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Survey and classification of business models for the energy transformation

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- Energy transition and change of business models
- Classification of business models
- Business model framework for energy transition
- Value creation networks

Abstract: The energy transition is changing the structure of the energy sector in Germany. The current structure is analysed both empirically as well as theoretically. Based on an exhaustive survey of current business models, classical business model designs are reviewed, a new framework for the energy sector is developed and a classification of the more than 600 business models surveyed is carried out. The work represents the current status of the business models in the energy sector as no other.

Content

1 Introduction

The energy transition process requires a consequent implementation of energy efficiency as well as a fundamental shift of the energy supply to renewable, CO_2-neutral energies. In addition to the decarbonisation of energy production, this includes the tendency towards decentralised structures. Furthermore, the digitalisation of processes and industries has an increasing impact on the energy sector and new players entering the energy markets. The "classical" structures of the energy industry that emerged after the liberalisation of the electricity and gas markets (see Figure *1-1*), including established business models, are subject to massive changes.

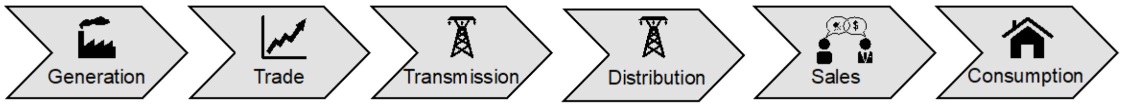

Figure 1-1: Classical value chain of the energy industry

Source: Own illustration

Separations and subsequent restructuring efforts of E.ON and RWE illustrate the displacement tendencies and disruptive processes in the energy industry. In order to analyse these structural changes in the business model landscape during the energy transition, a comprehensive empirical analysis is carried out. This includes both, business models and business model structures identified in practice as well as in research work. This includes some business models, which are expected in the future.

In the following, an overview of the current state of research on energy transformation related business models and the most common business model frameworks is given in Section 2. Using this as a basis, a proposal for an adjusted framework for the description of prototypical business models in the energy system transformation is developed in Section 3. This is followed by a brief description of the methodology used for the empirical (practical and theoretical) analysis. In Section 4 the results of this study are presented. Following on from this, a proposal is given for a categorisation of the identified prototypical business models. Then, the further development of the classical value chain architecture into value networks is elaborated by illustrating an exemplary environment around a business model. Concluding in Section 5, the core results are summarised and further research questions are identified.

The study answers the research question to what extent existing frameworks are appropriate for describing the current business models of the energy transition and if they need to further development. Based on these findings, the current structure of the business model landscape and respective value chains are presented by a detailed survey of business models. The results can be used for further analysis of existing business models and as basis for an individual economic quantification of business model (prototypes)[1]. On this methodical basis, detailed studies of business models can be prepared and developed into business plans.

2 Status Quo

The structures of the energy industry are constantly changing. However, liberalisation and energy system transformation have significantly increased the pace of change and have impacted the business model landscape substantially. In the following, the current business model frameworks for the systematisation of business models and current research on energy business models is presented.

[1] See chapter 3.4 for the definition of both terms.

2.1 Existing Business Model Systematisations

The term 'business model' describes a simplified abstraction of mechanisms of business activities used to generate profits. The use of the term has increased since the 1990s.[2] Various systematisations and analysis tools for business models exist:

The RCOV-Framework (Resources, Competences, Organisation, and Value(-Proposition)) by Demil and Lecoq (2010) analyses business models especially from a resource-based perspective and highlights value creation from internal structures.[3] The business model Canvas by Osterwalder and Pigneur (2013) provides a snapshot of a company and is used particularly for business model innovation due to its modular structure. In addition, it covers a very wide range of both internal and external aspects of a business model through open terms.[4] The Business Model Design by David Teece (2010), on the other hand, puts greater emphasis on the underlying technology, which explains its relevance to technology-driven business models.[5] Bieger and Reinhold (2011) complement Teece by considering the company's internal value distribution and the development concept for further improving the business model within the business model analysis framework. The framework is suitable for the description of cooperative and dynamic value creation.[6]

2.2 Research efforts for the adaptation of business model frameworks

A series of publications exist regarding the effects of energy system transformation and changing framework conditions on business models. The authors Provance et al. (2011) examine political and organisational factors influencing the business models of small electricity producers.[7] In a similar way, Doleski (2014) analyses the development and change of business models.[8] PWC (2016) investigates the expected impact of digitisation on existing energy business models.[9] Further studies analyse the influence of technologies on the development of the energy system transformation, e.g. Varone and Ferrari (2015).[10] The authors Burger and Luke (2017) use an empirical approach for the analysis of real business models. On the basis of 144 companies worldwide, they derive generic business models for photovoltaic applications, demand-side management and (thermal) energy storage.[11]

The focus of Löbbe and Hackbarth (2017) lies on individual prototypical business models of energy companies in the energy system transformation process.[12] Richter (2012) analyses business model prototypes for renewable energies in a comparable manner. The approach is related to utilities and the result shows a concrete need to adjust the existing business models to climate aspects.[13] To the same extent, Loock (2012) is developing generic business models for the use of renewable energies.[14] Strupeit and Palm (2016), on the other hand, focus specifically on strategies for business models of private and small scale photovoltaic users.[15] Okkonen and Suhonen (2010) elaborate production-side

[2] Bieger, Knyphausen-Aufseß and Krys 2011, 17–22
[3] Demil and Lecocq 2010, 234
[4] Osterwalder and Pigneur 2013, 20 ff.
[5] Teece 2010, 173 ff.
[6] Bieger, Knyphausen-Aufseß and Krys 2011, 32 f.
[7] Provance et al. 2011
[8] Doleski 2014
[9] PWC 2016
[10] Varone and Ferrari 2015
[11] Burger and Luke 2017
[12] Löbbe and Hackbarth 2017
[13] Richter 2012
[14] Loock 2012
[15] Strupeit and Palm 2016

business model types of the district heating sector[16] and the authors Jahnke et al. (2017) discuss decentralised combined heat and power applications combined with energy services.[17]

