Smart Meter based Business Models for the Electricity Sector - A Systematical Literature Research

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Abstract: The Act on the Digitization of the Energy Transition forces German industries and households to introduce smart meters in order to save energy, to gain individual based electricity tariffs and to digitize the energy data flow. Smart meter can be regarded as the advancement of the traditional meter. Utilizing this new technology enables a wide range of innovative business models that provide additional value for the electricity suppliers as well as for their customers. In this study, we followed a two-step approach. At first, we provide a state-of-the-art comparison of these business models found in the literature and identify structural differences in the way they add value to the offered products and services. Secondly, the business models are grouped into categories with respect to customer segments and the added value to the smart grid. Findings indicate that most business models focus on the end-consumer as their main customer.

Keywords: Smart Meter, Business Model, Electricity Sector, Business Model Canvas, Literature Review

1 Introduction

For a long time reliable energy provision served as a successful business model in the electricity sector. Consequently, the players in the electricity market focused on improving in this particular key activity in order to excel in competition. However, while the provisioning is and will be an important aspect in the future, findings indicate that it is already losing its significance due to the emerge of fundamental changes in the

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electricity sector [La13b, Va15]. Many of these changes are based on or linked to so-called smart meters, a game-changing-technology facilitating the potential to revolutionize the whole electricity industry [Ze14]. The major difference in contrast to traditional meters is that smart meters are equipped with communication capabilities [§ 2 Messstellenbetreibergesetz of 09.08.2016], which make them more 'intelligent' than their predecessors. This intelligence enables a whole range of new applications, for instance, remote monitoring of current power consumption [La13b]. As of today, it is still common practice to manually take readings in private households once a year and forward this information to the electricity provider. With smart meter technology this is no longer necessary, as it allows for a transmission of measurement data near real-time [La13b]. Furthermore, the frequency of readings is increased significantly such that updates in the energy consumption are available every quarter-hour [Ze14]. Since the communication is bidirectional, electricity providers can also harness the potential of smart meters in order to directly send relevant information to their customers, such as price updates [Va15]. To go even further, the technology can even be used to control consumer's household appliances via smart meter gateways [Os14]. As a potential use case, household appliances could be activated when energy prices are cheapest, thus providing its owner with cost savings. The before mentioned scenarios only represent a small fraction of potential use cases rendered possible by smart meter technology. Yet, it becomes apparent that this technology can serve as a basis for a range of innovative business models [La14].

In this study, we conducted a systematic literature review to examine the existing body of relevant research on business models based on smart meter technology. This paper focuses on the following research questions: (a) Which business models make use of smart meter technology?; (b) What are the structural differences in these business models?; and (c) How can these business models be categorized?

Due to the broad range of available literature, we restricted our research to findings dedicated to the electricity industry.

2 Methodology

In order to focus on the three presented research questions, a systematic literature analysis was conducted. The underlying method was adapted from Webster and Watson (2002). Relevant literature was captured from (a) Elsevier; (b) SpringerLink; and (c) Google Scholar since they provided the most relevant results during an initial explorative search phase. Search and analysis was conducted in November 2016 using the search criteria presented in Table 1.

As German literature was also of importance for this study, an equivalent and supplementary search with German search strings was conducted as well. Furthermore, in order to set the focus on the latest findings, we only considered literature published since 2010, the year when smart meters were initially deployed in private households.

Whenever possible, a filter criteria restricting results to scientific papers was applied. Due to the large amount of results, the search had to be narrowed down considering titles only.

Search	Search string
1	'Smart Meter' ∧ ('Electricity' ∨ 'Electric')
2	'Smart Meter' ∧ ('Utility' ∨ 'Transmission company' ∨ 'Distribution company' ∨ 'Generation company' ∨ 'Energy service company' ∨ 'Electricity generator' ∨ 'Electricity trading company' ∨ 'Electricity traders' ∨ 'Energy sector')
3	'Smart Home' ∧ ('Electricity' ∨ 'Electric' ∨ 'Smart Meter')
4	'Smart Grid' ∧ ('Electricity' ∨ 'Electric' ∨ 'Smart Meter')
5	'Smart Meter' ∧ ('Business model' ∨ 'Business Case')
6	'Smart Meter' ∧ ('Analysis' ∨ 'Analytics' ∨ 'Load profile')

Tab. 1: Search strings for the database research

After removing duplicates from the respective search results, a first content-related evaluation based on the documents' titles and abstracts was carried out. Results without any relevance to the object of this research had to be excluded from further analysis, as well as results which lacked high scientific standards. The remaining results were analyzed in full detail. Finally, the bibliographies of highly relevant results were examined to determine further literature contributing to answer the raised research questions. During this process, 105 relevant results were identified.

