Business model development and business ecosystem evaluation in the energy domain

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Abstract. *The energy turnaround, digitalization and decreasing revenues forces enterprises in the energy domain to develop new business models. Following a Design Science Research approach, we showed in two action research projects that businesses models in the energy domain result in complex ecosystems with multiple actors. Additionally, we identified that municipal utilities have problems with the systematic development of business models. In order to solve the problem, we captured together with the partners of the enterprises the requirements in a second phase. Further we developed a method which consist of the following components: Method for the creative development of a new business model in form of a Business Model Canvas (BMC). A mapping between the e3Value ontology and the BMC for modelling a business ecosystem. The Business Model Configurator (BMConfig) prototype for modelling and simulating the e3Value-Ontology. The Business model can be quantified and analyzed for its viability. We demonstrate the feasibility of our approach in business model of a power community.*

Keywords. Business ecosystem, e3Value, BMC, energy turnaround, BMConfig.

1 Introduction

As a result of the energy turnaround, digitization, the growth of renewable energies and dynamic markets, companies in the energy domain must adapt their business models to the new market conditions. Electricity or gas is not an emotional product, so, it is difficult to establish customer relationships and attract customers with another purchase criterion than price. Internet comparison portals enable customers of energy suppliers to switch their electricity or gas provider in a few minutes. In this context, business models must be developed that go beyond the sale of electricity and/or gas to tackle the high fluctuation of customers and generate constant revenues. The development of business models often takes place in innovation workshops. Methods such as design thinking or value proposition design (Osterwalder et al., 2014) are used. For conceptualizing, visualizing and structuring business models the business model canvas (BMC) (Osterwalder et al., 2010) is a well-established method in science and practice today. Many municipal utilities lack expertise in systematic customer-centric business model development (Meyer et al., 2021). Additionally, the business models, especially in the context of renewable energies are often based on complex energy systems, which is built on a different logic than centralized large-scale power plants. A number of authors in the scientific discourse and our experience in different case studies showed, that business models in the energy domain are realized as an ecosystem, and it is essential to examine one's own value chain and investigate the integration of new actors to enhance or develop a new value proposition (Bocken et al., 2014; Breuer & Lüdeke-Freund, 2014; Hellström et al., 2015; Küller et al., 2015). An isolated view of the business model, for instance in form of a BMC in the renewable energy domain is not enough. Therefore, the business ecosystem (BE) approach could be a suitable method to analyze the business models and gain a more profound understanding about their function. Moore (1996) defines a business ecosystem as: "economic community supported by a foundation of interacting organizations and individuals-the organisms of the business world." The energy system must not be reduced to its technical components alone. The term "energy system" must be understood in a broader way that includes raw materials, resources, technologies, economics, society, and law.

Thus, viewing after the systematic development of a new business model energy system business models need to be evaluated in their ecosystem. Evaluations about the possible outcomes of the proposed business model help to generate the needed information to reduce uncertainty and manage business model risks (Thompson & MacMillan, 2010). At the end of a business model innovation workshop, the question often arises as to how the creatively developed business model solutions visualized using the BMC can be transferred into more formalized methods that can be evaluated from a business management perspective.

This paper aims to develop an artefact for the development of business models in the domain of renewable energies and validate them for their economic viability in a business ecosystem setting. Following the proposed Design Science Research (DSR) method described by Johannesson and Perjons (2014) the following research question has been formulated: *What are the components of an integrated method for transforming business models into business ecosystems and evaluate their economic* viability*?*

The remainder of the paper is organized as followed. First, we give a short overview of the DSR methodology, followed by describing our research method. In Section three we explain the problem, in section four the capture of the requirements for our developed artefact. In section five we give an overview of the components and functionality of the developed artefact and section six we demonstrate its feasibility. In the last section we summarize the main findings and discuss future research.