The research presented by Rodríguez-Molina et al (2014) analyses business models for smart grid applications on the prosumer level[18] and Giordano and Fulli (2011) identify business models within the smart grid value creation network.[19] Moreover, the study "Geschäftsmodelle 2020" by EY (2016) addresses the future development and changes of classical business models without classifying them.[20]

Other authors discuss business models of sector coupling. Abdelkafi et al. (2013) focus on the further development of generic business models in the context of rising e-mobility.[21] The authors Kasperk and Drauz (2013) develop basic business models for the electro-mobile value chain within the changing energy system.[22]

The literature research on business models includes various studies referring to individual, specific business models, technologies and use cases. The analysis is often based on known levels and activities within the classical value chain. Few cases give an overall view of the energy system or a systematic approach to the determination and derivation of theoretical business models.

The approach developed in this study is limited to a high-level evaluation of different business models which aligns with other studies including Löbbe and Hackbarth (2017), Strupeit and Palm (2016) or Okkonen and Suhonen (2010). Burger and Luke (2017) apply a comparable approach to the empirical classification of business models of this study. However, in contrast to the approach developed here, their study is only related to a sub-sector of the energy industry.

The literature analysis shows the predominant use of existing approaches to characterise business models. These take only partial into account the special features and structural breaks of the energy system in the context of decarbonisation, decentralisation and digitisation.

With this background, three central research gaps are addressed:

- Existing business model systematisations are not sufficient to characterise the business models of the energy system transformation.
- There is no exhaustive overview of currently existing energy business models.
- There is no adequate approach to describe the effects of the energy system transformation on the interactions between business models and the structure of the energy industry.

In order to provide a complete description of the characteristics of business models in the energy system transformation process and to address the relevant energy industry dimensions, an own business model framework is developed based on the existing business model frameworks. This business model framework for the energy industry (BMFE) closes the mentioned gaps.

[16] Okkonen and Suhonen 2010
[17] Jahnke, Monjau and Dziomba 2017
[18] Rodríguez-Molina et al. 2014
[19] Giordano and Fulli 2011
[20] EY 2016
[21] Abdelkafi, Makhotin and Posselt 2013
[22] Kasperk and Drauz 2013

3 Methods for identifying business models and their structure

Based on the identified research gaps, it is necessary to obtain a comprehensive picture of the current business models of the energy sector. For this purpose, business models are analysed by means of primary and secondary data collection. The authors classify the qualitative data of the currently realised business models into the logic of the BMFE, which is described in the following section, and transfer it into a generalised model.[23]

The aim of the analysis is to obtain an as complete as possible overview of business models without duplicates. A company with an obviously already surveyed business model will therefore not be further analysed.

The combination of theory-based and practice-based analysis, internal expert discussion and the use of at least two independent sources ensures that the bias of the individual evaluation is minimised.[24] This is particularly necessary when analysing new business models. These are not always completely defined and are subject to dynamic development.[25]

3.1 Development of the business model framework

The development of the BMFE builds on a synthesis of the conducted literature analysis. The formulation of generally valid and energy-related business model components enables the description of business models of the energy industry. The framework characterises the business models on the basis of the following components:

- The 'value proposition' describes the value a company generates for its clients.
- The 'customer segment' defines which customer groups are addressed by the value proposition.
- The 'revenue model' describes how cash flows are generated out of customer relationships.
- The 'utilised technology' describes the central technology(s) that support the competitive advantage of the company.
- The 'required and offered data' serve within the framework to show (non-)monetary valued data links.
- The 'influencing factors' describe energy-specific technology, politics and market aspects.
- The 'level in the energy value chain' allocates the business model within the elements of the classical value chain.
- The 'function in the value creation network' is based on the business model systematics of Osterwalder and Pigneur (2013) and shows common characteristics of companies.
- The 'required partners' describe the extent to which a business model depends on the existence or success of others business models.

This framework is used to characterise the business models collected in the further process. The BMFE offers the possibility to describe the structure of a concrete business model on the basis of the characteristics of the nine BMFE components. In a further step, this systemisation can be used as a basis for quantifying a concrete business plan.

[23] Gioia, Corley and Hamilton 2013, 18–22
[24] Flick 2011, 323 f.
[25] Morris, Schindehutte and Allen 2005, 432 f.; Teece 2010, 176

3.2 Procedure of the practice-based analysis

The analysis of the practically realised business models is based on a primary data collection. The company data is collected via publicly accessible information. The applied case study principle corresponds with the procedure according to Yin (2013) for cases with embedded investigation units. Various business models can be realised by one investigated company.[26]

