How can new business models be technically realized to provide flexibility in the future German energy system?

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Abstract:

The transition to high shares of renewables leads to high demand for flexibility in the energy system. This flexibility might be fulfilled among other options by small-scale assets such as residential heat pumps and electric cars, potentially leading to new business models in this area. In the project C/sells, these types of new business models were analyzed both conceptually and in real-life field demonstrations. The aim of this work is to identify and compare the technical implementation of different new business models from C/sells, to highlight challenges and to identify relevant (new) technical components for the future German energy system.

To reach this aim, first a general process framework for marketing of flexibility is created. This framework is used to compare current and new business models, leading to relevant new technical components. These new technical components are analyzed in a final step by defining current challenges and the potential for the future German energy system.

Two relevant aspects for the technical implementation using the general process framework can be identified: data collection at and switching of the asset, and data transmission between the different players. For data transmission between the different players excluding the physical asset, existing data transmission standards from current processes are used in the new business models. However, there are no current processes with standardized solutions for connecting and switching small-scale assets, which leads to a wide dispersion of technical infrastructure in the new business models. Nevertheless, two new components for different steps in the process framework can be identified: intelligent metering infrastructure for data collection and switching and LTE as a data transmission standard between small-scale assets and other players.

The challenge with intelligent metering infrastructure is the lack of maturity which will, however, be addressed and reduced in future. The use of LTE in the energy industry provides both technical challenges such as incomplete LTE coverage in Germany and social challenges such as acceptance issues. Both challenges can be addressed in future as well, therefore, intelligent metering infrastructure and LTE standard might become important components for business models providing flexibility in the future German energy system.

Keywords: intelligent metering infrastructure, new business models, C/sells, LTE, small-scale assets, flexibility marketing, IEWT2021

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1 Introduction

In the context of the German energy transition [1-3] an extension of the installed net capacity of volatile renewable energies is planned, leading to a potential discrepancy of demand and supply. This increases the necessity of flexibility in the system. The future residential sector with increasing numbers of flexible assets such as heat pumps and electric cars can fulfil part of the necessary flexibility. However, these flexible small-scale assets can only be made available with viable business models.

In the project C/sells, different business models were created and tested in real-life field demonstrations. In this paper, the following three business models are analyzed: “intelligente Wärme München” (iWM, SWM), Altdorf flex market (ALF, FfE) and comax platform (TenneT).

- At iWM, the marketing of electrical storage heaters and heat pumps as a virtual power plant on the day-ahead market is being tested. For the implementation, the power-to-heat systems are technically equipped and schedules for the marketing of the virtual power plant are determined in the SWM control center. [4]
- At ALF, PV systems are technically equipped and connected to a platform, which represents both aggregator and flexibility market. On the platform, the aggregation of the PV systems and the matching of flexibility offers with flexibility demands of a DSO is performed in a day-ahead process. The PV systems are switched by an active external market participant (aEMT). [5]
- At comax, flexibility demands from TSOs and DSOs are connected with flexibility offers from different aggregators on a flexibility platform, taking into account distribution network constraints. [6]

The aim of this paper is to analyze how these different business models were technically realized, to highlight challenges and to identify relevant (new) technical components for the future German energy system.

This paper is structured as followed: first the methodology to compare adequately the different business models is explained. This is followed by the results, split into identified process framework to compare the business model, comparison of the different business models and identification of new technical components and closed with the conclusion.

2 Methodology

The methodology contains three parts (see Figure 2-1). The first part is the development of a general process framework for flexibility marketing. The second part is the comparison of the three business models and the third part the identification of new relevant technical components.