2 Methodology

Design Science Research (DSR) (Hevner et al., 2004) is a design-oriented research paradigm. The aim is to develop a solution in the form of artefacts based on an identified practical problem, which can then be systematically evaluated. The energy domain is facing an on-going change with a wide variety of external drivers. Therefore, a problem focused iterative methodology like the DSR is a valid research approach. It is a widely accepted research paradigm in the field of business informatics. A valuable contribution to the application of DSR is given by Hevner et al, through their conceptual framework and guidelines. However, their developed framework and explanations are very abstract. Johannesson and Perjons (2014) provide a detailed approach for the concretization of the explanations of Hevner et al. in the form of a method. This method consists of the following five activities: Explicate Problem, Define Requirements, Design and Develop Artefact, Demonstrate Artefact and Evaluate Artefact. Within DSR, it has become well established to identify four types of artefacts: constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices) and instantiations (implemented prototypical systems) (Johannesson and Perjons, 2014, Hevner et al., 2004). Depending on the research project, several types of artefacts may occur in combination.

The paper at hand is part of a larger design science research project and serves as a validation of our approach to construct an artefact for a concrete problem. Following the DSR approach described by (Johannesson and Perjons, 2014), the first two activities are Explicate Problem and Define Requirements. Explicate Problem is about answering the following question: *What is the problem that some stakeholders in practice experience and why is it important?* While Define Requirements focuses on: *What artefact can be a solution for the explicated problem and which requirements on this artefact are important for the stakeholders?*

Both questions were answered in two action research projects (Baskerville, 1999). In the first project three case studies were conducted in a broad research project, which focused on decentralized and flexible solutions for future energy production and distribution with seven universities and one non-university partner. In our second action research project we analyzed, developed and tested business models for municipal utilities in rural areas for economic viability. A university partner and two municipal utilities were involved. For both research projects, we used three data collection methods for case study research to increase construct validity and reliability (Yin, 2009): semi-structured interviews, participating observation, and document study.

The third activity of the DSR framework is Design and Develop Artefact, which creates an artefact that addresses the explicated problem and fulfils the defined requirements. In order to develop an artefact, we needed an integrated approach that supports the systematic development of new business models on the one hand and the modeling and simulation of business ecosystems with different business cases on the other hand. We conducted a literature and web search to identify different approaches to develop business models, analyze, simulate, and verify the economic viability of a business ecosystem and how to combine the two approaches. As additional research method we used prototyping to analyze and test intermediate implemented states of our prototype.

In the fourth activity, “Demonstrate Artefact”, we applied our developed artefact to the identified problems in our action research projects. Thereby, the design is strongly related the demonstration takes place in several stages, which allowed a stepwise validation of the approach and the identification of new problems. The results extend the own experience and serve for discussions with partners. The last step of the DSR method Evaluate Artefact has not yet been carried out.

3 Explicate Problem

Following the DSR approach described by (Johannesson and Perjons, 2014), the first activity is Explicate Problem.

The energy turnaround in Germany and the digitalization means a radical technical change from centralized to decentralized energy production and from a central distribution model to the Smart Grid. The long-established structures of energy production in large plants and conventional distribution networks which allowed stable economies of scale and low unit costs are over (Doleski, 2014). Drivers such as technological progress in energy generation, storage or control, but also organizational and cultural change through re-municipalization, strong citizen participation or the development of consumers into prosumers, have massively changed the face of the energy industry in the course of the energy turnaround. In this context, energy suppliers are facing a variety of challenges. (i) Increasing numbers of actors are entering the market to offer products and services along the energy value chain. (ii) As a result of the increase of renewable energies in the energy mix, revenues from many energy supplies are decreasing (Frantzis et al., 2008). (iii) Internet comparison portals enable customers of energy suppliers to switch their electricity or gas provider in a few minutes (Meyer et al., 2021). Additionally, electricity or gas is not an emotional product, as a result, it is becoming increasingly difficult to establish customer relationships and attract customers with another purchase criterion than price. (iv) The constantly changing legal framework makes the implementation of new business models difficult due to the lack of long-term planning security (Engelken et al., 2016). (v) The growth of renewable energies and new technologies creates new business model opportunities. However, the mindset and the skills of many employees of utilities are a barrier to dealing with new technologies (Meyer et al., 2021). (vi) Increasing customer demands e.g., for innovative and renewable value (Valocchi et al., 2014). These and other factors have a crucial impact on the profit of utilities and threaten their existence. From an ecological perspective, it is essential to develop new business models in the energy domain. Only through the right economic stimulation, the energy turnaround can be successfully implemented and thus make a valuable contribution to achieving the 2°C target set in the Paris Climate Agreement (*The Paris Agreement*, 2015).

