchiMate models, we used the tool Signavio. The modeled Energy Enterprise Architecture (figure 3) shows a simplified representation of the case study energy system. The model enables the visualization of the as-is energy data process, the identification of digital gaps, and the planning of a roadmap towards a better fitting, future to-be Energy Enterprise Architecture.

The Energy EA (figure 3) reflects the business case “increasing park visitors” and its resolution in higher energy demand in catering facilities (chapter 4.1). It describes the data sources for generated and consumed electrical power linked to side-by-side existing Excel-files. Today, the energy data recording process is carried out manually. 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 decentralized energy management system and is therefore a useful method for managing the energy domain in a digital, data driven process. Until now the modeling 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.

### 4.3 Value Network approach

Today, enterprises do not compete among individual companies, but among networks of interconnected enterprises [PeRy06]. Such interconnected enterprises are compounded to an ecosystem and can’t be viewed individually. Moore [Moor96] defines a business ecosystem as an “economic community supported by a foundation of interacting organizations and individuals –the organisms of the business world”. The performance of an enterprise is influenced, or even determined, by the performance and behavior of its partners. Therefore, it is necessary to analyze the

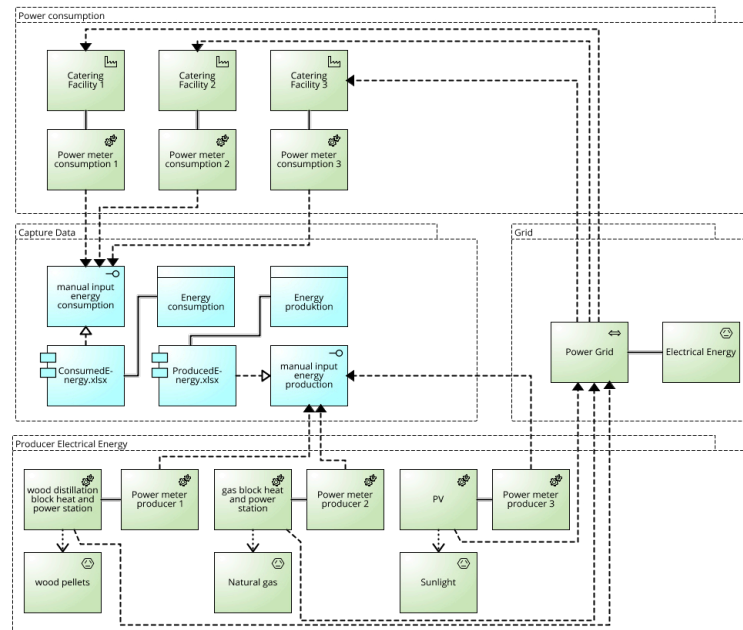


Fig. 3: Energy Enterprise Architecture.

cooperating partners and the exchanged values to provide the relevance for each enterprise. The focus of a value network (VN) is to collectively determine value for each party involved [AlAF13]. This trend can be seen in the energy sector as well [Hert16], [KüHK15]. It can be observed that especially new, smaller actors in the energy value chain are dependent on such partnerships [KüHK15].

Our case with its multiple-actors-landscape verifies this point too, so it is reasonable to examine and model the value exchanges between the different partners. A modeling approach including multiple actors is the e3v-method by Jaap Gordijn [Gord02]. It enables the visual representation of value exchanges between VN actors by modeling their interactions. E3v provides a set of components by representing the actors, the activities, the value exchanges and the value chains involved in the network. Based on the case the VN was modeled with the e3v-method (figure 4).

The diagram shows the actors of the ecosystem arranged around our case file (energy supplier, photovoltaic supplier, grid manager, wood pellets supplier). Several similar actors are aggregated into market segments (customer). Lines between the actors and market segments represent the value exchanges between the actors. These exchanges can be energy, money, energy generation sites, rent, governmental grant, material or data. Actors that do not have a direct value exchange are not pictured.

