Investigation of Data Exchange Processes for Electricity Supplier Change in German Smart Grid Scenarios

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Abstract: In future smart grid scenarios, a greater involvement and active participation of customers are desirable in order to integrate renewable energy. Based on today's electricity tariff schemes an evolutionary process could lead to real-time pricing and a significantly higher frequency of supplier changes. If this becomes reality, the business-to-business processes and the corresponding data exchange processes require most likely adjustments. In this paper it is investigated if current data exchange processes for supplier change are suitable for application to shorter cancellation periods and much shorter contract period for final customer's energy contracts than today in Germany. Market actors and exchange processes are modelled as a multi-agent simulation and three different scenarios of aforementioned future contractual characteristics at the final customers' site are examined. Main focus is given to the processes at the business-to-business level; final customers only act as triggers by contracting new suppliers.

1. Introduction

Today, Europe's energy market has significantly changed when compared to its state 15 years ago. Several legislative packages have forced it towards great liberalization, natural monopolies are unbundled, and market parties are interacting in a complex network of roles and processes. Germany implemented its first liberalization processes in 1998 with the objective to support customer's free choice of energy supplier. Germany's approach favoured utilization of federal associations of the German energy industry and resulted in a strong degree of self-organized market structures. But this so-called negotiated network access had only limited success. Due to missing mandatory standards and various blockades, the desired competition increased slowly. In 2005, politics decided to implement a national regulatory authority and, hence, established the Federal Network Agency (Bundesnetzagentur: BNetzA). This regulatory entity was supposed to identify problems and obstacles in the liberalization process and came up with a bundle of measures and regulations for increased competition during the next years. The number of supplier changes is a good indicator of competition intensity and was steadily increased from year 2006 on, resulting in 3.8M of 45.0M final consumers in Germany changing their electricity supplier in 2012 [1]. Such a high ratio of competition is the result of standardized market processes and intensive observation of potentially discriminating market activities. Especially the standardized and mandatory market processes, which consist of clear process descriptions and fine grained IT interfaces, have a major impact.

Simultaneously to increased competition, the energy turnaround is running. Consumers are provided with more sophisticated energy meters and devices, forming the basis for a much higher degree of automation at the residential level. Moreover, new tariff schemes are frequently discussed by researchers and utilities [8]. Some European countries already applied tariffs with different price-levels based on fixed timeslots. Future scenarios predict real-time electricity tariffs and, consequently, real-time competition accompanied by changes of suppliers within much shorter periods than today. The question is whether existing market communication processes will still be satisfying and whether they are scalable to the vision of a smart grid. We, therefore, investigate the impact such scenarios have on existing standard processes and interfaces established by BNetzA and the associations of German energy industry.

2. Market Processes

The abovementioned standard processes are designed to fulfil today's market requirements. Efficient operation, clear interfaces, and a minimum of manual process steps are facilitated by different regulations. There are three major regulations which concern market processes: Uniform business processes for the supply of electricity to customers (GPKE), change processes in metering (WiM), and market rules for accounting grid billing in the electricity sector (MaBiS). Regarding the introduced future smart grid, a main focus will be on processes described in GPKE. Such processes deal with the change of electricity providers triggered by the final consumer. Today, the timeline fo the complete process as requested by the regulator is three weeks long. This leads to a minimum cancellation period of one month in retail products offered by German utility companies.

Several research projects proposed tariff schemes based on real-time pricing in order to face smart grid challenges like integration of dispersed small-scale generation of electricity and electric vehicles. Such tariffs should support load balancing in order to avoid extensive investment at the grid level (cf. Section 3). If we imagine real-time pricing as a widely available product, the desire for supplier changes in a much shorter timeframe than one month is logical. But is it realistic to achieve this with established market processes or is it wiser to find new solutions as proposed by some research projects concerning smart grids?

The scenario which is subject to investigation emphasises on supplier change processes as defined by GPKE with three different cancellation periods. A detailed description of the scenario and the corresponding multi-agent-simulation can be found in Section 4. It starts with an introduction of GPKE's sub-processes and the underlying messaging technology. Incorporated market parties are final consumer, distribution system operator (DSO), and supplier (a.k.a. electricity retailer).