We (Fauser et al., 2019) examined three different energy business models in a larger action research projects in the domain of renewable energy. We discovered that energy systems cannot be reduced only to their technical components. The concept of the "energy system" must be understood in a broader form, including raw materials, resources, technologies, economy, society and law. Another issue discussed with the case study partners is the economic viability of the energy system business model. Due to the complexity of multiple actors involved in the business model and the governmental regulation and subsidies, the calculation of different scenarios to determine the best economic value of the business model is difficult. The scientific literature also states the fact that distributed energy systems rely on a very different logic compared to large-scale centralized power plants (Magnusson et al., 2005; Mirata et al., 2005; Richter, 2012), imply a need for considering the underpinning business models. The development of business models in the renewable energy domain often requires a broader and systemic perspective (Hellström et al., 2015). Serval scholars discuss that a BM in the energy domain will be established as an ecosystem, thereby it is also necessary to investigate how actors integrate their own value chain with those of others (Bocken et al., 2014; Breuer and Lüdeke-Freund, 2014; Hellström et al., 2015; Küller, Hertweck and Krcmar, 2015). An investigation of isolated BMs is not enough in the domain of renewable energy. Therefore, the business ecosystem approach could be suitable to understand their business. We identified the following problems:

In our second action research project, we wanted to examine our developed artefact (BMConfig) (Fauser et al., 2019), which we developed in the three previous mentioned case studies in a larger action research project, for modeling, analysis and simulation of different business cases in a business ecosystem setting. The aim of this project was to develop business models for municipal utilities in rural areas and to test them for their economic viability. A municipal utility is a company that is usually majority-owned by the municipality and mainly provides services of public interest. One of the municipal utilities has 350 employees and provides the following services to their customers: Electricity, gas, district heating, drinking water and wastewater management. In addition, the company operates several parking garages and parking lots in the city area as well as the thermal baths, the city indoor swimming pool and the three outdoor baths. The second municipal utility in our project also focuses on energy, heat and water supply and the operation of a parking garage and it has 50 employees. The first problem we identified was that the participating municipal utilities have limited or no methodological knowledge for the systematic development of new business models. This relates to an interview study we conducted, that energy suppliers have a lack of competencies in the IT area and around the systematic business model development of customer-centric business models (Meyer et al., 2021).

For the systematic development of the business models, which should be developed from the perspective of a focal actor. We conducted a business model innovation workshop for the initial development of a business idea and the conceptualization of a business model. In the next step, we developed a method how we can transfer the creatively developed business model solutions visualized using the BMC into a more formalized methods that can be evaluated from a business management perspective. According to Osterwalder et al. (2010) or Wirtz (2016) managers evaluated feasibility and profitability of the proposed BMI, before implementing it. Based on the state-of-the-art research on distributed energy systems (Funcke & Bauknecht, 2016), but especially on the previous mentioned case studies, we showed that business models in the renewable energy domain are mostly realized in the form of a complex business ecosystem (Koppenhoefer et al., 2017, 2018). Therefore, a description in the representation of a BMC is not sufficient to develop a holistic understanding about the business model.

In the first action research project and the state of the art we were able to show that business models in the energy domain are mostly based on a business ecosystem. The business ecosystem must be visualized for analysis and to ensure the understanding of all stakeholders involved. We derived the problems 1-3 from the three different case studies.

- Problem 1: The multiple actor's structure of the business model ecosystems and their graphical visualization.
- Problem 2: The relationships between the actors and their value exchanges need to be transparent to fully understand the business model.
- Problem 3: Determination and comparison of the economic viability of various specifications of the energy system business model.
- We identified the following problems in our second research project business models for municipal utilities in rural areas.
- Problem 4: Systematic business model development. The municipal utilities have problems with the systematic development of customer-centric business models. At the same time, the municipal utilities were not familiar with methods such as VPC or, in some cases, BMC.
- Problem 5: Form a business model to a business case. From the representation of a business model in the form of a BMC, a variety of different variants of the business model can be implemented. The question arises how different business cases can be calculated for a business model and which components must be considered.