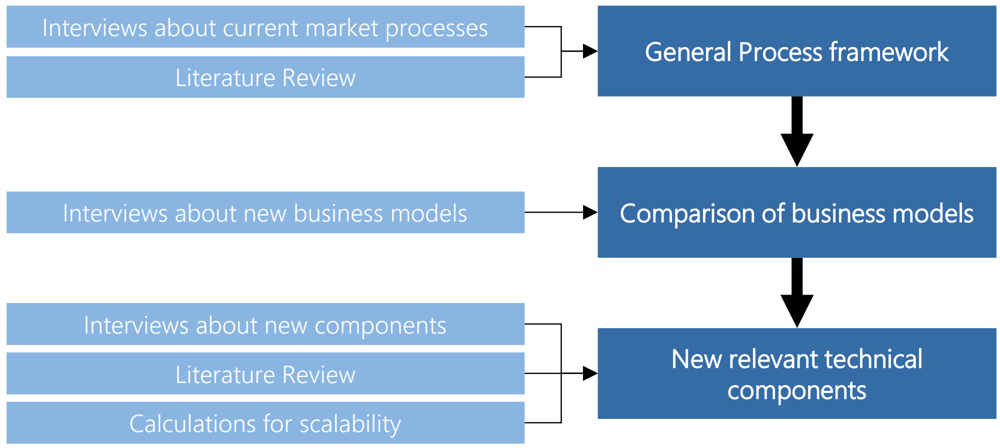

Figure 2-1: Methodology Scheme

For the development of a general process framework for energy flexibility marketing, expert interviews on current marketing opportunities for flexible assets and their technical realization are conducted, accompanied by a literature review. For the comparison of the business models, a questionnaire based on the general process framework is created and answered via interviews. After conducting all interviews about the three different business models, new technical components are determined. To analyze these components regarding current challenges and their potential for the future German energy system, expert interviews, literature review and some rough potential estimations are utilized.

3 Results

To create a general framework on how the technical realization at flexibility marketing is performed, in a first step the specific process “Marketing of flexibility on the spot market via an aggregator” is determined. The process starts with the physical asset, which can be for example a flexible industrial plant, where data collection at the physical asset takes place. These data are then forwarded to the aggregator. The data transmission from the asset to the aggregator represents the next technical requirement. The aggregator aggregates its pool and prepares a bid for the spot market, which is submitted to EPEX – the next data transmission between players (data transmission aggregator market). If the bid is accepted, this information must be transmitted back to the aggregator (data transmission market-aggregator), who then sends a new schedule or switching commands to the assets in its pool (data transmission aggregator-asset), which results in a switching process. At the same time, EPEX transmits the data of the entire traded schedules to ECC (transmission market-clearing house). ECC forwards the aggregated schedules for each grid area to the responsible grid operator (data transmission clearing house-grid operator). In the presented process, data transmission between different players, data collection and switching of the physical asset can be identified as technical processes. [7-10]

To allow the comparison of the new business models of C/sells, this process is generalized in a general process framework (see Figure 3-1). It starts with a physical asset with data collection and switching, followed by aggregator, market, clearinghouse, and grid operator with data transmission between adjacent players.