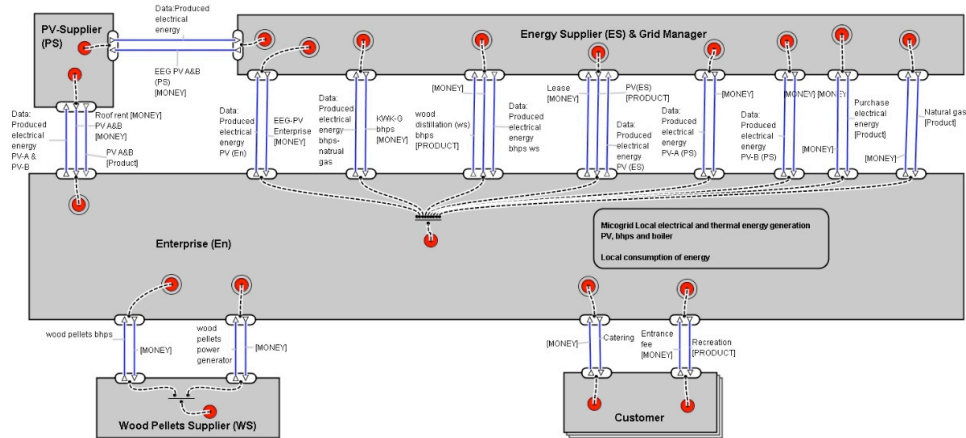


Fig. 4: Value Network

The VN demonstrates the interdependencies between the different actors. Our case study company achieves its energy goals (renewable decentralized energy production) with the help of the PV- and the energy supplier. In return the company offers its building roofs to the PV supplier. Each partner brings its competence into the VN which add up to the overall value. The modeled value network is also the starting point for describing the needed IT-services or data models between the actors and for expanding the Energy Enterprise Architecture towards an Energy Network Architecture. Currently, digitized energy data hardly flow between the network actors. Paper-based billing procedures takes place once a year. An online-energy-tool to monitor the energy demand of the case file company is set up by the energy supplier. The retrieved data hardly matches the energy information needs of the company. Therefore, a better alignment of energy information between the two actors is necessary. Additionally, it is currently not possible to automatically retrieve the energy information into the company's energy management system. No digital energy information exchange exists at all between the PV supplier and the case company.

Modeling the VN clearly has a positive impact on the company's transformation towards a digitized decentral corporate energy system regarding the role and the importance of each actor as well as providing a starting point for establishing an Energy Network Architecture.

## 5 Conclusion

Decentralized corporate energy systems have evolved constantly in recent years, changing the role of enterprises to energy prosumers. Establishing an effective and

efficient EnMS depends on the digitization of the energy processes in- and outside of the company. The success of managing a decentralized EnMS relies on nine categories. Applying these to our conducted case, three main challenges were identified: Managing multi-dimensional target systems, energy enterprise complexity and relying on an energy value network.

Three practice-proven methods that address these challenges, the Balanced Scorecard, Enterprise Architecture Management and the Value Network approach were identified and evaluated in this paper. The BSC enables enterprises to manage complex multi-dimensional strategies. However, the current energy EA can't deliver the necessary energy data for proper system management. EA Modeling enables the visualization of the energy enterprise architecture to identify gaps in data flow and digital processes. These gaps define the roadmap to-wards a future digitalized Energy Enterprise Architecture that copes with the planned future development. The Value Network Approach displays dependencies with other actors and shows additional value opportunities. All three methods clearly show the need for digitization to accomplish energy goals.

The transfer and partial integration of BSC, EAM and VN to the energy do-main seem to offer a promising impact for managing decentralized corporate energy systems. Further research in the integration of these methods is required to find standardized interfaces between business demand and necessary energy sys-tem data sources. Future research on conceptual models and their validation by empirical use cases will elaborate the data driven management of decentralized energy systems.

## Bibliography

- [AkGo03] Akkermans, J. M.; Gordijn, J.: Value-based requirements engineering: exploring innovative e-commerce ideas. In: Requirements Engineering vol. 8, Nr. 2, pp. 114–134, 2003.
- [AIAF13] Al-Debei, M. M.; Al-Lozi, E.; Fitzgerald, G.: Engineering innovative mobile data services: Developing a model for value network analysis and design. In: Business Process Management Journal vol. 19, Nr. 2, pp. 336–363, 2013.
- [ALMN99] Avison, D. E. et al.: Action research. In: Communications of the ACM vol. 42, Nr. 1, pp. 94–97, 1999.
- [ApTW12] Appelrath, H. J.; Terzidis, O.; Weinhardt, C.: Internet of energy: ICT as a key technology for the energy system of the future. In: Business and Information Systems Engineering vol. 4, Nr. 1, pp. 1–2, 2012.
- [ArFK03] Arnold, W.; Freimann, J.; Kurz, R.: Sustainable Balanced Scorecard (SBS): Integration von Nachhaltigkeitsaspekten in das BSC-Konzept. In: Controlling und Management vol. 47, Nr. 6, pp. 391–401, 2003.