4 Define Requirements

The second activity defines the requirements. First, the artefact is outlined. This means deciding upon the type of artefact and its basic characteristics. Due to the high number of different identified problems in both research projects, which makes it difficult to transfer into an integrated approach, for instance a model or an instantiation. In our opinion an artifact as a method addresses the identified problems the most. According to (Johannesson & Perjons, 2014) a method defines guidelines and processes for how to solve problems and achieve certain goals. A Method can describe how an artifact is created. Its contains a collection of procedures, which are based on concepts and whose results are represented by a notation (Goldkuhl, 1997) The combination of procedures, concepts and notation forms a method component. Thus, the individual method components are linked in a meaningful way and it is possible to enrich the different activities of the method with models, instances or methods that lead to the achievement of a certain goal. In our case the individual method components should reflect the analysis, ideation and design process for the creation of an initial business model, a mapping between the BMC to transfer into our artefact BMConfig for modelling and simulating business ecosystem different business cases.

In conclusion, this argumentation leads to the following research goal, which is to be addressed through the following conception of the artefact:

Support for the development of new business models and modelling and evaluation of business ecosystems in the energy domain and their economic viability.

Based on the research objective and the underlying identified problems, the next step is to derive requirements for the artefact. The requirements of the artefact were derived from the case studies. We carried out interviews with the involved stakeholders in each case study. That result in a list of requirements, which should be addressed by the artefact.

- Systematic approach for the development of customer centric business models.
- Transformation guidelines from BMC to a business ecosystem approach.
- Graphical visualization of the network.
- Presentation of value-related exchange relationships between the actors.
- Good/easy understandable for non-domain experts.
- Possibility to model elements of value networks: tangible and intangible value flows, processes, resources, organizations (multiple actors).
- Calculation of different business cases.
- Presentation of multiple business models.
- Presentation of the results of the simulation.

5 Design and Develop Artefact

The third activity was to design and develop the outlined artefact.

Figure 1 summarizes our method and its individual components. First, the DIGITRANS method (*Digitrans*, 2018) for a systematic business model business model innovation is described. In the next step, the BMC is transformed into a business ecosystem using a mapping process. Then a quantification of the model with costs, prices quantities and a time specification for how many years/months the ecosystem is to be simulated is carried out. By simulating and analyzing the individual business cases, a validation of the business proposal can be carried out. The individual components of the method are described below.

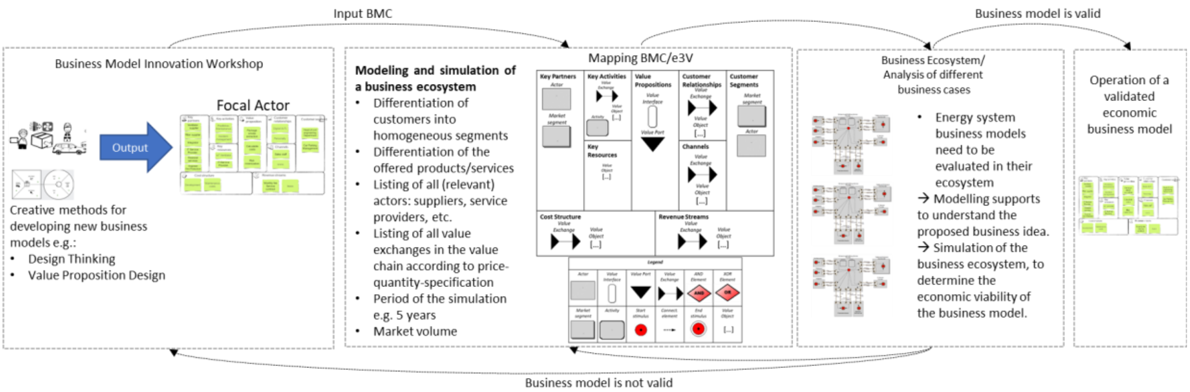

Figure 1. Method integration for the transfer and evaluation of business models in business ecosystems

The business model development process supports the systematic design of the creative process to develop a new business model(Jonda, 2004; Köster, 2014). Wirtz & Daiser (2018) conducted a systematic literature review of business model innovation processes and derived seven generic BMI process steps: Analysis, Ideation, Feasibility, Prototyping, Decision making, Implementation, and Sustainability. In most cases, the development of business models does not follow a linear process, but it is instead continuous adaptation.