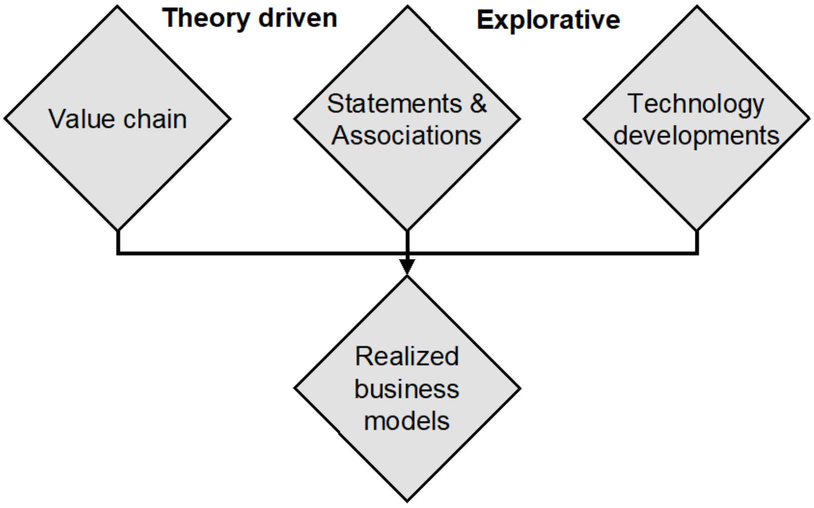

Figure 3-1: Approach of the practice-based analysis
Source: Own illustration

The search has three starting points (see Figure 3-1) and is both theory-driven and explorative. In the theory-based approach, companies with the highest turnover are analysed, i.e. large utilities and communal utilities, along the value chain. This ensures high representativeness.[27]

The explorative approach is oriented towards technological developments and shows the future structure of the energy industry. Start-ups are identified using incubators from the large utilities, the Global Cleantech 100 and the High-Tech Gründerfonds.

In addition to these two approaches, the search is conducted via associations and statements. Based on the umbrella association BDEW and comments on the EEG 2017[28], further business models beyond the large companies will be examined.

3.3 Procedure of the theory-based analysis

The secondary data collection conducted in a literature analysis is based on Kitchenham and Brereton (2013).[29] By combining a keyword-based search and a citation-based snowballing approach, thematically related publications are identified. Due to the rapid changes within the energy system transformation and the importance of current trends, especially digitalisation, decarbonisation and decentralisation, the search is focused on the recent five years. The period of investigation is limited to the ten-year period 2008-2017.

The search keywords correspond to the subject of the study and include the terms 'energy system transformation' and 'business models' (in German and English). Based on this, further equivalent and related terms are derived and combined to appropriate search strings using a keyword matrix. The collected publications are first checked for business models. If a business model is described, the cita-

[26] Yin 2013, 56–63
[27] This approach is consistent with the approach described in BMWi 2017a, 5.
[28] BMWi 2017b
[29] Kitchenham and Brereton 2013

tion-based snowballing is used to search for further publications. Finally, all positively evaluated publications are analysed in detail and the given information is transferred to the components of the BMFE.

3.4 Synthesis to prototypes and classification of business models

The objective of developing prototypical business models and business model classes is to group similar business models. The formed groups are as homogeneous as possible with regard to their characteristics. At the same time, they are clearly distinguishable to other prototypes or classes.[30]

The collected business models are analysed in a two-stage filter procedure. First, business model prototypes (typing) are derived and then, based on the prototypes, business model classes (classification) are built. In the first step, the characteristics of the main components of the business model framework (value proposition, revenue model and customer segment) are used to characterise different prototypes as abstractions of concrete business models. In the second step, these prototypes are classified on the basis of their position in the value creation network on prototype level. In particular, the transformation of the energy industry from a carbon-intensive, capacity-oriented producing industry to a decarbonised, flexible and networked industry is taken into account.

Synthesis to business model prototypes

The synthesis of the prototypes is based on the main components of the BMFE. For the differentiation of the prototypes, the characteristics of the value proposition, revenue model and customer segment are used (see Figure 3-2). If two business models are identical in terms of their value proposition and if following the revenue model and the customer structure are (almost) identical, they form one prototype. The other components of the BMFE are summed up under the three main components, so that a clearly differentiated value proposition and revenue model can also be expected if, for example, a clearly differentiated technology is used. Since the three main components already have a wide range of different possible characteristics, it does not make sense to include further components for prototyping and thus expand the scope of possibilities and the expected number of prototypes. Therefore, the further components provide a detailed description of concrete business models and are not used to generate prototypes.

According to this logic, the main components within a business model prototype are identical. Consequently, all business models with identical main components are summed up in one prototype.

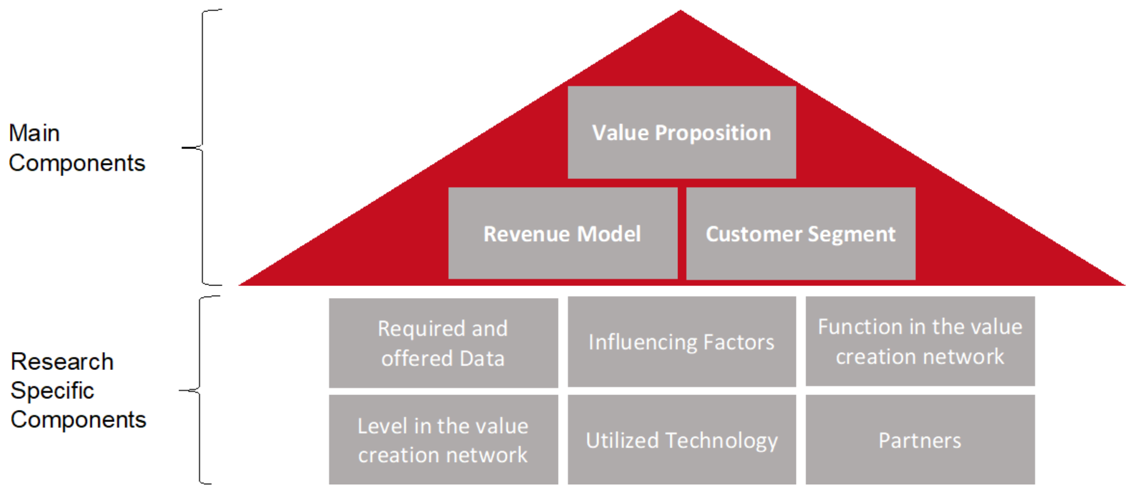

Figure 3-2: Overview of Components of the Business Model Framework Energy Industry
Source: Own illustration

[30] Backhaus et al. 2016, 455 ff.