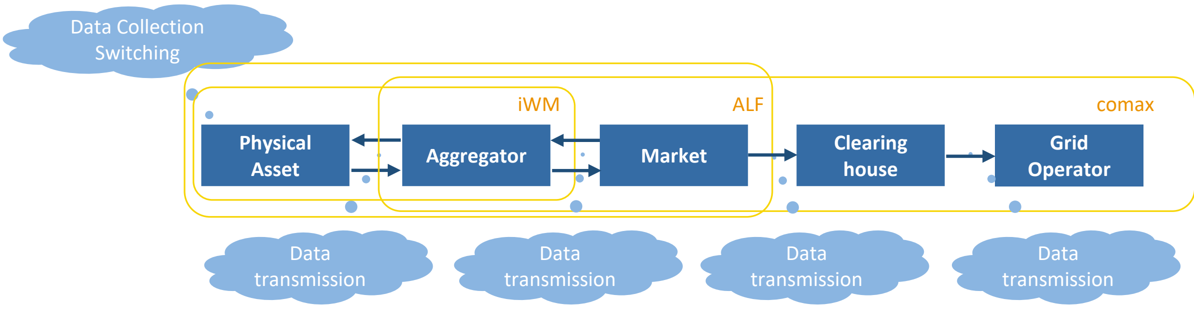

Figure 3-1: General Process Framework

The new business models cover only a part of the identified general process framework, due to on one hand the partial realization in real-life field demonstrations and on the other hand the concepts themselves. In iWM, the process ends at the aggregator, as the schedules from the virtual power plant are not sent to EPEX in real terms. However, on the next day the determined schedules are dispatched, so that the switching takes place. In ALF, the process ends at the market, as the role of the grid operator is taken over by a virtual control room, so neither clearinghouse nor grid operator are participating in the real-life field demonstrations. In a future implementation, this would, however, change. In comax, the other side of the process chain is covered. The physical asset is explicitly not part of the concept. The concept stops at the aggregator, the aggregator is then responsible for the physical realization of the flexibility offer. [4-6]

3.1 Comparison of the different business models

Even though the business models cover only a part of the framework, there is enough overlap to compare the different approaches. The comparison is split into (1) data collection at and switching of a physical asset, (2a) data transmission between physical asset and other players and (2b) further data transmission. For the first two parts only ALF and iWM are considered, for the third part only ALF and comax.

Data collection at and switching of a physical asset

To compare the technical implementation of data collection and switching, the following aspects are analyzed: hardware and aggregation level as well as the consideration of latency in switching operations and the implementation of a proof of the switching operation ("switching proof").

In ALF, households with PV systems are equipped with a non-certified intelligent metering system from PPC and a non-certified EON control box for switching. The use of certified intelligent metering systems was not possible as at the time of the real-life field demonstration, the certified intelligent metering systems could not perform switching operations. Another missing feature of the certified intelligent metering systems for the real-life field demonstration in ALF is TAF 9 (Actual feed-in of a generating facility). The real-life field demonstration in ALF is also a test for PPC for new features to be certified, so the features of the certified intelligent metering systems were evolving dynamically in C/sells. Prerequisite for the PV systems to participate in ALF is a ripple control interface or a possible step by step power reduction. Each household receives an intelligent metering system, a control box, and an additional modern metering equipment (mME) for the PV system, so that it is both an individual measurement and an individual control as aggregation level. In case of a flexibility call of the PV system, the intelligent metering infrastructure is activated 2 minutes before switching and the power measurement is started. The switching channel is set up 1 minute before switching. In this way, latency times are considered in any case. The power measurement ends approx. 1 minute after the successful switching, so that sufficient measurement data is available to verify the successful switching. The switching proof is a two-stage verification: on the one hand, there is a communicative feedback via the intelligent metering system that the process has been successfully executed ("control command sent to control box") and, on the other hand, the power values at the PV system. [5]

At iWM, several different hardware options are used to equip the power-to-heat systems since the goal is to create a (mostly) hardware independent solution and to integrate current commercially available options. Four power to heat systems are equipped with non-certified intelligent metering system in combination with an FNN compliant Theben control box. In addition, some systems are equipped with Tekmar systems in combination with a mME. However, most power-to-heat systems are equipped with the StromPager and a mME. To integrate all these different solutions, a ‘field transfer layer’ was developed, which connects the different technologies to the virtual power plant. Regarding the aggregation level, there is single system control for an individual apartment but also multi-system control for an entire block of apartments. Analyses has shown that multi-system control results in relevant cost savings with only slightly lower revenues, therefore, in a future system multi-system control would be used. Data collection always takes place directly at the individual system or the individual apartment. All metering systems continuously record power values, which are continuously sent to the SWM control center. Thus, with this also the proof that the switching operation has taken place is given. Unlike ALF, individual switching commands are not sent to the systems, but schedules for the next day. As a result, latency times are not relevant. [4]