- [ASML12] Ahlemann, F. et al. ; Ahlemann, F. ; Stettiner, E. ; Messerschmidt, M. ; Legner, C. (eds.): Strategic Enterprise Architecture Management, Management for Professionals, Springer, Berlin, Heidelberg, 2012.
- [Bask99] Baskerville, R. L.: Investigating Information Systems with Action Research. In: Communications of the Association for Information Systems vol. 2, Nr. 3, pp. 1–32, 1999.
- [Bra113] Breyer, C.; et al.: Vergleich und Optimierung von zentral und dezentral orientierten Ausbaupfaden zu einer Stromversorgung aus Erneuerbaren Energien in Deutschland, a study of the Reiner Lemoine Institut gGmbH on behalf of the 100 prozent erneuerbar stiftung, Heleakala-Stift, Berlin, 2013.
- [ChRo95] Christensen, C. M.; Rosenbloom, R. S.: Explaining the attacker’s advantage: Technological paradigms, organizational dynamics, and the value network. In: Research Policy vol. 24, Nr. 2, pp. 233–257, 1995.
- [DiVe14] DIHK - Deutscher Industrie- und Handelskammertag; VEA - Bundesverband der Energie-Abnehmer e.V.: Faktenpapier Eigenerzeugung von Strom, 2014.
- [DiVo15] Dilger, M.; Voigt, K.-I.: Analyse des Geschäftsmodellwandels im Zuge der Digitalisierung der Wertschöpfungskette Energie hin zu einem Smart Energy Systems ( Nr. 2), 2015.
- [Dole16] Doleski, O. D.: Utility 4.0, essentials, Springer, Wiesbaden, 2016.
- [Döri15] Döring, S.: Energieerzeugung nach Novellierung des EEG, Springer, Berlin, Heidelberg, 2015.
- [FHSW02] Figge, F. et al.: The Sustainability Balanced Scorecard - linking sustainability management to business strategy. In: Business Strategy and the Environment vol. 11, Nr. 5, pp. 269–284, 2002.
- [Flyv06] Flyvbjerg, B.: Five Misunderstandings About Case-Study Research. In: Qualitative Inquiry vol. 12, Nr. 2, pp. 219–245, 2006.
- [Giro09] Giroti, T.: Integration Roadmap for Smart Grid: From Accidental Architecture to Smart Grid Architecture. In: Proceedings of the Grid-Interop 2009, 2009.
- [GoAk01] Gordijn, J.; Akkermans, H.: e3-value : Design and Evaluation of e-Business Models. In: IEEE Intelligent Systems vol. 16, pp. 11–17, 2001.
- [Gord02] Gordijn, J.: Value-based requirements Engineering: Exploring innovatie e-commerce ideas., Vrije Universiteit Amsterdam, 2002.
- [GrSa01] Van Grembergen, W.; Saull, R.: Aligning business and information technology through the balanced scorecard at a major Canadian financial group: its status measured with an IT BSC maturity model. In: Proceedings of the 34th Annual Hawaii International Conference on System Sciences. vol. 0 : IEEE Comput. Soc, p. 10, 2001.
- [Hans12] Hanschke, I.: Enterprise-Architecture-Management - einfach und effektiv: ein praktischer Leitfaden für die Einführung des EAM, Hanser, 2012.

