Analysis of Technical Devices Relevance for Remote Readings of Electric Meters

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Abstract. The following article presents analysis results of technical devices relevance for remote readings of electric meters. Real communiqués of reading centrals with selected types of meters were charted by using different protocols for individual readings. Types of stored data, the system of their collection and results of analysis from different points of view were described. The analysis of individual data transition ratio was done initially; next, times of readings for selected types of meters, total readings of data and error rate of meters according to used transmission protocols VDEW, DLMS and SCTM were assessed for continuous period of four months. Results presented here are based in real operations and they are important for effectivity evaluation of the currently used system of electro meters remote readings and its next development.

Keywords: Smart metering · AMR · GPRS · SCTM · VDEW · DLMS

1 Introduction

At the beginning of building the remote communications with meters in Czech Republic, it was important that the offtake site was equipped with connection to public phone network. This requirement transferred part of expenses in form of providing phone lines to operators of offtake sites. At first this included mostly big customers, transfer sites in the system, and producers of high voltage and extra-high voltage electricity. The situation changed slowly after implementation of GSM and GPRS technology because all expenses for remote readings go to the energy company. Considerable increase of offtake sites with remote communication was, inter alia, contributed by new legislation connected with electric energy market liberalization. At this point the progress concerned the exchange of real data among market participants with help of direct reading technology: electro meter – data central – invoice system (i.e. SAP). In the mid 1990s only several dozens of sites were read remotely, primarily in properties of energy companies. After development of technologies at the time of data analysis realization, there were ten thousands sites in the Czech Republic. Data collection standard is an automatic electro meter reading technology as can be found in [1, 2] (AMR), which belongs to Smart metering group [3–5], which is a fundamental cornerstone for creating Smart Grids as mentioned by authors [6] or [7–9]. However, AMR system only allows sending data from electro meters to reading central [10]. It is, however, only one-way

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communication that allows arbitrary data readings and lowers expenses of manual collection of data by a reader. GSM and GPRS technologies are still used for data transfer between metres and data central. Despite GSM technology being proven with years, it is unsuitable for remote meters readings for its financial costs. Especially when there is a need to read more sites. Therefore, GSM technology is used mostly as a backup line when GPRS is unavailable or absent. An integral part of data collecting is communication protocols defining rules of transfer between electro meters and the reading central. Serial Code Tele Metering (SCTM) is among the oldest used protocols, which is used exclusively on the meters of older production date; details about this protocol can be found i.e. in [11]. Two different protocols have the largest percentage of use: one of them is VDEW protocol based on three-layered architecture EPA described in detail in [12] and DLMS protocol which had become international communication standard working on server-client principle and its specification is stated in [13]. Some electro meters can work with both mentioned protocols or with only one of them. Therefore, the statements above show the significance of analysis of current results from the point of view of reliability and effectivity of readings in real-time operations that can point out potential imperfections of used technical equipment and individual protocols. Potential high level of unreliability and error rate has a wide range of impact not only for technical solution itself but also economic impact in a form of redundant expenses invested in human resources, and non-effective expenses in communication and technical equipment.

2 Selected Meters Testing Procedure

Group of meters including the most commonly used types for high voltage and extra-high voltage levels disturbed in the Czech Republic were chosen for the testing. Testing and analysis realization took place in 60 places, while the emphasis was put on that the metres were located in electric distribution network of ČEZ Distribuce, a.s. company, and in the location with sufficient mobile operator signal or trouble-free lines in case of PSTN technologies readings. Data readings were done with the help of mobile operator (O2) and they were realized by GSM or GSM/GPRS technology, where GSM held a backup way of reading if GPRS was non-functional. All meters had to use modems supplied and recommended by their producers. Data collection was executed with the help of data central Converge from Landis&Gyr company. Meters samples from all meter technology producers were used and from every line 5 m with corresponding modems were integrated into the analysis. The exception was a meter group from the same type line communicating in multi-master operation (cascade) with 11 pieces. Data for analysis were acquired from data/reading central Converge in version 3.9.7 from Landis&Gyr company and managed by ČEZ Distribuce, a.s. company.

2.1 Testing Data Use Overview

Two types of data are saved in electro meters to two different memories (buffers). First data area includes Load profile (sometimes labelled as Last profile), which is a data row containing measured physical unit values with time mark and with possible status of the respective value. For reading measurement in offtake sites measures with three profiles are used. One profile is used for active offtake and two for reactive energy. Electro meters with six profiles (6LP) are used when measuring producers of electric energy and transferring places between distribution systems. There two profiles measure active offtake and supply. The other four is used for reactive energy. The principle comes from a four-quadrant model of measuring electric energy where the difference among three profiles has no significant role and from the time point of view is negligible. All tested meters use fifteen-minute time period for measuring the profiles, which is the highest reached average maximum per time unit.

The second data area includes register values (BV – Billing Values) that contain information about parameters of electro meters (serial number, type of electro meter, number of systems, records, etc.). Values of energy in certain time or certain time period are recorded into registers. Measured data are stored here in a form of enumeration such as total used or created energy in the previous time period. Measured maxims including time marks also belong here. Range and type of recorded registers depend on parameters of specific meters before placing it at the offtake location. From the transfer point of view registers usually have smaller data capacity than values of the firstly named profiles. Part of the electro meters register telegram is illustrated in Fig. 1.