Classification of business model prototypes

While the prototyping builds on the main components, the classification requires a further abstraction. The prototypes are grouped on the basis of their position in the value creation network and classified according to the dimensions of proximity to the end consumer and to the core process of the energy industry. Double allocation of prototypes to classes are not permitted, although this may be possible in principle. The classification takes the disruptive character of the energy system transformation into account by an explicit formation of individual classes based on decarbonisation, digitisation and decentralisation and splitting the proximity to core processes of the energy industry into traditional business models on the one hand and modern business models on the other. Figure 3-3 shows the basic categorisation of classes in the value creation network. An overview of the classes in the value creation network is illustrated in Figure 4-1.

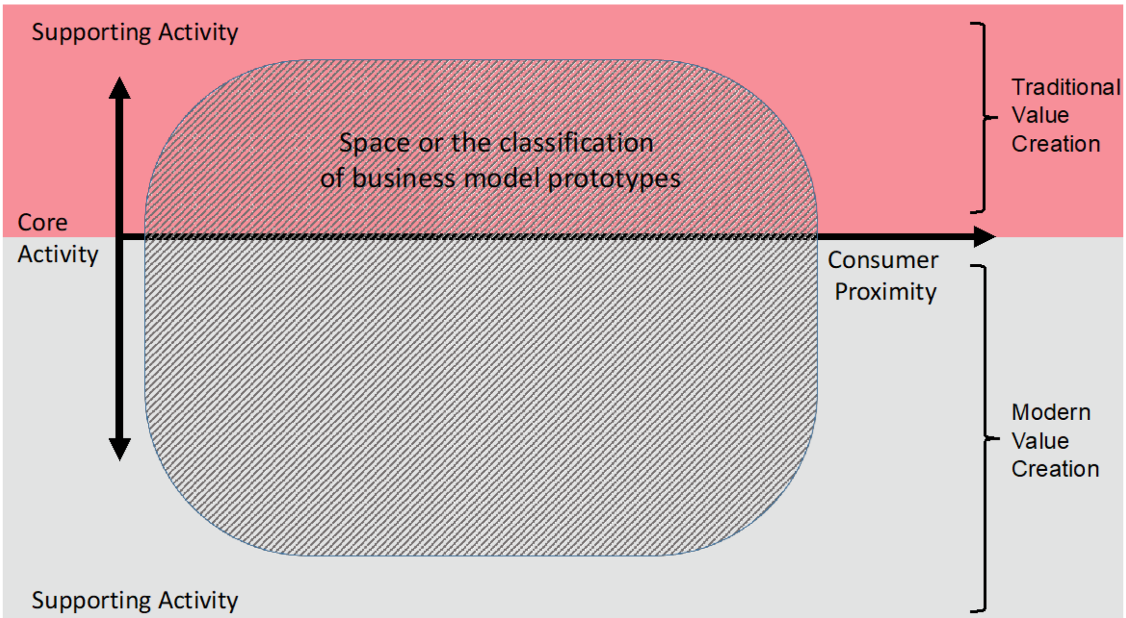

Figure 3-3: Dimensions for classifying the business models
Source: Own illustration

In the long run, it is expected that some classes (as well as prototypes and business models) no longer exist, while further classes (as well as prototypes and business models) emerge. This corresponds to the study objective to state a classification on the basis of a snapshot of the current situation in the energy industry.

3.5 Extension of the Value Chain Approach to Value Networks

The dynamic development caused by decarbonisation, decentralisation and digitalisation in the energy system, as well as the addition of new market roles and market players from outside the sector, are changing the traditional energy industry. Due to the novel, complex and multi-layered interdependencies of actors, a shift away from the value chain approach is a logical step. Instead of the classical value chain approach based on relationships between the business models themselves, value creation networks are identified as a new analysis system which illustrates the interrelationships between the business model classes or business model prototypes. This is represented by the dimension 'proximity to the classical value chain' in the classification of business models.

The approach is based on the introduction of the value system by Porter (2004).[31] However, it goes one step further by including not only interdependencies along the steps of the classic value chain, but

[31] Porter 2004, 33–36

also a large number of cross-sectional functions as well as related supporting value creation areas and industries. The latter cannot be represented in the classic value chain. Furthermore, the representation of a multitude of interactions represents a significant extension of Porter's approach.

In a first step, the analysis of value networks at the prototype level is limited to those business model prototypes directly connected to the analysed business model prototype. Prototypes involved indirectly via several prototypes are not mapped. Thus, the development of value creation networks is an instrument for the visualisation and analysis of the corresponding interactions. Analytically, this includes the representation of the respective product, service, energy, data and financial flows between the market players.

4 Current Business Models, Business Model Prototypes and Classes

According to the focus on the impact of decarbonisation, decentralisation and digitisation, the analysis shows that innovative business models are clearly evident in addition to traditional ones. In the same way as the increasing importance of digitisation in all areas, many business models are linked to energy services, renewable energies or sector coupling.

The comparison of the two analytical strands shows that the practical and the theory-based search are supported by each other. Consequently, the most of the business models are found in both analyses. Some business models are identified more often via one or the other analysis approach.

4.1 Results of the practice-based analysis

The practice-based analysis of the energy sector covers 134 companies. On this basis, 242 business models were identified.

As expected, (integrated) utilities and municipal utilities cover many business models in the field of traditional business models. However, their contribution to more innovative business models is low. In the case of new technology developments, the business model description is less precise. This is due to the fact that business models are not completely mature and applied on the market at the moment. This affects in particular recent business models of software providers and from analytics.