For the further analysis and evaluation of the two business models, data collection and switching of business models on current markets is compared. For balancing services, the participation is strongly determined by the prequalification, which has high requirements regarding security, automation, and real-time data [11]. Aggregators, such as Entelios or NextKraftwerke, developed proprietary solutions to meet the requirements. Entelios installs the e-Box at the customer's site, while NextKraftwerke installs the Next-Box. When a bid has been accepted, real-time data (with a resolution sometimes in the millisecond range when ramps are run) is continuously sent to the aggregator. The switching proof is done via the real-time data. In intraday/dayahead-marketing, there is no prequalification like for balancing services and thus no fixed specifications regarding data collection and switching of the system. The minimum requirements to participate in the spot markets are low, automation is not necessary. Therefore, there is no standardization. The degree of automation mostly depends on the frequency of use as well as on economic considerations. At NextKraftwerke, for example, the connection is made via interfaces of the inverter. Intelligent metering systems are not used in current processes. The reason for this is the rollout, which has only just started, and some legal questions. [7,8,10]

In summary, it can be stated that for data collection and switching current processes could not serve as a model, because, on one hand, the solutions of the balancing services are very cost intensive and can hardly be economically applied to small-scale assets and on the other hand, in flexibility marketing at the spot markets, there are no standards and often little to no automation, so it is not applicable to small-scale assets due to the manual effort involved. Therefore, the two new business models choose their own solutions. Both business models have the intelligent metering infrastructure in mind, but iWM focuses on the StromPager due to low maturity of the intelligent metering infrastructure at the start of the real-life field demonstrations with missing features.

Data transmission between the different players

In the following, data transmission between physical asset and other players (2a) is analyzed. The focus is on the type of data transmission (technical infrastructure) and the frequency of data transmission.

In ALF, data transmission from the PV system to the platform is done using LTE or a combination of LTE and powerline. Here, the powerline connection is used to connect the customer to the local network station to address the partially poor or missing LTE connection in the basements of the household customers. In ALF, the frequency of data transmission is general low, data transmission is performed on demand or at specified points in the process (for example 2 minutes before switching), there is not continuous data transmission in the concept. However, switching commands instead of entire schedules are being sent which increases the frequency of data transmission. In addition, there is no aggregation of systems on the level of data collection and switching which also increases the total data transmission. [5]

In iWM, data transmission from the power-to-heat system to the aggregator is done using the mobile (phone) network (if available, LTE) for measuring and Long-Range Wide Area Network (LoRaWAN) for switching. Measurement data are sent continuously, the focus here is on robustness/redundancy rather than data economy, while data transmission of new schedules is on demand and only one time a day and at the house level instead of the plant level (i. e., a higher level of aggregation). [4]

On current spot markets, data transmission from the customer to the aggregator is not standardized. For example, data transmission via mail, which is automatically forwarded to the machine via schedule management, is possible. For the communication via mail the public internet is used. This distinguishes it from balancing services, where VPN or non-public mobile (phone) network must be used for security reasons. [7,8,10].

For the data transmission between the different players excluding the physical asset different type of data transmission is used.

In ALF, the flexibility demand of the (virtual) network operator is provided via an internal interface and thus via the network of the platform. The communication of the platform to the aEMT for switching is done via API. [5]

In comax, initial data transmission to the market platform is done via web interface. Data transmission from the market to the other players is via mail (with csv file). [6]

On current spot markets, data transmission between aggregator and market takes place via mail and csv file. The market sends the schedules via ftp and csv file to the clearing house, which forwards them in aggregated form via mail and xml file to the network operators. As mentioned before, at the spot market public internet is used, while for balancing services VPN or non-public mobile (phone) network is used. [7-10].

In summary, it can be stated that data transmission between the different players without the physical asset is mainly via mail and csv file. This standard has been transferred from current processes to the new business models. In contrast, there is no uniformity in data transmission from the physical asset to other players. In the new business models, however, mobile (phone) network, especially LTE, seems to be one approach. The requirements of the business models for the resolution of the data or even the frequency of data transmission vary. Data economy has not yet been the focus of the research projects, so continuous data transmission is sometimes used, although only a subset of the data is actively required.