3 Theoretical Foundation

3.1 The traditional business model of electricity suppliers

The conventional business model of electricity suppliers can be summarized as "guaranteed power supply for end-consumers" [BG14]. It is based on the traditional value chain of the power industry, which is shaped by the central energy production of major coal-fired factories and nuclear power plants. The transportation 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 [La13b]. In order to adjust production to demand, standard load profiles are used for estimation of the power consumption [SW15]. The main customer value of this conventional business model lies in the guaranteed power supply. In the further consideration the immediate customer benefit can be regarded as the result of this guarantee and is expressed by the possibilities that derive from the given power supply – like operating devices or cooling food [Ze14]. The long-established structures of energy production in large plants and conventional distribution networks allow for stable economies of scale and low unit costs [Do14]. Revenue is generated through the direct sales of kilowatt hours to the end-consumer in a combination of the basic price and a corresponding kilowatt-hour rate [Ze14].

3.2 Market changes force business model innovations

Energy giants like EnBW, E.ON, RWE and Vattenfall including their subsidiaries used to control the electricity market in all its aspects [Ze14]. Until 1998 they held a monopoly for most parts of the value chain [Ba14]. Since then there has been fundamental changes concerning the power market as a whole driven by three significant influencing factors: Ecology, technology and politics [DH14, Va15].

Climate risks and scarcity of resources render fossil fuels increasingly unattractive and force electricity suppliers to improve their production efficiency as well as to strive for alternative energies [Ve11]. Hence, the technological progress leads to an enhancement in efficiency of these renewable energies while the costs are declining thus making them a reasonable alternative to coal power or nuclear energy. Furthermore there has been a strong improvement in power storage technology [Si14] and in information and communication technology for the electricity sector [Ve11]. Home Automation came up and Big Data concepts allowed manageability of large quantities of data produced in the power supply chain [Ve11]. These innovative technologies paved the way for a fundamental reformation of the power market [Si14]. Last but not least political change had and still has a great impact on the development of the market. In 1998 changes to Germany's Energy Industry Act (EnGW) were passed aiming for the liberalisation of the power market. The abolition of exclusive rights regarding the power generation as well as the infrastructural development in order to open up the market and increase competition were at the top of the agenda [DH14]. Secondly, activities of management and accounting of production, transmission and distribution were unbundled into vertically-integrated companies and the European Energy Exchange has been founded in order to ensure transparent accounting and discrimination-free competition [DH14]. The risk of losing customers to new competitors in the liberalized power market became a threat to the energy giants [DH14]. In conclusion, the dismantling of the existing monopoly was the highest aim [DH14].

Furthermore, with the politically induced energy turnover around the turn of the millennium reductions of CO_2 emission as well as an increase of energy efficiency were targeted. The subsidies for CO_2-neutral power sources led to an enormous rise of modern power plants providing sustainable energy [DH14]. In order to increase the efficiency, the government relies on the use of intelligent metering systems at customer-side. By means of this smart metering the customer should be enabled to independently manage the power consumption [DH14]. In a first step, households with a consumption of more than 6.000 kWh per year have been obliged by law to install a smart metering device until 2020 [§29 Gesetz zur Digitalisierung der Energiewende of 29.08.2016].

The changes in the market did not only put the providers under pressure but also had positive effects, offering new possibilities for innovative business models and services – mainly based on smart metering. For instance, new services can now be offered not only to energy consumers but also to members participating in the smart grid.

