Modelling and evaluating of business model ecosystems 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. Business models for renewable energy are compound on different logic than business models for larger scale power plants. Following a Design Science Research approach, we examined the business models of three enterprises in the energy domain in a first step. We identified that these business models result in complex ecosystems with multiple actors and difficult relationships between them. One cause is the fast changing and complicated state regulation in Germany. In order to solve the problem, we captured together with the partners of the enterprises the requirements in a second phase. Further we developed the prototype Business Model Configurator (BMConfig) based on the e3Value Ontology on the metamodelling platform ADOxx. We demonstrate the feasibility of our approach in business model of energy efficiency service based on smart meter data.*

Keywords. Business ecosystem, e3Value, ADOxx, energy turnaround, energy system business model, BMConfig.

1 Introduction

The traditional business model of electricity suppliers can be summarized as “guaranteed power supply for end-consumers” (Budde and Golovatchev, 2014). It is based on the typical value chain of the power industry, which is shaped by the central energy production of major centralized power plants. The transportation of the electrical power to end-consumers is provided via transmission and distribution networks and in conjunction with the billing and customer service marks the final element of the value chain (Lauterborn, 2013). The energy turnaround in Germany does not only mean a radical technical change from centralized to decentralized energy production and a central distribution model to the Smart Grid. New technologies make it possible to expand the classic power supply with additional products such as home automation, health services and electromobility. These new configurations in the Smart Market make completely new roles possible: specialists for energy production, network operation, smart metering, IT operation, financial service providers, mobility service providers. These players are combined to form new business models within a network of a wide variety of actors. Lange (2012) and several other authors point out the need of new BMs for the energy turnaround. Additionally, enterprises do not compete among individual companies but rather, among networks of interconnected enterprises (Peppard and Rylander, 2006). Such interconnected enterprises are compounded into an ecosystem and cannot be viewed on its own. Moore (1996) defines a business ecosystem as an “economic community supported by a foundation of interacting organizations and individuals—the organisms of the business world.” Business models in the energy domain are based on a multiplicity of actors and their complex relationships with each other which result in a highly complex and diverse system (Koppenhöfer, Fauser and Hertweck, 2017; Koppenhoefer, Fauser and Hertweck, 2018). Therefore, actors in the energy domain need to shift the innovation effort from the products or processes they control to the larger systems they are part of (Hellström *et al.*, 2015). Thus, viewing 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 and MacMillan, 2010). As in all BMs the economic viability is the key factor for realization of a proposed business idea.

This paper aims to develop an artefact to model and simulate business ecosystems in the energy domain. Following the proposed Design Science Research (DSR) method described by Johannesson and Perjons (2014) the following research question has been formulated:

How can actors in the energy domain be supported by modelling and evaluating business ecosystems?

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 and capture the requirements for our developed artefact. In section four we give an overview of the components and functionality of the developed artefact and 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 first 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 three case studies of a larger action research project (Baskerville, 1999). The 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. 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 conducted a literature and web search to identify different approaches to model an ecosystem. In the next step we verified, which approaches addressed the defined requirements. Following on the findings we developed the artefact. First, we created a metamodel based on an approach we had identified in the literature. Second, we implemented the model on a metamodeling platform.

In the fourth activity, Demonstrate Artefact, we applied our developed artefact on one of our three case studies to demonstrate its function and feasibility.

The last step of the DSR method Evaluate Artefact has not yet been carried out.

3 Business ecosystems in the energy domain

In our research project, we examined three different energy business models. For deriving the data we used three data collection methods to increase construct validity and reliability (Yin, 2009): semi-structured interviews, participating observation, document study.

The first case study we investigated, 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.

Many cities in Germany suffering from fine dust produced by industry and also to a considerable part by traffic. This condition plus the overall climate objectives in Germany require the development and realization of innovative mobility concepts. In our second case study, we analyzed a business model for a e-scooter sharing platform which is run by the municipal energy supplier. The aim was to identify relevant actors, how the business model works and to optimize the business model.