Within the field of sector coupling, power-to-mobility concepts are predominant in practice and more advanced than other sector coupling concepts. In contrast, business models for smart homes are more fragmented and limited to selected individual technologies rather than complete solutions. Start-ups are usually concentrated on one technology option. Similarly, new entrants from other industries only enter the sector where they have the appropriate skills. Nevertheless, it is clear that several companies are involved as part of the necessary value creation network for a specific customer solution.

4.2 Results of the theory-based analysis

The literature analysis covers 166 thematically matching publications. 396 theory-based business models result from this analysis strand.

The theory-based analysis is dominated by traditional business models of the energy industry for generation, transport, distribution and sales. The influence of decarbonisation on the value creation of the electricity sector is also evident from numerous business models for renewable energies. In comparison to the practice-based analysis, the theoretical business models are more holistic. This applies in particular to cross-sectoral concepts. Therefore, power-to-gas, power-to-heat and smart grid concepts are available in the area of sector coupling, which are currently not implemented on the market. Compared to the practice-based strand the prosumer is explicitly mentioned and listed as an important part of the energy industry's value creation network.

4.3 Classification of business models

The theory and practice-based analysis results in 69 prototypical business models. This results in 17 business model classes illustrated in Figure 4-1. A detailed list can be found in the appendix. The business models and classes cover the traditional, liberalised, decarbonised and digitised energy industry.

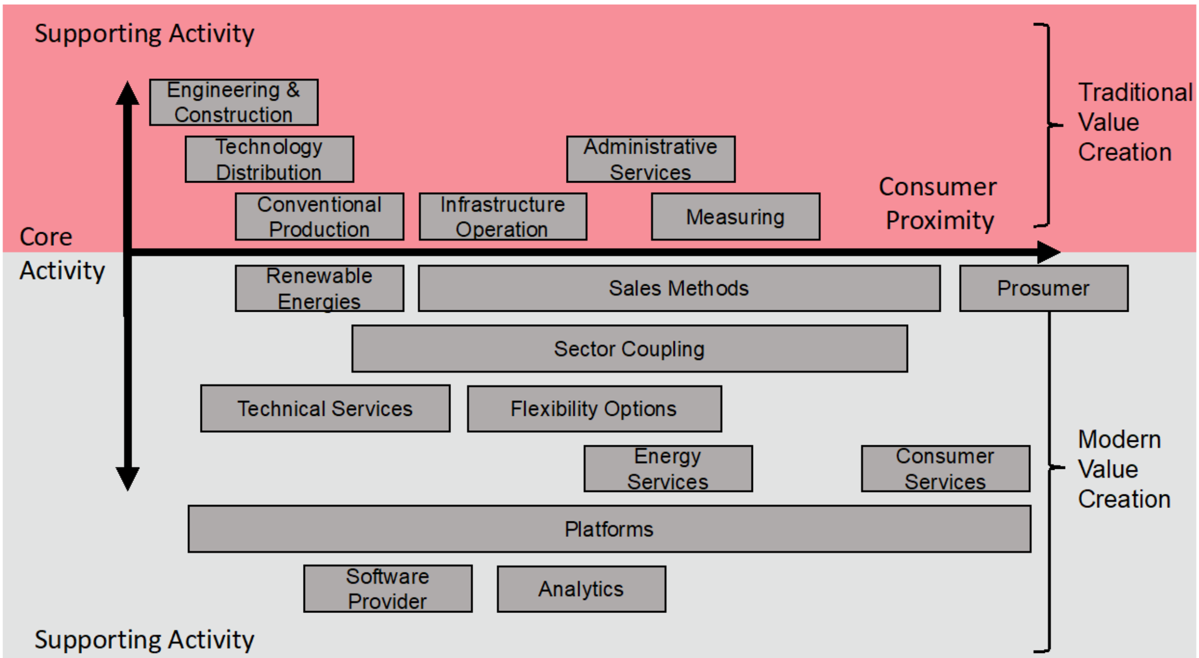

Figure 4-1: Overview of the business model classes
Source: Own illustration

The selection of examples from the next paragraphs shows that the complete range of business models is covered. At the same time, the selected prototypes ensure sufficient selectivity between different prototypes. The 17 business model classes derived from them also show the development of the energy industry in recent years. The business model classes that have emerged in addition to the traditional area are the result of the trends decarbonisation, liberalisation, decentralisation and digitisation.

Examples of the traditional energy industry are the business models of the class 'Infrastructure Operation':

- **'Conventional Energy Supplier'**
- **'Network Operator'**

The liberalisation process has led to the addition of ‚Metering' as an independent class. This includes, for example, the prototypes:

- **'Metering Operator'**
- **'Smart Meter Services'**

Decarbonisation has triggered the establishment of business models in the class 'Renewable energies':

- **'Renewable Fuels'**
- **'Renewable Generation'**
- **'Renewable Energy Supplier'**

The two business model prototypes **'Renewable Generation'** and **'Renewable Energy Supplier'** show that the necessary accuracy of differentiation between business model prototypes is given. Both offer the same value proposition with renewable electricity or heat. However, due to the different customer groups addressed and the technologies used, there are two clearly differentiated business model prototypes. Nevertheless, due to the proximity to each other, a company may offer both in an integrated way.

As a result of digitisation, the energy industry is extended by the class 'platforms'. This includes the following prototypes:

- **'Crowd-Storage'**
- **'Virtual Power Plant (VPP) Energy Marketing'**
- **'Peer-to-Peer-Platform'**

The 'sector coupling' class includes further new business models:

- **'Power-to-Gas'**
- **'Power-to-Heat'**
- **'Power-to-Mobility - Charging Infrastructure'**

On the basis of this data, some combinations of the entries of the components of the BMFE can also result in meaningful business models. One example is the business model of a smart home provider with local generation technologies, which was not found in the study and which generates revenues through trade gains in conjunction with user knowledge. On the other hand, not all other combinations of BMFE components result in meaningful business opportunities.[32] Due to the objective of identifying the current status of existing business models in the energy industry, business models that have not been empirically confirmed have not been further investigated.