3.3 Smart Grid as an emerging market for energy services

The technological changes in the power market imply new challenges for the participating companies. Due to the integration of feature-dependent power generation like wind power or photovoltaics new aspects like weather conditions have to be taken into account rendering the forecast more difficult [DH14, Va15]. With the energy input of renewable sources exceeding the load on distribution centres many times over, the risk of instabilities arises. The result is an upcoming need for a higher degree of automation, with the aim of a market-driven load management in order to compensate the volatility of renewable energies [DH14]. A power grid with these capabilities is referred to as a Smart Grid. This is achieved by the integration of intelligent information and communication technologies into the existing grid. The smart meters provide relevant information that allow for an optimized load management within the grid as well as energy input from decentralized production plants [Va15]. In the following chapter we will discuss related business models associated with these approaches as well as other smart meter based models.

4 Results of the state-of-the-art literature review regarding smart meter based business models in the electricity sector

In order to ensure relevance of the discussed business models in this study, we focused on models which have been described in full detail. On the other hand, business model ideas that were only outlined without further discussion of the underlying value proposition or revenue generation had to be disregarded. In order to allow comparability of the models, we utilized the scheme of Business Model Canvases as introduced by Osterwalder [OP11]. Since the key activities, value proposition and revenue streams are the central elements defining a business model [Do14], we concentrate on these elements of the business model canvases in the following descriptions. In chapter 5 we will elaborate on the customer segments targeted by each business model. Obviously, all analyzed business models share smart meter technology and the respective data as the key resources.

Optimized sales of electricity: This business model is based on improving the traditional sale of electricity with the help of smart meters [Ze14]. For instance, electricity providers can optimize their internal processes in order to support automatic billing based on actual consumptions [La13b]. Furthermore, having a better understanding about the current electricity demand also leads to a more accurate sourcing on the electricity market [Ze14]. Thereby, poor planning which causes unnecessary costs is avoided. This business model also yields benefits to the electricity consumers. First of all, there is no longer a need for taking manual readings at the households. Besides that, transparency with regard to costs and consumption is enhanced through a monthly bill based on smart meter data [La13b]. And finally, some electricity providers might pass on their cost savings to their customers by offering more favorable charges. Overall, the main activity of the electric utilities is still the provisioning of electricity to the customers [Ze14]. Furthermore, revenue streams are still generated as today via billing of the consumed energy.

Dynamic tariffs: As before, the main activity of this business model is the provisioning of electricity. However, in contrast to traditional meters, smart meters do not only capture the energy consumption, but also when it is consumed. For electricity providers this makes it possible to create offerings with dynamic electricity prices. For instance, electricity consumers can be informed about the current prices and thereupon decide if they maybe want to postpone their consumption to when energy is cheaper again [Ve11]. Modern household appliances can even be programmed such that they automatically switch on as soon as prices fall below a certain threshold [Ve11]. This is especially relevant to industrial consumers though, since their electricity demand is much larger and thus offers a greater potential for possible cost savings [La13b]. In general, one must distinguish in between time and load-variable tariffs. The former are valid for a certain timeframe only and are determined upfront. The latter instead are oriented towards a previously defined maximum load offered at a specific price, before the next jump in prices occurs [Ve11]. Again, revenue streams are generated via billing of the consumed energy [Ve11].

Energy Efficiency Services: This business model extends the existing one by offering consulting services. These services are offered to the customer in order to support with the increase of energy efficiency by providing energy reports or tips on energy saving based on the collected smart meter data [Ro13]. 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 analysed smart meter data to use in order to discover savings potential [Ro13, Ze14]. From a financial perspective, the offered services open up new revenue streams which complement the existing ones [Ze14].

Smart Homes: Smart Home involves intelligent automation systems that allow inhabitants to monitor and control functions over their building. Possible scenarios include control of energy consumption, automation of lightning or heating, ventilation and air conditioning (HVAC) appliances as well as services regarding assisted living, security and convenience. These automation applications can be linked to the energy usage in order to turn off devices if there is nobody at home, detect intruders or notify relatives about anomalies in the consumption patterns of elderly people [Ed14, KPM12, La13b]. From a business model perspective, participants of the energy sector could form strategic alliances with hardware and software providers to become solution providers. Revenue streams could increase by offering service flat rates, claiming commission fees or generating turnover through hardware sales [KPM12].