The major difference in contrast to traditional electrical meters is that smart meters are equipped with communication components, which make them more 'intelligent' than their predecessors. This intelligence enables a whole range of new applications. In our third case study, we investigated energy efficiency services based on smart meter data which can be offered by a municipal utility.

3.1 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 mean 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. Increasing numbers of actors are entering the market to offer products and services along the energy value chain. The growth of renewable energies and new technologies creates new business model opportunities. This forces many companies in the energy domain to develop new business models. These business models are often based on complex energy systems. The success of the initiated energy turnaround depends also to a large extent on the development of sustainable business models which, can succeed without government subsidies and which are able to sustain the transformation from their own economic strength. Yet, according to (Burger and Luke, 2017) the influence of regulation is greater than the influence of technology in the industry.

One of the business models we investigated was a corporate microgrid of an SME. 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 built up several energy generations sites in the past years to achieve this corporate vision but also faces high energy demands due to green houses and several catering facilities. The microgrid 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 ecosystem demonstrates the complexity of relationships between the actors and diverse systems. To analyze the existing problems of the case study we used the best practice energy management framework (Natural Resources Canada, 2015). The results showed three major gaps: multi-dimensionality, high complexity and multiple actors.

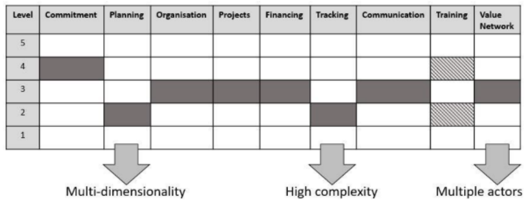

Figure 1 Overview of the ratings and resolving

In our e-scooter sharing case study, we analyzed the BM and the underlining business ecosystem. As a result of the increase of renewable energies in the energy mix, revenues from many energy supplies are decreasing (Frantzis *et al.*, 2008). Therefore, many municipal utilities must develop new business models. The e-scoter business model results in large ecosystem and consist of serval actors. The utility offers a e-scoter free-floating mobile service to the customers. Sharing models propose a means of transport while sharing the product instead of buying it. The Sharing model creates gains like parking everywhere and maintenance done by the provider and it relieves pains like dependency on location. The customer has to pay a registration fee and is charge for every ride. The payment processing is outsourced to an external service provider. The verification of the customers driver's license is also provided by an external service provider. The e-scooters are purchased directly from a manufacturer. To manage the e-scooter fleet a cloud application offered as Software as a Service is used form an external software provider. Another service provider is responsible for the maintenance, repair and replacement of the battery's services. To replace the batteries, the service provider has access to the "Fleet Management Software", which lists the e-scooter with critical battery charge. These batteries are then change at the location of the e-scooter. A call center supports the customer with any trouble 24/7. The utility pays an external call center service provider to provide this service. Customers use a smartphone app for renting an e-scooter. The mobile app is developed by an external software provider. The marketing for the business model is carried out by a marketing agency.

The third case study describes smart meter energy efficiency Services. Energy Efficiency Services business models extend the existing one by offering consulting services. These services are offered to the customer in order to support the increase of energy efficiency by providing energy reports or tips on energy saving based on the collected smart meter data (Von Roon *et al.*, 2013). Beyond these automated reports, personal consultation could be provided as added-value to households as well as business customers. This individual consulting service again puts the analyzed smart meter data to use in order to discover savings potential (Von Roon *et al.*, 2013; Zeller, 2014). From a financial perspective, the offered services open up new revenue streams which complement the existing ones (Zeller, 2014).

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.

In the findings of the case studies, 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.

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, Tell and Watson, 2005; Mirata, Nilsson and Kuisma, 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 stablished 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.

The first problem (i) we derive form the case studies is the multiple actor's structure of the business model ecosystems and their graphical visualization. (ii) the relationships between the actors and their value exchanges need to be transparent to fully understand the business model. (iii) determination and comparison of the economic viability of various specifications of the energy system business model.

3.2 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. We concluded involving the partners of the research project, that a possible solution to the problem can be the introduction of a software solution that provides the possibility to model and simulate an ecosystem. Thus, the artefact is a combination of the two artefact types model and instantiation. The model is in this case the basis for the working system (instantiation) (Johannesson and Perjons, 2014).