4.4 Example of a value creation network

The individual business model prototypes can be presented within the value creation network after they have been identified by the BMFE. This representation can be used as an analytical tool to determine relations between business models and to develop diversification strategies. Regions can use the tool to identify gaps in their business model landscape. As an example, the value network for the business model prototype 'VPP Energy Marketing' is illustrated in Figure 4-2.

Services, data, products and energy flows to the business model prototype VPP are mapped. The input data for the network was collected within this study. Payment flows are opposite to the services and products and not depicted.[33] The result illustrates the multitude and variety of customers, suppliers and partners that a VPP requires. It also shows that a VPP only transports data with regard to the energy flow, but is neither directly involved in generation nor in transport.

Such a network can be created for each of the business model prototypes and offers practical use. For example, a region can map a value creation network for already existing prototypical business models or existing companies and their business models and consequently identify gaps in this network to be filled by the local economy.

[32] For example, this is illustrated by a fuel-producing domestic consumer (e.g. refrigerator) that generates income through software rental.

[33] Exceptions are possible, for example within the framework of mandatory notification obligations, which can result by information flows without a financing stream.

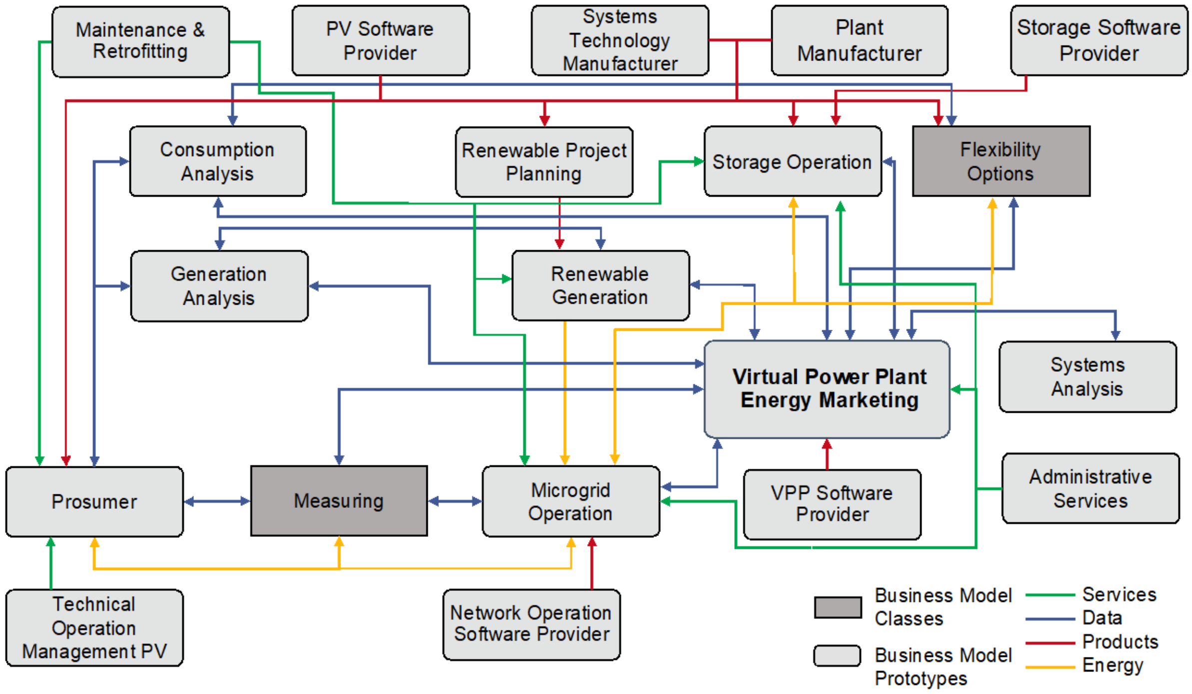

Figure 4-2: Value Creation Network VPP
Source: Own illustration

Incentives can be established to fill these gaps in order to promote regional value creation. Companies can use a value creation network for their own business models or those of their customers to identify potential for diversification or disruption.

5 Conclusion and further research

The paper shows that previous business model designs are insufficiently suited to capture the current business models of the energy industry. Especially for further work, there is a need for continued monitoring of business models in the energy sector in order to continue developing the proposed modular design of the BMFE. Therefore, Chapter 5.1 gives a brief summary of the results of the analysis, while Chapter 5.2 summarises the resulting need for further research.

5.1 Summary of the analysis

Based on the structure of the energy industry and the effects of energy transition on business models, the BMFE is a tool developed to describe the business models of the energy industry. A total of 638 business models have been identified using practice-based and theory-based data collection. The results of both analysis approaches confirm each other. In synthesis, 69 business model prototypes were extracted from the analysis strands and described by the BMFE. One prototype summarises various business models with similar value proposition, revenue model and customer segments. The 69 prototypes were grouped into 17 business model classes according to the dimensions of 'customer proximity' and 'proximity to the classic value chain of the energy industry'.

The synthesis represents the current status of energy business models, business model prototypes and business model classes in Germany. The ongoing energy system transformation and the growth of renewable energies are changing the structure and value creation of the energy industry. The business model classes show that traditional business models are affected by the decarbonisation, decentralisation and digitisation of the energy system in all segments and economic sectors. Consequently, the energy transition is beginning to have an impact beyond the borders of the electricity sector. The increasingly decentralised use of technologies from the heat, gas and mobility sectors shows that the requirements for coordination between sectors are increasing. Therefore, one company can no longer master all complex value creation tasks. Moreover, new and more complex interdependencies are emerging between business models.