In our method we used the DIGITRANS method (*Digitrans*, 2018), which supports the development of business models for SMEs. The method is divided into the innovation and transformation phase. The innovation phase focuses on developing of a new digital business idea, while the transformation phase is addressing the sustainable implementation and realization of the new digital business model in the company's overall organization. The conceptual design and development of the business models takes place in the innovation phase. The transformation processes were only conceptually elaborated in the Digitrans project, but not empirically validated. So, we only used the innovation phase for our method. The Digitrans innovation phase addresses many of the aspects identified by (Wirtz & Daiser, 2018). The innovation phase is divided into two sub-phases analysis and design. The team for the development of the new business model should consist of cross-functional employees of the company. In the analysis phase the environment and strategy of the enterprise involved is analyzed to identify potentials or market trends. A different aspect of the analysis phase is to build empathy to understand the customer, which is crucial to a customer-centric business model development method. This allows to set aside different assumptions form the team members and to gain insights into the customers' situation. The new developed value proposition should add value for the customer. Potential customers can also be integrated into the development process at an early stage. In the design phase the whole ideation process starts based on the findings form the analysis phase. The new developed ideas should reflect the customer needs. Thereby the whole process is supported by different methods testing, feedback loops, mockups and other methods to encourage the team members to think out of the box. As well the iterative working processes will form an integral part of this phase on the way to improve or modify the business model. After having completed the whole innovation phase a new business model conceptualized in form of a BMC is outlined.

The next step of the method is to transfer the developed business model, which is documented in the form of a BMC, into a business ecosystem. To model and simulate the business ecosystem, we use our own prototype BMConfig, which is based on the e3Value method (Gordijn, 2002) and enables the modelling of value networks or BEs and addresses many of the identified requirements in Chapter 4. In the BMConfig one or more business ideas are realized by a network of actors that jointly create, distribute, and consume value in the context of cross-organizational business models. Thereby it stands for an approach to discuss innovative business ideas and explore their environment with the aim of making a statement about the profitability of a value network or BE. In an initial literature and internet research, we identified that the e3Value-ontology were used in different scientific contribution to model value networks in the energy domain (Kartseva et al., 2004; Koppenhoefer et al., 2018; Küller et al., 2015). A value network is a network of organizations that form a value creation system in which suppliers, partners and customers collaborate to create value (Peppard & Rylander, 2006). The BE approach goes beyond value networks and includes actors who are not directly involved in value creation process (Iansiti & Levien, 2004). Therefore, the BE approach appears to meet the requirements in the energy domain much better.

Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
• Community solution provider and photovoltaic installer • Grid Operator • Marketing agency • Battery supplier	• Sales • Marketing • Customer Relationship Management **Key Resources** • Virtual power plant • CRM • Sales personnel • Energy management system • Customer App • Account system • Sales guide • IT infrastructure	• Regional Community Electricity • Electricity sharing • Own power optimization • Customer App • Battery • PV system • Part of the energy transition • Virtual power plant • Fixed compensation for power feed-in • Sector coupling	• Consulting • Self-Service • Energy Community **Channels** • Homepage • App • Flyer • Events	• Homeowner without PV system and storage

Cost Structure	Revenue Streams
• Provider Community Solution FrontUp 29.000 € • Licenses 6.000 € • PV systems • Storage • Sales	• PV plant • Battery • Service fee • Residual power supply Fee

Figure 2. BMC Power Community

Figure 1 shows the individual concepts of the e3Value ontology. The basic elements of e3Value are defined as follows: The Actor is defined as an independent economic entity. A Market Segment is a generalization of an Actor and groups several Actors with similar characteristics. A Value Activity is an operational activity whose execution serves to generate value. It is intended to illustrate transparency about operations within an Actor. Value Ports enable the offering or consumption of value objects. A Value Interface summarizes the exchange of values. For each offer of value objects to the environment, it also contains an adequate reception, so that trade between the actors is created. The value ports are a part of the value interface. Value Exchanges connect two Value Ports for the transfer of values between two actors. Value Objects illustrate which values are exchanged via the Value Exchanges. These are, for example, goods, services or money, whereby a Value Object must represent a value for one or more actors. Scenarios are used to calculate different business cases of the business model. For this purpose, value interfaces are linked via connection elements. A start stimulus marks the beginning of a scenario. The end is represented by an associated stop stimulus. AND/OR operators enable the mapping of logical operations for a scenario and thus the possibility to represent several business models in one business ecosystem.