	Current markets with Aggregator	iWM	ALF	comax
Physical Asset	pool of flexible assets	power-to-heat systems (heat pumps and electrical storage heaters)	PV systems with ripple control or a possible step-by-step power reduction	not specified
Hardware for Data Collection & Switching	balancing Services: high prequalification requirements results in proprietary solutions of aggregators spot markets: very low requirements with no standardization	several: noncertified intelligent metering system + Theben control box; StromPager or Tekmar system + modern metering equipment	noncertified intelligent metering system + eon control box	not in concept
Data Transmission between asset & other players	balancing Services: VPN or non-public mobile network Spot markets: public internet	mobile network (LTE if available) for measurements, LoRaWAN for switching	LTE or LTE + powerline	not in concept
Data Transmission between other players	balancing Services: VPN or non-public mobile network Spot markets: public internet (mail or ftp + .csv or .xml, depending on players)	not in concept	internal interface / network API	web interface mail + .csv

Figure 3-2: Summary of technical implementation of the new business models in comparison to existing processes

In general, the comparison of the new business models with existing processes (summarized in **Fehler! Verweisquelle konnte nicht gefunden werden.**) has shown that in some parts existing solutions can be used while in other parts no standardized solutions exist which leads to a wide dispersion of technical infrastructure in the new business models. Nevertheless, two new components for different steps in the general process framework can be identified: intelligent metering infrastructure for data collection and switching and LTE as a data transmission standard between small-scale assets and the other players.

3.2 Analyses about new relevant technical components for the energy industry

Intelligent Metering Infrastructure

As stated before, at the time of the real-life field demonstration there were some missing features of the certified intelligent metering systems to be used in these new business models. However, development is going on, so a new certified version can be expected soon. Currently, according to [12], the intelligent metering infrastructure consists of 49 features which primarily cover safety-relevant aspects but also some basic features. The features were derived from the defined use cases (TAFs, LAFs, WAFs, HAFs) in [13] for the intelligent metering system and in [14] for the FNN compliant base meter which add to a total of 87 features. There is also already defined which features will be added via software update (no timeline has been published so far). This is for example “Recording and transmission of the current consumption / generation” which is relevant for the new business cases. For a large-scale implementation of new business models such as ALF or iWM, changes in the concept and their technical implementation might be necessary which might also enable the implementation with certified intelligent metering infrastructure with new software updates. There seem to be no critical time restrictions in these two new business models regarding latency of the intelligent metering infrastructure. In ALF, a response time to switching instruction of 5 minutes is necessary, which is no critical time constrain since the latency times for the intelligent metering infrastructure is less than 5 minutes, considering channel setup, switching action, channel clearing and measurement [15].

LTE mobile network

LTE is currently used for mobile devices such as smart phones. In an interview [16] we discussed with an expert how it can be used in the energy industry.

One major challenge for the use of LTE in the German energy system is LTE coverage. In general, LTE coverage in Germany is still very low in some areas. In addition, LTE quality is often inadequate in basements, where intelligent metering systems are mostly located. Unlike for other mobile devices, the transmitter in intelligent metering systems does not move, so short-term poor transmission quality cannot be compensated in this case. Data quality can be improved with the installation of antennas, but this is mostly undesirable in private households for aesthetic reasons. During installation for ALF's real-life field demonstration, 20 % to 30 % of installations had to be abandoned due to lack of or inadequate LTE network. Various options exist to address this issue: In ALF, the combined solution of LTE and powerline has been chosen where LTE has been used till the local network station and powerline then from the local network station to the households. An alternative approach is to set up a totally separate mobile network or to get 5G network's own resources instead of LTE which also results in different both economic and social challenges.

Another challenge for the use of LTE in the energy industry is customer acceptance. Mobile network solutions in the energy industry are often viewed critically, both for safety reasons and health concerns. This challenge is not technical and has to be addressed with for example communication strategies.