Modelling as the creation of purpose-oriented abstractions has a long tradition in business informatics (Frank *et al.*, 2014). Traditionally, modelling uses different qualitative and quantitative analysis methods to collect the relevant information. A model is a representation of a system, made of the composition of concepts which are used to help people know, understand, or simulate a subject the model represents. Simulation is an analysis method used in almost all scientific disciplines for the optimization of the planning. Thereby it is defined as mimicking or acting out an actual or probable real-life situation or condition to find a cause of a past occurrence or to predict future outcomes and impacts of assumed factors and scenario. The characteristics of a model and an instantiation help to solve the identified problems. The investigation of the practice showed the difficulties in explaining the business ecosystem and if the business model is profitable.

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 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.

- 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.

In addition to the definition of the requirements, it is important as well to show the underlying problem on which they were derived (Johannesson and Perjons, 2014). The classification of the requirements to the identified problems is shown in Table 1.

4 Business model configurator

4.1 Design and Develop Artefact

The third activity was to design and develop the outlined artefact. In an initial literature and internet

Table 1. Mapping requirements to problems

Problem	
Multiple actor	Graphical visualization of the network.
Value exchanges	Presentation of value-related exchange relationships between the actors.
Economic viability	Calculation of different business cases.
Multiple actor/ Value exchanges	Possibility to model elements of value networks: tangible and intangible value flows, processes, resources, organizations (multiple actors).
Multiple actor/ Value exchanges	Presentation of multiple business models.
Economic viability	Presentation of the results of the simulation.

research, we identified that the e3Value ontology were used in different scientific contribution to model value networks in the energy domain. Kartseva, Gordijn and Tan (2004) used the e3value-method to design a conceptual model of a value network for distributed energy generation in Spain. Küller, Hertweck and Krcmar (2015) describe a value network for regional energy cooperatives and smaller utilities using the e3Value method to illustrate the complexity of the relations in such a network. Koppenhoefer, Fauser and Hertweck (2018) describe a company microgrid based on a case study, using e3Value-method to visualize the complex value network. 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 and Rylander, 2006). The business ecosystem approach goes beyond value networks and includes actors who are not directly involved in value creation process (Iansiti and Levien, 2004). Therefore, the business ecosystem approach appears to meet the requirements in the energy domain much better.

The e3Value method is a modeling approach to include multiple actors (Gordijn, 2002). It enables the visual representation of value exchanges between value network actors by modeling their interactions. e3Value 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. Thus, the e3Value--model is a way to visualize complex business models in value networks with a focus on value exchanges. The main modelling objects are actor, market segment, value activity, value interface with associated value ports, value exchange and value object. With these elements it is possible to represent a value network. The actor is defined as an independent economic entity, with the ability to operate profitably or to increase its economic value. A market segment component is the generalization of an actor and combines several actors with similar characteristics. Value activities symbolize operational activities whose execution serves to increase value or to generate value. Value activities must always be assigned entirely to an actor. With the value port, an actor can offer value objects or display their consumption to others. The exchange of values is then modelled with a value interface. It also contains an adequate reception for each offer of value objects to the environment, so that a trade between actors is created. The value ports are part of the value interface. With the value exchanges, two value ports are connected to each other to exchange values. The already mentioned value objects are exchanged. These are, for example, goods, services or money, whereby a value object must represent a value for one or more actors. A start stimulus indicates the start of a scenario. The end is indicated by a stop stimulus. The scenario with its associated scenario path, which shows the required value exchanges, is represented by connection elements. An example is shown in Figure 1.