- [Hert16] Hertweck, D.: Methoden zur Entwicklung digitaler Serviceinnovationen. In: Lang, M. (ed.): CIO-Handbuch. Strategien für die digitale Transformation : Symposium Publishing GmbH. Düsseldorf, pp. 241–284, 2016.
- [HRSM14] Hauder, M. et al.: Agile Enterprise Architecture Management: An Analysis on the Application of Agile Principles. In: 4th International Symposium on Business Modeling and Software Design, 2014.
- [Hubb16] Hubbuch, M.: Energy Management in Public Organisations. In: Nielsen, S. B. ; Jensen, P. A. (eds.): Research papers for EuroFM's 15th research symposium at EFMC2016 : Kgs. Lyngby: Polyteknisk Boghandel og Forlag., pp. 172–184, 2016.
- [HuHu07] Huang, C. D.; Hu, Q.: Achieving IT-Business Strategic Alignment via Enterprise-Wide Implementation of Balanced Scorecards. In: Information Systems Management vol. 24, Nr. 2, pp. 173–184., 2007.
- [KaGT04] Kartseva, V.; Gordijn, J.; Tan, Y.-H.: Value-Based Business Modelling for Network Organizations : Lessons Learned From the Electricity Sector. In: ECIS 2004, 2004.
- [KaNo92] Kaplan, R. S.; Norton, D. P.: The balanced scorecard: Measures that drive performance. In: Harvard Business Review vol. 70, Nr. 1, pp. 71–79, 1992.
- [KaNo96] Kaplan, R. S.; Norton, D. P.: Using the Balanced Scorecard as a Strategic Management System. In: Harvard Business Review vol. 74, Nr. 1, pp. 75–85, 1996.
- [Krcm11] Krcmar, H.: Business Model Research - State of the Art and Research Agenda, München, 2011.
- [KüHK15] Küller, P.; Hertweck, D.; Krcmar, H.: Energiegenossenschaften - Geschäftsmodelle und Wertschöpfungsnetzwerke. In: Zimmermann, A. ; Rossmann, A. (eds.): Digital Enterprise Computing 2015 (LNI) : Gesellschaft für Informatik. Böblingen, Bonn, pp. 15–26, 2015.
- [Lank13] Lankhorst, M.: Enterprise Architecture at Work, The Enterprise Engineering Series, Springer, Berlin, Heidelberg, 2013.
- [Laue16] Laue, H.: Die Umwelt geht vor. Solarpark, Ökogas & Co. - Ensinger Mineral-Heilquellen wirtschaften nachhaltig. In: Die Getränkeindustrie vol. 2, pp. 16–18., 2016.
- [MaPi13] Manthey, C.; Pietsch, T. ; Marx Gómez, J. ; Lang, C. ; Wohlgemuth, V. (eds.): IT-gestütztes Ressourcen- und Energiemanagement, Springer, Berlin, Heidelberg, 2013.
- [Moor96] Moore, J. F.: The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems, HarperCollins, New York, 1996.
- [Natu15] Natural Resources Canada: Energy Management Best Practices Guide.
- [Open16] The Open Group: ArchiMate 3.0 Specification, p. 181, 2016.
- [PeRy06] Peppard, J.; Rylander, A.: From Value Chain to Value Network.: Insights for Mobile Operators. In: European Management Journal vol. 24, Nr. 2–3, pp. 128–141, 2006.
- [Posc11] Posch, W.: Ganzheitliches Energiemanagement für Industriebetriebe. vol. 1, Gabler, Wiesbaden, 2011.

- [RaAB11] Razavi, M.; Aliee, F. S.; Badie, K.: An AHP-based approach toward enterprise architecture analysis based on enterprise architecture quality attributes. In: Knowledge and Information Systems vol. 28, Nr. 2, pp. 449–472., 2011.
- [Reht15] Rehtanz, C.: Energie 4.0 – Die Zukunft des elektrischen Energiesystems durch Digitalisierung. In: Informatik-Spektrum vol. 38, Nr. 1, pp. 16–21, 2015.
- [Usde17] U.S. Departement of Energy: Federal Sustainability/Energy Scorecard Goals. .
- [USDT13] Uslar, M. et al.: Standardization in Smart Grids, Power Systems. vol. 71, Springer, Berlin, Heidelberg, 2013.
- [ViOS16] Vieira, R.; ODwyer, B.; Schneider, R.: Aligning Strategy and Performance Management Systems: The Case of the Wind-Farm Industry. In: Organization & Environment, pp. 1–24, 2016.