A mapping between the e3Value-ontology and the BMC is shown in Figure 1. This builds on the prior work of Gordijn et al. (2005) and Caetano et al. (2017). Jaap Gordijn the developer of the e3Value ontologies and Alexander Osterwalder and Pigneuer the authors of the Business Model Ontology (BMO) and the BMC, compare in (Gordijn, Osterwalder and Pigneur, 2005) the BMO and the e3Value-ontology. Similarities, differences and integration possibilities between the two ontologies were analyzed. This should improve the representation, design and analysis of business models. Caetano et al. (2017) uses the approach of (Gordijn, Osterwalder and Pigneur, 2005) and transfers it to the BMC.

The two concepts of the BMC Customer Segment and Key Partners can be translated 1:1 into an e3Value model. For modelling either Actors or Market Segments can be used. The concept Key Activities are the central activities a company has to perform to deliver the Value Proposition. This can be represented in e3Value by a Value Activity, which an actor performs to increase its value, or by Value Exchanges containing Value Objects, which represent the procurement of required resources from a Key Partner. A Key Resource is represented by a Value Object in e3Value, which is acquired from a Key Partner. The Value Proposition is the value that a company offers to its customers. In e3Value the Value Proposition is represented by a Value Interface and the corresponding Value Ports. The Customer Relationships and Channels are represented by Value Exchanges and Value Objects. Revenue Streams and Cost Streams are related to the Value Exchanges and Value Objects and have to be provided with price and quantity accordingly.

The BMC allows a business model to be represented at a higher level of granularity, taking a more strategic perspective (Caetano et al. 2017). Using the BMConfig, a modelling which is closer to the actual operationalization of the business is enabled. Therefore, when transforming a BMC to the e3Value model, additional information about the business