Another possible limitation, which has not been addressed so far, is the possible scalability. Here, three aspects are relevant: how many intelligent metering systems can be addressed within 5 minutes in one LTE cell, how many calls can reach the central platform simultaneously and do the large-scale implementation have a high impact on the data consumption in the LTE network? For the last aspect, the impact in comparison to the use of other mobile devices is expected to be low. It depends mostly on how many measurement data and switching commands are necessary in the concept. On the central platform side (receiving measurement data and sending switching commands), there are initially no limitations, although scaling up the real-life field demonstration would result in many parallel dedicated communication channels between the platform and the intelligent metering infrastructure (required number of CPU increases). Non-public cloud solutions could be targeted here. Regarding the aspect 'use in one LTE cell': according to experts [16], 5,000 data transmissions from intelligent metering systems should be possible within 5 minutes. This figure includes security factors and simultaneous use by other mobile devices. This figure increases if LTE is only used up to the local network station and then switched to powerline, as this results in pool control at LTE level. To put this figure in context with the business model ALF, we compare the maximal possible data transmission with the potential ALF participants leading to the conclusion that in a widespread implementation no bottlenecks are expected neither on country level nor on regional level considering metropolitan regions and rural regions as long as an LTE system exist in this area. For detailed calculations see [17].

To summarize, the intelligent metering infrastructure is not mature yet, but it is expected to fulfill the necessary requirements with the next updates. The use of LTE in the energy industry currently still presents some challenges which can, however, be addressed in future. Even with large-scale implementation, no bottlenecks are to be expected due to the LTE infrastructure. In future, both technical components might, therefore, become part in flexibility marketing of small-scale assets.

4 Conclusion

In this paper, the technical requirements of new business models from C/sells are identified and analyzed. Here, particular attention is paid to the intelligent metering infrastructure as a new component of the energy industry and to LTE as a possible mobile communications standard for the energy industry.

To analyze the new business models, a general process framework derived from current flexibility marketing has been defined. Two relevant technical aspects can be identified: data collection at and switching of the physical asset as well as data transmission between the different players.

For data collection and switching, the two business models ALF and iWM have been analyzed. It has been shown that it is possible to use the intelligent metering infrastructure. However, non-certified intelligent metering systems with additional features are used, as some features could not be provided at the time in the certified version. Due to the missing features, intelligent metering systems are also currently not used in current processes. Especially in flexibility marketing at the spot market, data collection and switching currently varies greatly. Thus, it is not possible to build on established standards here. However, with full development of the targeted features and a widespread rollout of the intelligent metering systems, this could change. C/sells was also used here as a test for further features to be certified, so that the implementation of new features can be expected. Therefore, it can be assumed that the intelligent metering infrastructure will become a relevant component of the future energy system.

In the case of data transmission from the physical asset to other players, in the two new business models ALF and iWM, one possible infrastructure identified is mobile (phone) network (with LTE quality, if available). The use of LTE in the energy industry currently still has some challenges such as the incomplete LTE coverage in Germany and acceptance problems for the use of LTE in the energy industry. In the future, however, coverage is expected to improve. With good communications strategies, the use of LTE in the energy industry can thus gain entry. Even with large-scale implementation, no bottlenecks are to be expected due to the LTE infrastructure, as was shown for the concept of ALF. Data transmission between the different players excluding the physical asset is mainly done via mail and csv file. This standard was transferred from current processes to the new business models.

All in all, the technical implementation of new business models can be partly built on current processes mostly regarding the communication between different energy industry stakeholders. However, new processes must be developed for the technical connection of small-scale assets. The intelligent metering infrastructure as a new component of the energy industry can be used for this, but must be further developed for later scalable implementation, as the currently certified version is not sufficient. LTE as a potential mobile communications standard for the energy industry still faces some challenges. However, if these are addressed, large-scale implementation is also possible.

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