A first solution was developed by Gordjin with a prototype for modelling and simulating the e3Value ontology. However, the tool was not considered user-friendly from different stakeholders in our three case studies in terms of handling. For the adaptation of the tool and further developments and its limitations in integration with other modelling languages we developed an metamodel based on the proposed e3Value ontology and an algorithm for simulating ecosystems based on the open metamodeling platform ADOxx[1], using the ADOxx programming language ADOScript. In the first step we refined the requirements to an UML class diagram (Omg, 2017). We transferred the different concepts described by Gordijn in an UML class digramm and specified the relaitionships between the different classes. For defining the variables, we used an workshop approch including different stakeholders. Brainstorming tecniques where used to define the variables for the different classes. The two logical opertators XOR and AND were implemented for the representation of several business models, which are operated simulataneously. By double-clicking on a value interface in our artefact BMConfig, a user can enter values for a simulation. Fixed costs, variable costs, price and output quantity can be entered for the simulation. On this basis, the individual value interfaces in the business ecosystem are offset against each other. To simulate the ecosystem, individual scenarios can be defined through the ecosystem using

[1] https://www.adoxx.org/live/home

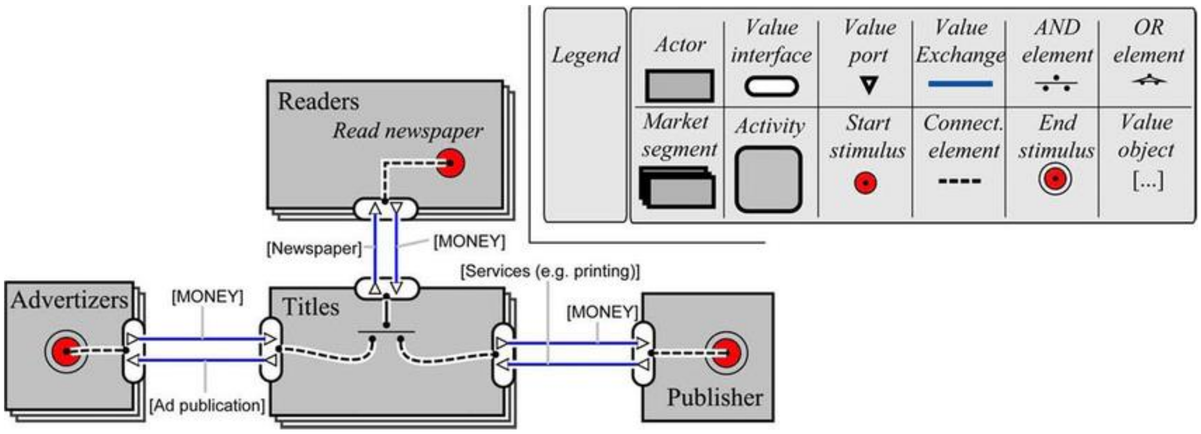

Figure 2. e3Value Metamodel

the scenario path concept. This enables the calculation of different business cases in an ecosystem. A scenario path connects a start event with a value interface via a connection element. A value interface can be connected to another value interface or an end event using a connection element. The individual paths considered in the simulation are highlighted. The results of the simulation can be viewed at the level of value exchanges, value interfaces and actors. The individual value interfaces are integrated into the overall result of an actor and calculated. This provides a complete overview of all revenues and costs of an actor and of the profitability of the business.

4.2 Demonstrate Artefact

In the activity Demonstrate Artefact, the developed BMConfig is demonstrated on a case, thereby proving its feasibility (Johannesson and Perjons, 2014). We demonstrate our artefact on the energy efficiency case study, which is described in chapter 2.1.

The modeling and the simulation of the case showed that it is more attractive for utilities to sell additional services in combination with a smart meter in which the customer saves energy than to sell only electrical energy to the customer. Through high taxes and fees for the sale of electrical energy, an energy utility earns about 1 - 4 cents per kWh. In Figure 3, a business model in the form of a business ecosystem is shown, in which the business model of energy efficiency services is represented. By offering energy efficiency services, an energy utility can generate a profit of up to €120 per year and thereby create real added value for a customer. It is often difficult to create real added value for a customer by just selling electrical energy. In order to provide the service, a smart meter is purchased from a manufacturer. The cost per Smart Meter for the utility is 80 €. The utility sells the Smart Meter for 100 € to the end customer and calculates costs of approximately 10 € for the installation of the smart meter. The utility thus generates a one-time profit of 10 € for the sale of a Smart Meter. For providing the energy efficiency services, an IT service provider is required who evaluates the load profiles and makes them available to the utility. The costs of the data analysis service are assumed with 20 €/a per household. The data are in the possession of the measurement point operator and must be purchased. Costs of 1 €/a for the purchase of the data per household are assumed. The energy savings achieved with a smart meter are around 15% per year. Thus, the end customer of an utility has saving of approximately 215 €/a. Thereby the customer is charged one-time costs of 100 € for the smart meter and annual costs of 120 €/a for the energy efficiency services. During the first year the end customer has a loss of 5 €. In the following years the customer has a saving of 95 €/a by a lower energy consumption. The utility generates a profit of 128.80 €/a in the first year with selling Smart Meter Services. A profit of 25.8 € is generated for the sale of electrical energy, 93 € for the sale of energy efficiency services and 10 € for selling a smart meter. In the following years with a static market, the annual profit per customer is 118.8 €/a.