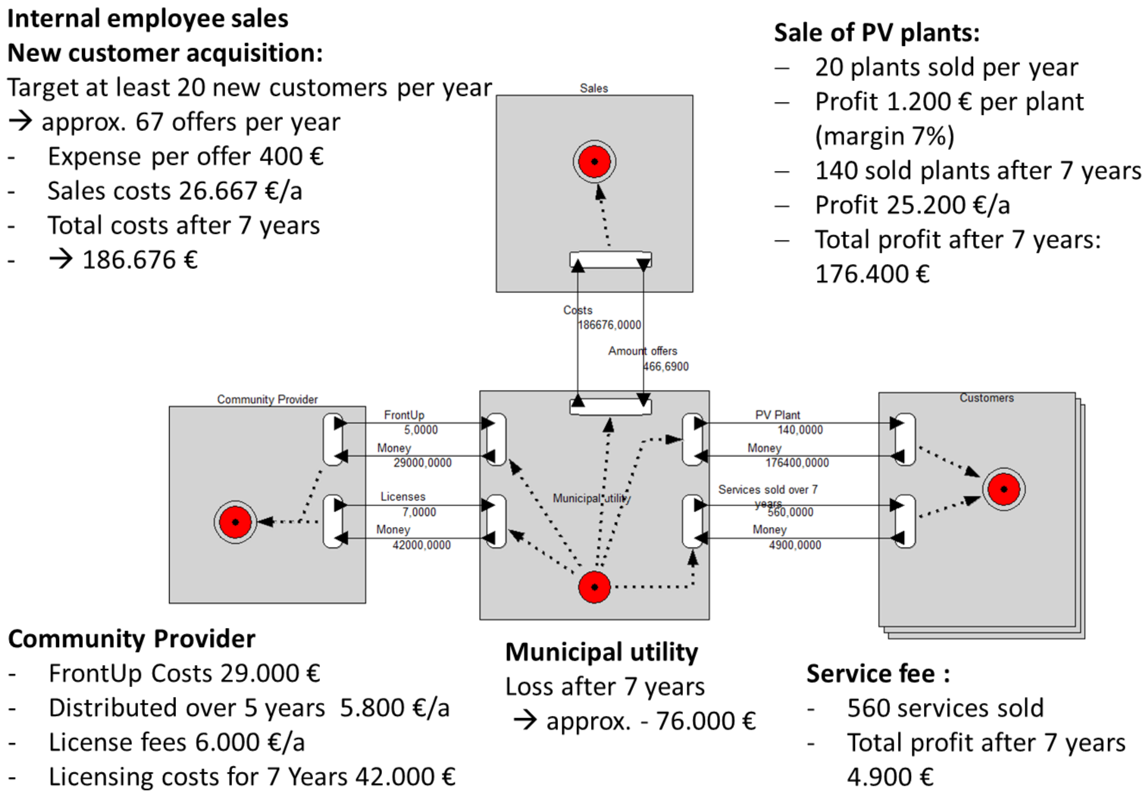

Figure 3. e3Value-Modell: Power Community

model is needed. The transformation of the BMC into an e3Value ontology enables an analysis based on the BE approach and, through simulation, an investigation of the economic viability of the business model.

6 Demonstrate Artefact

In the activity Demonstrate Artefact, the developed Mapping is demonstrated on a case, thereby proving its feasibility (Johannesson and Perjons, 2014).

Using the presented mapping, the developed BMC was transferred into a e3Value modeling in the BMConfig. The power community offer of a company was considered, which was designed as a white label business model especially for the clientele "rural municipal utilities". The BMC for this is shown in figure 2. The provider of the electricity community solution supplies the municipal utilities with a white-label product with its own app, a module for optimizing in-house consumption of electricity from photovoltaic plants and the components for setting up their own electricity community. For the transfer, the BE is modeled from a company's point of view with a specific value proposition. In the first step, the customers and key partners from the BMC were transferred to the e3Value model. Afterwards, we discussed which actors are related and which values they exchange. For this purpose, the Value Exchanges and Value Objects were defined. Through the fine-granular modeling, additional actors and exchange relations were identified, which enable an even more realistic business scenario. For the simulation, costs and prices of the individual services were defined. In addition, the market volume, sales volumes and the desired duration with which the business model should be simulated were determined. Figure 3 shows a simplified model of the power community. The largest cost driver in this business model is photovoltaic plant sales. As a result, a simplified business model was modeled and simulated for an initial analysis and for presentation purposes. The sales department is modeled as an independent actor for a better overview. The business model is simulated for a period of seven years. For the acquisition of 20 new customers per year, the municipal utilities calculate that approximately 67 offers have to be written. The expenses per offer are approximately 400 €. The front-up costs for the solutions are amortized over five years. License costs totaling 42,000 € will be generated over the seven years. 140 PV systems and 560 services are sold over the seven years. The business case examined shows a loss of approximately 76,000 € after seven years.

The transfer of the business model into the BMConfig makes it possible to compare the representation of different specifications of the business model and thereby to reflect on design decisions and to identify relevant components for the further implementation of the business model. New insights are gained through the concretization of various parameters and regarding the simulation. In the context of the electricity community business model, the following three key barriers were identified, through the modeling and simulation and the resulting discussion: the high distribution costs, the higher price for PV plants compared to the competition, and the low scaling due to the regional roots of the municipal utilities. The analysis shows that selling PV systems is uneconomical for the municipal utilities at the current point in time and that further investigations are necessary.

7 Conclusion

New business models are needed to realize the energy turnaround. As a result of decreasing revenues, digitization and new market entries, enterprises in the energy domain must develop new business models. In four investigated case studies, we identified 5 main challenges, which occurred by developing and analyzing an energy system business model and determine the economic viability. Thereby the stakeholders struggle to fully understand the business ecosystem there are part of. In addition, difficulties in the systematic development of new business models were identified. In order to address the identified problems and requirements, we outlined the artefact a method. We captured the following requirements in our action research projects. A method for systematic development of business model from scratch, the graphical modelling of the business ecosystem and the relations between the actors. Furthermore, the simulation of different business cases to identify the business model with the most economic value was essential to the stakeholders. We developed an artefact that addresses the identified problems and requirements and demonstrated its feasibility on a case study in the field of power community.

The validation and the identification of further requirements which should be addressed in our method is part of our future research with the aim to improve our artefact systematically.

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