2.1. Supplier Change Processes

2.1.1. Contracts

In Germany, the regular power supply contract is modelled to provide all-inclusive service to the final consumer. Such contracts include network access fees, metering fees, and tariff information, such as unit costs and base costs. The respective contracting parties are the final consumer and its supplier. The supplier collects grid access fees and metering fees and transfers them to the responsible company. If the customer favours separate contracts with DSO and the metering company, it is possible to conclude a power supply agreement which excludes both, access fees and metering fees. In this paper, we focus exclusively on all-inclusive power contracts. As defined by GPKE, all messages concern future events, for example upcoming begin of delivery.

2.1.2. Cancellation

If a final consumer contracts a new supplier, the cancellation process is triggered by the new supplier. It is unnecessary to come up with documented evidence since the promise of cancellation is enough. The former supplier checks the legitimacy of the cancelation and answers with either an acknowledgement or a denial.

2.1.3. End of Delivery

If cancellation is acknowledged, the former supplier is forced to start the process called “end of delivery”. A message sent to DSO indicates the end of delivery for the consumer's metering points. DSO checks its legitimacy and answers with either an acknowledgement, in case GPKE's deadlines are respected, or a denial otherwise.

2.1.4. Begin of Delivery

If cancellation is acknowledged, the new supplier is forced to start the process denoted as “begin of delivery”. This process is the same for new metering points, in case there is no former supplier. Information about metering points, consumer, and grid accounting is sent to the responsible DSO. After checking the deadlines and the availability of a corresponding cancellation process, the DSO sends an acknowledgement. If cancellation is missing, DSO sends a message to the former supplier. If no answer is received within deadlines, the termination of “delivery for a metering point” is processed automatically. It is increasingly uncertain whether this sub-process is still relevant if a high ratio of automated processes applies to internal business processes of DSO and supplier. Therefore, it is neglected in Section 4.

2.2. Message Definition

The protocol used for message definition is UN/EDIFACT. This protocol has originally been developed by the United Nations for intercompany electronic data interchange (DIN ISO 9735). German utility association (BDEW) is responsible for a subset of messages called EDI@Energy, which are used to implement market communication based on BNetzA decisions [3]. Relevant message definitions for our investigation are UTILMD and

CONTRL. The first one is applied to any message in a supplier change process. The second format is used for technical acknowledgement of a UTILMD message reception. Various use cases utilizing UTILMD are implemented by so-called categories of information.

3. Related Work

The field of standardized market processes could not attract a lot of researchers. Nevertheless, some work was done and, especially in connection with smart grids, the topics start to be of more interest. An international initiative for data modelling in energy domain is CIM IEC 61970. With a strong focus on equipment and grid management [6], the model has the potential to be applied to the market layer and its data exchange too.

The German E-Energy funding programme supported several approaches for future electricity grids and corresponding IT infrastructure. Based on the project *Smart Watts,* a so-called Smart Architecture was introduced [7]. The authors claim that a better support for inter-company data exchange is necessary to let a so-called *Internet of Energy* become reality. The developed architecture mainly consists of a messaging middleware function and brings support for identification, information, and security needs. The GPKE supplier change process is used as an example. Detailed analysis of current cost-effective solutions to market data exchange is missing. Another E-Energy project named MEREGIO created new market roles and applied novel incentive systems to a field test with up to 1,000 customers. The supplier's role was reinvented to be the future energy service supplier and to fulfil needs of EVs, dispersed generation, and shiftable loads at the customer's site. Furthermore, the need for a demand side management responsible was addressed by extension of the *imbalance settlement responsible* to a new *dynamic imbalance settlement operator* [8].

4. Simulation Approach

4.1. Design

The simulation environment uses Repast Symphony 2.0 to provide the general multi-agent-framework and runtime. We created essential agents (DSO, supplier, final consumer) and implemented a restrictive message flow based on legal relations (see Fig. 1). The final consumer is a residential or small business consumer managed with synthetic load profiles. For agents' interactions, only asynchronous messages are allowed. Processing time required by companies is modelled as individual timeouts based on 1) maximum allowed deadline today and 2) new deadlines necessary if shorter cancellation periods appear.