5 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 three investigated case studies, three main challenges could be identified, which occurred by analysing the energy system business model and which determine the economic viability in the case studies. Thereby the stakeholders struggle to fully understand the business ecosystem there are part of.

In order to address the identified problems and requirements, we outlined the artefact in a combination of a model and an instantiation. We conducted interviews with the case study partners to capture the requirements. Thereby two main requirements were the graphical modelling of the business ecosystem and the relations between the actors. Furthermore, the simulation of different business cases to identify the

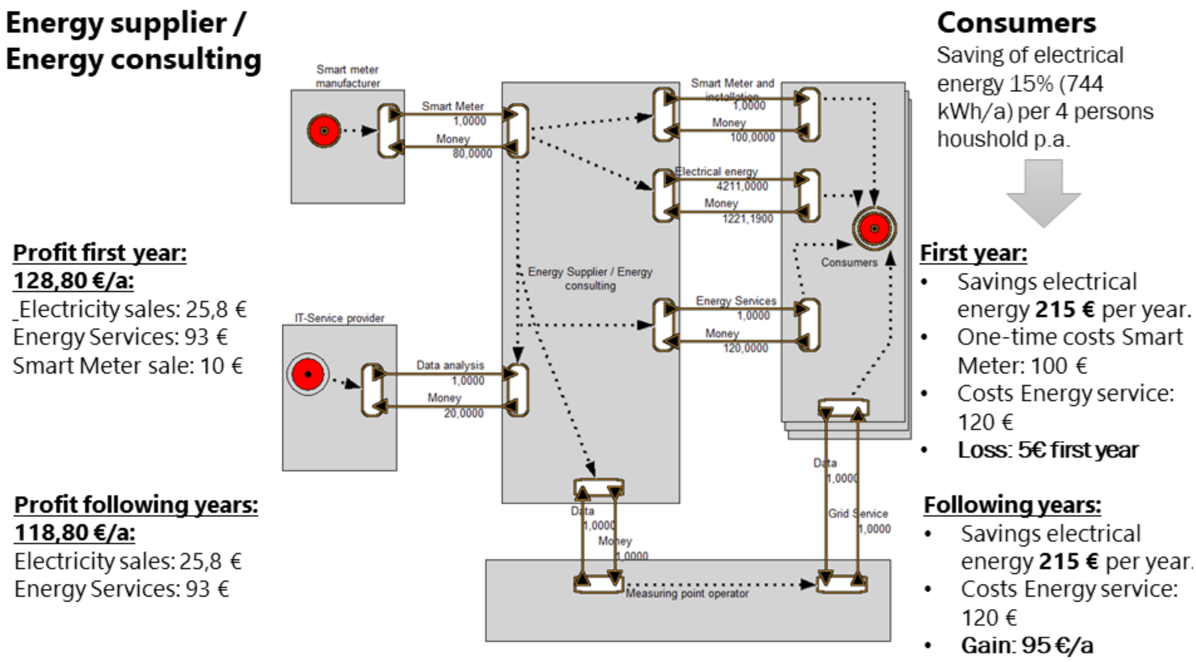

Figure 3. Smart meter business ecosystem

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 smart meter energy efficiency services.

The identification of further requirements which should be addressed in the BMConfig is part of our future research with the aim to improve our artefact systematically. This compounds as well on-going demonstrations of the BMConfig with other cases.

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