Demand Response Services: Demand Response describes interruptible loads that are made available to the electricity grid operator and can be turned off if necessary to better match demand for power with the supply and avoid throttling in the production rate of the power plants [Ze14]. Electric utilities can buy these loads from their private and industrial customers and provide them to the grid operators so that for example appliances are turned off for a short period of time if necessary [Ei14, Ze14]. Smart meters are used for the regulation of these interruptible loads. With demand response the demand for power is adjusted instead of adjusting the supply which helps compensating the volatility of renewable energies [Ei14, SS14]. From the business perspective, revenue is generated through the sale of these interruptible loads to grid operators that are charged a fixed amount [Ze14].

Virtual Power Plants: A virtual power plant describes the combination of small and medium-sized generation plants and their control systems to one virtual unit centrally managed by one provider [DA14]. This is realized through the use of a smart metering network [Ro12]. The intelligent linkage facilitates a more efficient management as well as the possibility for small competitors to join forces regarding the power generation and marketing to gain competitive advantages [Ei14, La13b, Ro12]. The opportunity that arises from this concept is held by the providers of virtual power plants. Being the provider of a service that is regardless of the amount of energy – a regular charge can be considered a desirable revenue model [Do14]. On the other hand, small electricity producers are enabled to offer their services at the electricity wholesale market generating additional revenue [Ro12].

Data Hubs: A liberalized power market allows customers to freely choose their meter operator and electricity provider. The smart meter data collected by the meter provider not only has to be made available to the electric utility but also to the power grid operator. This situation leads to highly dynamic and volatile business relationships between a vast number of market participants requiring a high degree of flexibility regarding data distribution [SWB11]. A data hub is a multi-sided platform used to bring these participants together. It provides a reliable means of standardised bidirectional communication and automatic data exchange between the participants that furthermore poses a requirement for business models like 'Demand Response' [SS14]. Moreover, the data hub can be considered to be an enabler for new data-driven business models [GF12]. In contrast to the previously discussed business model, the data hub provider is given the chance to generate revenue based on usage of the platform instead of a regular charge [SWB11].

Representation of discussed business models in Osterwalder's Canvas

In order to provide an overview of the different aspects of the previously described business models, the following table summarizes them in one Business Model Canvas. This also includes the categories of Osterwalder's model not described above.

Key Partners	*Key Activities*	*Value Proposition*	*Customer Relationship*	*Customer Segments*
• IT-Service providers • Electricity producers • Grid operators • Electricity providers	• Data analytics • Consulting *Key Resources* • Access to Smart Meter Gateway • Smart Meter Data	• Cost savings • Better usage transparency • Improvement of environmental sustainability • Enhanced convenience • Stabilization of grids • Improved load management	• Auto-mated service • Personal assistance *Channels* • Website • App • Sales	• Electricity consumers • Electricity producers • Electricity providers • Grid operators • Non-Energy businesses
Cost Structure • Depending on the business model, often IT infrastructure costs			*Revenue Stream* • Depending on the business model, mainly usage-dependent charges	

Table 1: Business Model Canvas for smart meter based business models

This overview shows that in the majority of the business models customer benefit is created through cost savings and improved load management. One of the main activities of the service providers is the analysis of the smart meter data. Important key partners are IT service providers.

5 Categorization Schema

In order to gain a better overview and a basis for further discussions, it is useful to consider the presented business models within the framework of a categorization schema. Based on the literature, several different approaches could be identified. For instance, Zeller suggests examining the business models by means of the two dimensions novelty and complexity [Ze14]. On the other hand, Lange advocates in favor of a categorization based on availability (currently and in the future) and the target market (B2B or B2C) [La13a]. Finally, a categorization along the customer level in terms of private and business customers, key customers and prosumers as recommended by Lauterborn might also serve as a viable option [La14b].

Since the formerly presented business models are very heterogeneous, a categorization based on customer level seems most suitable, but also, in particular, because this also directly depicts the associated benefit dimension of the business models. Furthermore, we propose to expand the schema of Lauterborn to not only consider electricity user, but also cover novel customers, which have not yet been addressed in conventional business models. This allows for a more precise categorization and also enables integration of more diverse business models with uncommon customer segments.

For the second dimension of the schema, we suggest considering the added value for the Smart Grid which arises from the respective business models. Based on the literature analysis, we identified a strong variation in this facet among all inspected business models. Some of them may have a direct impact on energy provisioning as well as its usage in the future and are closely-linked to the load management of the Smart Grid. In this context, they have great potential to strengthen and stabilize the whole electricity infrastructure, and thereby benefiting all players in the electricity sector.