In an energy sector increasingly characterised by complex value creation networks, the integrated combination of material and services is gaining in relevance. In particular, existing business models with direct end customer contact are dependent on the integration of additional services in the long term. In this context, the analysis confirms that digitisation drives and enables the transformation of energy systems. Many new companies are entering the market with innovative products based on digital solutions. The change is increasingly driven by companies from the information and communication sector and other companies from outside the industry. This is particularly true for new services that go beyond the pure supply of energy. For example, software, automation and platform solutions or solutions for sector coupling with the related areas of mobility and heat are gaining importance. Here, new entrants from other sectors can provide important skills for the provision of innovative value propositions by entering the energy sector. However, traditional companies in the energy industry can also expand their product portfolio on the basis of their expertise within their value creation network.

5.2 Further research

The result of the analysis represents the status quo of the business models and business model classes of the energy industry in Germany. In this respect, the identified business model prototypes have to be reviewed in the future and, if necessary, complemented. While in this project a qualitative methodical description of the value network approach is applied, an extension of the analysis instrument by a quantitative evaluation of cash flows is possible. Therefore, one starting point for further research is the development of a quantitative model-based evaluation system, which allows a quick decision on the microeconomic applicability of business model (-prototypes). The authors have already started working on this issue. Furthermore, it is possible to extend individual value creation networks into higher-level overall networks. Thus, indirect effects in the broader sector environment can be analysed.

In the empirical analysis, business model prototypes were analysed independently of the companies realizing them. By identifying the market players and recording the regional scalability of a business model prototypes, it is possible to transfer the systematisation to small-scale study regions. This could be realised in further projects. Initial research work has also started recently at the department of Energy and Resource Management.

Due to constant changes in the (energy) economy, it is necessary to consistently monitor business models in order to add further components to the modular BMFE, if empirical evidence shows that this is necessary. This covers a possible extension or reduction of business model prototypes or classes if new developments result in new business models. Such an adaptation of the results of this analysis is quite feasible with the presented methodology.

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7 Literature

Abdelkafi, N., Makhotin, S. and Posselt, T. (2013): „Business Model Innovations for Electric Mobility - What Can Be Learned from Existing Business Model Patterns?“ *International Journal of Innovation Management* 17 (01): 1340003-1-1340003–41. https://doi.org/10.1142/S1363919613400033.

Backhaus, K., Erichson, B., Plinke, W. and Weiber, R. (2016): *Multivariate Analysemethoden: eine anwendungsorientierte Einführung*. 14., überarbeitete and aktualisierte Auflage. Berlin Heidelberg: Springer Gabler.

Bieger, T., zu Knyphausen-Aufseß, D. and Krys, C. (2011): *Innovative Geschäftsmodelle: konzeptionelle Grundlagen, Gestaltungsfelder and unternehmerische Praxis*. Academic network. Berlin Heidelberg: Springer.

BMWi. (2017): „LEISTUNGSBESCHREIBUNG zum Dienstleistungsvorhaben, Die Energiewirtschaft im Rahmen der Energiewende: Wissenschaftliche Analysen zu wirtschaftlichen Fragen and Zukunftsperspektiven der Energiewirtschaft (Kurztitel EVU Strukturwandel)“. https://www.evergabe-online.de/tenderdocuments.html?3&id=176478.

BMWi. (2017b): „Stellungnahmen - Konsultationen zu aktuellen Gesetzesvorhaben“. 2017. http://www.erneuerbare-energien.de/EE/Navigation/DE/Service/Stellungnahmen/stellungnahmen.html.

Burger, S. P. and Luke, M. (2017): „Business Models for Distributed Energy Resources: A Review and Empirical Analysis“. *Energy Policy* 109 (Oktober): 230–48. https://doi.org/10.1016/j.enpol.2017.07.007.

Demil, B., and Lecocq, X. (2010): „Business Model Evolution: In Search of Dynamic Consistency“. *Long Range Planning* 43 (2–3): 227–46. https://doi.org/10.1016/j.lrp.2010.02.004.

Doleski, O. D. (2014): „Entwicklung neuer Geschäftsmodelle für die Energiewirtschaft – das Integrierte Geschäftsmodell“. In *Smart Market*, herausgegeben von Christian Aichele and Oliver D. Doleski, 643–703. Wiesbaden: Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-02778-0_24.

EY. (2016): „Geschäftsmodelle 2020 - Wie in der Energiewirtschaft zukünftig noch Geld verdient werden kann“.

Flick, U. (2011): „Triangulation“. In *Empirische Forschung and Soziale Arbeit*, herausgegeben von Gertrud Oelerich and Hans-Uwe Otto, 323–28. Wiesbaden: VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-531-92708-4_23.

Gioia, D. A., Corley, K. G. and Hamilton, A. L. (2013): „Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology“. *Organizational Research Methods* 16 (1): 15–31. https://doi.org/10.1177/1094428112452151.

Giordano, V. and Fulli, G. (2011): „A Business Case for Smart Grid Technologies: A Systemic Perspective“. *Energy Policy*, November. https://doi.org/10.1016/j.enpol.2011.09.066.

Jahnke, P., Monjau, R. and Dziomba, H. (2017): „Geschäftsmodellansätze für Mini-/Mikro-KWK and intelligente Infrastrukturen“. In *Lokale Impulse für Energieinnovationen*, herausgegeben von Gerhard Fuchs, 161–204. Wiesbaden: Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-14801-0_8.

Kasperk, G. and Drauz, R. (2013): „Geschäftsmodelle entlang der elektromobilen Wertschöpfungskette“. In *Elektromobilität*, herausgegeben von Achim Kampker, Dirk Vallée, and Armin Schnettler, 103–48. Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-31986-0_4.