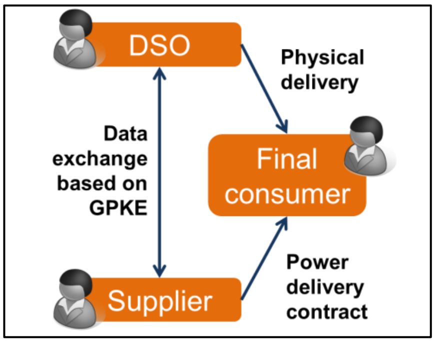

Fig.1: *Relations between agents.*

The actual messages taken from GPKE and corresponding EDI@Energy documents [3][4][5] are modelled as reduced version of the original data model. We counted the number of messages on several measuring points in the simulation. Amount of data in Bytes is calculated using individual size for every message category. A selected sub-set of all possible messages represents the significant message flow during a supplier change process (see Tab. 1). Every message is sent individually to avoid delays of bundled and batch processed messages.

4.2. Simulation Scenarios

All scenarios cover a number of one thousand final consumers, completely equipped with smart meters. Furthermore, two DSOs and ten suppliers are implemented. Initial assignment of consumers, DSOs and suppliers is made by random. A baseline scenario deals with a certain situation for the next five years. Typical power delivery contracts are running for six month fixed. After that point in time, the consumer decides whether to change or keep its supplier. Final consumer's propensity of supplier change is 50 %, which is quite higher than today (around 10 % [2]). The cancelation period is four weeks. The second and third scenario reflects higher propensities of supplier changes, shorter contract periods, and shorter cancellation periods (detailed data see Tab. 2).

Market Processes	Sub-Processes	UTILMD Message (Size)
Cancellation	Transmission of cancellation	E35 (803 Bytes)
	Acknowledgement of cancelation	E35_E15 (879 Bytes)
End of delivery	Delivery deregistration	E02 (553 Bytes)
	Acknowledgement	E02_E15 (506 Bytes)
Begin of delivery	Delivery registration	E01 (890 Bytes)
	Deregistration request	E02 (553 Bytes)
	Information of existing registration	E44_Z26 (494 Bytes)
	Deregistration answer	E02_E15 (506 Bytes)
	End of registration message	E44_ZC8 (478 Bytes)
	Acknowledgement of registration	E01_E15 (1472 Bytes)

Tab.1: *Implemented messages based on GPKE / EDI@Energy.*

Parameters	Scenarios Baseline	A	B
Propensity of supplier change	50 %	70 %	90 %
Cancellation period	4 weeks	1 week	1 hour
Contract period	26 weeks	4 weeks	1 hour
Number of final consumers	1000		
Number of suppliers	10		
Number of DSOs	2		

Tab.2: *Scenario parameters.*

Scenario	Category E01	Category E02	Category E35
GPKE	4 wd	3 wd	3 wd
Baseline	5.6 d (134.4 h)	4.2 d (100.8 h)	4.2 d (100.8 h)
A	1.4 d (33.6 h)	1.05 d (25.2 h)	1.05 d (25.2 h)
B	0.2 h (12 min)	0.15 h (9 min)	0.15 h (9 min)
h: hours, d: days, wd: Working days			

Tab.3: *Deadlines within different categories and scenarios.*

The baseline scenario respects all deadlines stated in GPKE documents. For scenario A and B, the deadlines need to be adjusted; otherwise processes will not finish in time (see Tab. 3).

4.3. Performance Indicators

All measured data coming from the simulation is aggregated to three key performance indicators, which allow statements about investigated scenarios (Tab. 4).

5. Evaluation

Essential results of the evaluation are displayed in Tab. 5, Fig. 2 and Fig. 3. The baseline scenario leads to a total number of 989, scenario A to 9,135 and scenario B to a number of 7.7 M supplier changes. Whereas in the baseline scenario, 13,852 messages were managed per day, the possibility of monthly supplier change led to 128,981 messages per day and the hourly change to 109 M messages daily. In all cases, the data volume is not significant. Not even the extreme scenario B reaches a notable volume.

Indicator	Unit	Description
Processed messages	Messages per agent	Overall, individual effort of market communication
Load factor	Processes per agent	Internal effort, stated by maximum in parallel running processes (supplier changes)
Daily data volume	MBytes per agent	Technical effort of EDIFACT data

Tab.4: *Performance indicators.*

Results	Scenarios Baseline	A	B
Yearly supplier changes	989	9,135	7,784,400
Yearly Messages	13,852	128,981	109,649,600
Daily data volume of Supplier	2.5 KB	23 KB	19,505.7 KB
Daily data volume of DSO	6.7 KB	61.8 KB	52,754.4 KB