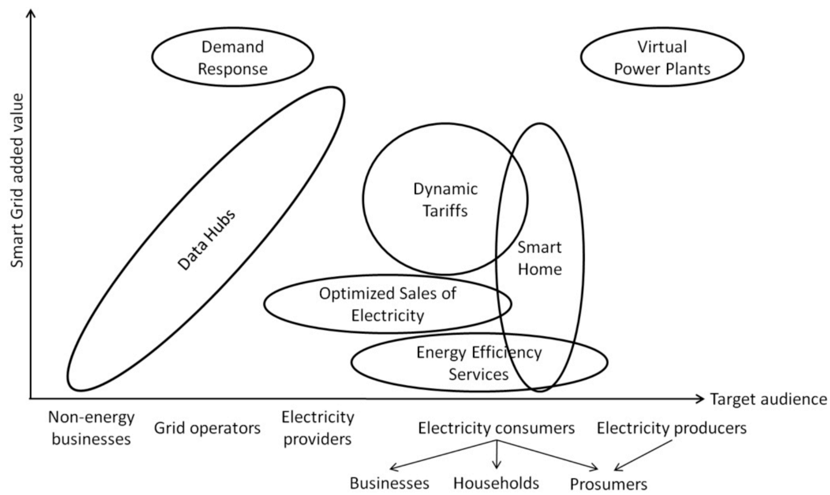

Fig. 3: Categorization of smart meter based business models

The business model 'Demand Response' provides a high added value for the smart grid, as electricity grid operators can utilize interruptible loads for load management [Ze14]. With the 'Data Hub' there is no direct value for the smart grid if smart meter data is analyzed with regard to marketing aspects [AD13]. However, if the data is used for structural planning and optimization of load management the smart grid benefits [Va15]. 'Dynamic Tariffs' on the other hand incentivize the energy consumers to postpone their energy consumption to times when energy prices are low which has positive effects on the load management. Ideally, household appliances are automatically managed by smart meters [He14, La13b, Os14]. Assisted living, security and convenience services as the other part of the smart home business model offer no benefit to the smart grid [La13b]. The 'Energy Efficiency' business model as well provides no significant added value to the smart grid. Although the required total energy demand is slightly reduced, it cannot be specifically controlled by third parties. Due to more precise forecasting achieved by 'Optimized Electricity Sales', this business model on the other hand has a marginally higher added value. This is due to the fact that electricity providers are less reliant on expensive backup capacities required during load peaks. With 'Virtual Power Plants' the natural fluctuations of energy production can be better compensated, which results in a higher added value for the smart grid [Do14].

If one now looks at result of the categorization, it is apparent that nearly every actor of the electricity market is addressed as target customer by some new business model. Although most business models still aim at end-consumer segment that is proven to the be most profitable, it is advised to also address the other actors as potential customers as they represent new customer groups that are not yet tied to a specific provider. Furthermore, most of the discussed business models contribute to the stabilization of the smart grid so that their realization is also desirable from a macro economical perspective. With the comparison of business models, it becomes evident that new possibilities arise from the combination of models merging different customer groups and revenue streams. For example, electric utilities could provide contracts that include smart home services for the end-customer on the one hand and interruptible loads for the grid operator as demand response services on the other hand.

6 Conclusion

In this state-of-the-art review several quite heterogeneous business models have been discussed. Although most of the business models still aim at the end-customers, new potential customer groups should be taken into consideration. As the large part of the discussed models has yet to be proven in practice, a final assessment cannot be given. However, a combination of several business models appears especially promising. Furthermore, all business models employing the more and more widespread smart meters have potential for success insofar as they meet the existing customer requirements whereas the conventional business model of electricity providers will become less important. In order to remain successful, the current market actors must prepare for the changes and potential competition. Crucial factors will be the acquisition of know-how and new competencies – particularly in the IT area.

In this research paper not all categories of the Business Model Canvas could be described in detail for each business model. To obtain a more comprehensive picture about this subject, we encourage further studies on smart meter based business models relevant to the gas and heat market. In the near future a similar literature review should be conducted again in order to cover also the business models which are not described in detail in today’s literature.

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