Kitchenham, B., and Brereton, P. (2013): „A Systematic Review of Systematic Review Process Research in Software Engineering“. *Information and Software Technology* 55 (12): 2049–75. https://doi.org/10.1016/j.infsof.2013.07.010.

Löbbe, S. and Hackbarth, A. (2017): „Geschäftsmodelle in der Energiewirtschaft: Ein Kompendium von der Methodik bis zur Anwendung“. Reutlinger Diskussionsbeiträge zu Marketing & Management. Hochschule Reutlingen. https://doi.org/10.15496/publikation-17713.

Loock, M. (2012): „Going beyond Best Technology and Lowest Price: On Renewable Energy Investors' Preference for Service-Driven Business Models“. *Energy Policy* 40 (Januar): 21–27. https://doi.org/10.1016/j.enpol.2010.06.059.

Morris, M., Schindehutte, M. and Allen, J. (2005): „The Entrepreneur's Business Model: Toward a Unified Perspective“. *Journal of Business Research* 58 (6): 726–35. https://doi.org/10.1016/j.jbusres.2003.11.001.

Okkonen, L. and Suhonen, N. (2010): „Business Models of Heat Entrepreneurship in Finland“. *Energy Policy* 38 (7): 3443–52. https://doi.org/10.1016/j.enpol.2010.02.018.

Osterwalder, A., and Pigneur, Y. (2013): *Business Model Generation A Handbook for Visionaries, Game Changers, and Challengers*. New York, NY: John Wiley & Sons. http://nbn-resolving.de/urn:nbn:de:101:1-2014122414260.

Porter, M. E. (2004): *Competitive Advantage: Creating and Sustaining Superior Performance*. 1. Free Press export ed. New York, NY: Free Press.

Provance, M., Donnelly R. G. and Carayannis, E. G. (2011): „Institutional Influences on Business Model Choice by New Ventures in the Microgenerated Energy Industry“. *Energy Policy* 39 (9): 5630–37. https://doi.org/10.1016/j.enpol.2011.04.031.

PWC. (2016): „Deutschlands Energieversorger werden digital“.

Richter, M. (2012): „Utilities' Business Models for Renewable Energy: A Review“. *Renewable and Sustainable Energy Reviews* 16 (5): 2483–93. https://doi.org/10.1016/j.rser.2012.01.072.

Rodríguez-Molina, J., Martínez-Núez, M., Martínez J.-F. and Pérez-Aguiar, W. (2014): „Business Models in the Smart Grid: Challenges, Opportunities and Proposals for Prosumer Profitability“. *Energies* 7 (9): 6142–71. https://doi.org/10.3390/en7096142.

Strupeit, L., and Palm, A. (2016): „Overcoming Barriers to Renewable Energy Diffusion: Business Models for Customer-Sited Solar Photovoltaics in Japan, Germany and the United States“. *Journal of Cleaner Production* 123 (Juni): 124–36. https://doi.org/10.1016/j.jclepro.2015.06.120.

Teece, D. J. (2010): „Business Models, Business Strategy and Innovation“. *Long Range Planning* 43 (2–3): 172–94. https://doi.org/10.1016/j.lrp.2009.07.003.

Varone, A., and Ferrari, M. (2015): „Power to Liquid and Power to Gas: An Option for the German Energiewende“. *Renewable and Sustainable Energy Reviews* 45 (Mai): 207–18. https://doi.org/10.1016/j.rser.2015.01.049.

Yin, R. K. (2013): *Case Study Research: Design and Methods*. https://nls.ldls.org.uk/welcome.html?ark:/81055/vdc_100025422049.0x000001.

A. Appendix: Business Model Classes and included Prototypes

Platforms
Stock Exchange
Crowd Storage Platform
Information Platform
Power-to-Mobility Charging Infrastructure Platform
Peer to Peer Platform
Platform for Energy Services
VPP Energy Marketing
VPP System Services
Software Provider
Energy Efficiency Software Provider
Network Operation Software Provider
Power-to-Mobility Software Provider
Platform Software Provider
PV Software Provider
Storage Software Provider
VPP Software Provider
Sales Methods
Consumer Sales
Energy Trading
Customer Services based on Energy Data
Storage Trade
System Services Marketing
Marketing
Distribution of related Goods
Technical Services
Carbon Capture and Storage (CCS)
Energy Management System
Renewable Project Planning
Power Plant & Grid Project Planning
Modernisation
Maintenance & Retrofitting
Flexibility Options
Demand Side Management (DSM)
DSM system services
Power-to-Mobility DSM & System Services
Storage DSM
Storage System Services
Analytics
Data Trading
Generation Analysis
Systems Analysis
Consumption Analysis

Consumer Services
Energy Consulting
Mobility Services
Procurement
Testing Services
Energy Services
Energy Contracting
Power for Tenants
Technical Operations Management
Technical Operations Management PV
Infrastructure Operation
Asset Leasing
Microgrid Operation
Network Operation
Storage Operation
Sector Coupling
Power-to-Gas
Power-to-Heat
Power-to-Mobility Power Supply
Power-to-Mobility Charging Infrastructure
Administrative Services
Billing Services
Administrative Services
Distribution Services
Renewable Energies
Renewable Fuels
Renewable Generation
Renewable Energy Supplier
Measuring
Measuring Services
Metering Point Operator
Smart Meter Services
Engineering & Construction
Plant Manufacturer
Systems Technology Manufacturer
Technology Sales
System Distribution
Technology Distribution
Conventional Production
Conventional Production
Conventional Energy Supplier
Prosumer
Prosumer

Bold: business model classes

Normal print: business model prototypes