Tab.5: *Results of random supplier changes and data volume.*

A look at the load factor, however, is more interesting. The expected increase of operational effort is clearly visible (Fig. 2). It indicates the maximum number of processes running in parallel. This is crucial because a supplier change is a sequence of processes (cf. Tab. 1). Suppliers came up with an average load of 8.1 processes and a maximum of 18 processes. Within scenario A, the average increased to 19 and the maximum to 39 processes. The extreme scenario B leads to a maximum load of 219 and an average load of 121.9 processes. The reason for such a high load is the increased number of supplier changes on the final consumer's side. The high difference between average and maximum load is due to the small amount of DSOs. In the worst case, a DSO has to process 48 messages per minute, meanwhile, the average is only 35 messages per minute (Fig. 3).

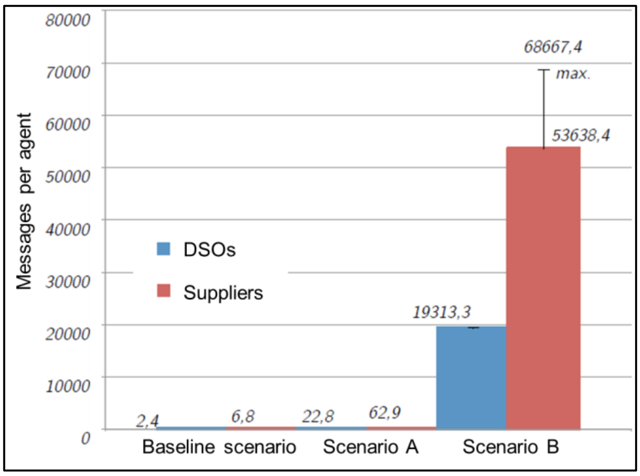

Fig.2*: Daily processed messages per agent type.*

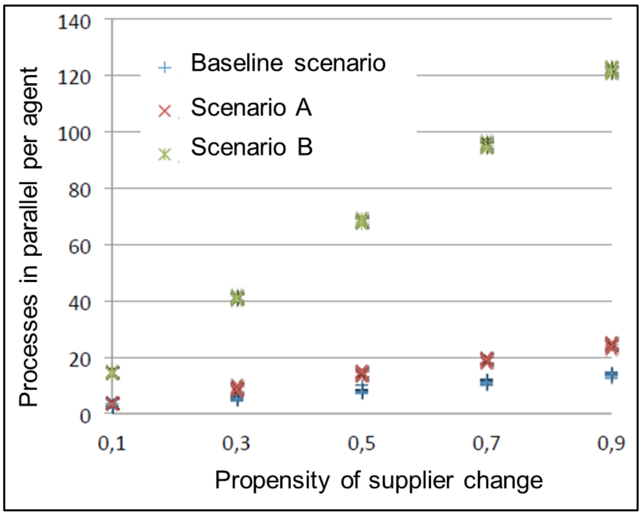

Fig.3*: Load factor analysis showing processes running in parallel per agent.*

6. Discussion

As anticipated, the operational effort for suppliers and DSOs increases if the propensity of supplier changes is higher. While partly manually managed processes are imaginable in the baseline scenario, scenario A already implies to have all operational processes automated. Starting with monthly possibilities of supplier changes, however, the operational effort increases significantly. All following company-internal business processes require a maximum amount of IT support. Outliners are rarely accepted anymore. Nevertheless, one of the core findings needs to be stated: Adjusting deadlines to allow for faster processes was the only change we made. All other messages were the same as in the basic scenario. Thus, the existing market processes for supplier change seem to be fine for a long time. At a certain point in time, the number of processes and exchanged messages will increase to an amount where classic batch processing is not sufficient anymore and the ability to handle messages in parallel will be crucial.

7. Conclusion

Starting with an enthralling research question accompanied by high practical relevance, the investigation explained selected market processes and their historical background. We created a necessary connection between today's data exchange processes and future requirements resulting from smart grid concepts. Unlike common practice in research, we took the challenge to include real existing standards within the simulation.

Furthermore, a powerful multi-agent simulation is created, which allows further sophisticated scenario analysis. Meanwhile, existing market processes of GPKE could be validated to fit for much more flexible scenarios of supplier changes or even completely new tariff schemes. Based on the achieved results, a scenario with fixed contract periods and implicit cancellation would be reasonable in order to reduce the number of exchanged messages. Furthermore, real-time pricing or dynamic grid access fees could be applied here.

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