Historical Profile:

Reset Time From Meter	Reset Counter	OBIS Code	Value	Scale	Unit	Status
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:21.8.0	13523594.00	1000.00	Wh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:41.8.0	13300953.00	1000.00	Wh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:61.8.0	13707545.00	1000.00	Wh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:1.8.0	40529682.00	1000.00	Wh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:22.8.0	32339.00	1000.00	Wh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:42.8.0	31114.00	1000.00	Wh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:62.8.0	30393.00	1000.00	Wh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:2.8.0	92144.00	1000.00	Wh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:23.8.0	3077569.00	1000.00	varh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:43.8.0	2928120.00	1000.00	varh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:63.8.0	2999941.00	1000.00	varh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:3.8.0	8991257.00	1000.00	varh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:24.8.0	98045.00	1000.00	varh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:44.8.0	100802.00	1000.00	varh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:64.8.0	103700.00	1000.00	varh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:4.8.0	289742.00	1000.00	varh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:25.8.0	3061682.00	1000.00	varh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:45.8.0	2911669.00	1000.00	varh	0
01.04.2016 00:00:00.000 DST W. Europe Standard Time	37	1-1:65.8.0	2981416.00	1000.00	varh	0

Fig. 1. Example of part of the meter register telegram

2.2 Overview of Meters Used During Testing

General marks used in practice were used for labelling of meters. Individual type series differ only in details that are insignificant for testing, such as difference in accuracy grade, number of tariffs, or if the meters is used for primary/secondary reading. Following meters were used for the testing:

- **ZxD (ZxD3xx/4xx)** – electro meters by Landis&Gyr company are represented by ZMD405CT44.0457 1A, ZFD410CT44.0459B and ZMD410CT44.2407 types. Meters feature profiles and registers. Part of the electro meters communicated through DLMS protocol and part through VDEW. Reading took place with the help of GSM/GPRS technology. 11 electro meters communicated in multi-master operation with DLMS protocol and GSM/GPRS communication.
- **Type SL7000** – electro meters by Itron (Actaris) company are represented by SL7C71_100V2_1A10 and SL7 B71_58V3_1A10 types. These electro meters also have profiles and registers. Protocol DLMS is exclusively used for communication. All devices used GSM/GPRS technology for remote data gathering.
- **Type E700** – are older electro meters by Enermet company. Registers and profiles are stored in the electro meters. Meters of E705DJZ and E705DNJZ type were used through communication protocol SCTM and GSM technology.
- **Types FAG and FBC** – encoders by Landis&Gyr company used only fifteen-minutes profiles in active/reactive offtake and supply as output values. These devices do not read registers. Readings were taken with SCTM protocol and PSTN technology.
- **Type LZQ** – electro meters by Schrack (EMH) company were LZQJ_100V2_5A6_E8 types. For data gathering VDEW protocol and GSM/GPRS technologies were used. Meters read profiles and registers data.
- **Type EKM647** – meters are not classical electro meters but coders for summative measurement. Unlike FAG and FBC types they can read registers. SCTM protocol and GSM communication technology was used for data reading.
- **Type DC3** – older electro meters DC371D types were originally produced by Schlumberger Industries company and they were read by VDEW communication protocol and GSM communication technology. DC3 type can read profiles and registers values.

2.3 Reading Methods and Statistic Data Collection

According to specifications of individual meters the readings were done by GSM/GPRS and PSTN communication technologies. With some meters reading was possible only with GSM technology given by a possibility of installed modem and device. In all occurrences the meters were of older manufacturing date. Virtual electro meter with pre-defined protocol types and number of profiles was created in Converge data central. Readings took place once a day from 1.9.2016 to 31.12.2016. During every reading the values of individual telegrams, therefore values of profiles and registers, were downloaded, and simultaneously check of the time unit was executed. All profile values had a fifteen-minute period. Value reading always started at the last recorded time mark so the data would not override each other or stored profiles. During the register readings the remote data collection was different. A part of the data is overwritten (enumerations of immediate values), changed (phase voltage) or added (maximal values, values from the past period). During the data reading the time control with meter time was realized in reading central. If the time gap reaches up to two second synchronization with time in the reading central happens automatically. If the time gap is longer than two seconds, the synchronization does not happen and it is necessary to adjust the time manually. Reason for the time desynchronization can be too long a time period between individual readings caused for example by operator signal being out of reach, weak battery in electro meter or error in electro meter's memory. In the last two cases service maintenance is necessary at the offtake site.

2.4 Reading Course

In GSM mode the communication with electro meter is very similar to a regular phone call. In the reading central virtual electro meter with data number is created. Using this number the central calls to specific electro meter. GPRS communication is very similar to a network connection between two devices. Both devices identify each other with an IP address. Every place with GPRS remote reading has SIM with an IP address assigned. This address is registered in the system of reading central. Converge data central uses exclusively static IP addresses for remote readings. Except for IP addresses a data phone number is filled in communication. That is so in order to choose between GSM and GPRS modes. Communication in multi-master operation is used only in case of cascade connection when all electro meters are connected through one data number. Every electro meter in cascade has specific identification number (ZDUE Password, Physical address) that guarantees its uniqueness. Most of the time they are serial numbers of individual electro meters either in their full or partial form. Meters in cascade cannot be mixed. PSTN communication is similar to GSM. All tested devices used SCTM protocol at the same time. Every meter has specific address in the central, which is not kept in practice and the passwords are set collectively.

3 Operation Evaluation

All meters were chosen to be situated in the same or close locations to eliminate possible influence of mobile operator signal accessibility during testing. During data reading the reading success in everyday operation was compared, therefore the execution of all predefined and planned tasks, such as already mentioned profile and electro meters registers readings, including control or synchronization of time unit. A part of the testing was also one the offtake site working in multi-master operation in order to analyse negative influences of this meter group to common reading.

3.1 Reading Times Comparison

In Fig. 2 average data volumes between data central and individual meters are depicted. From the picture it is clear that the values of tasked profile have the largest share and the smallest one is the time.

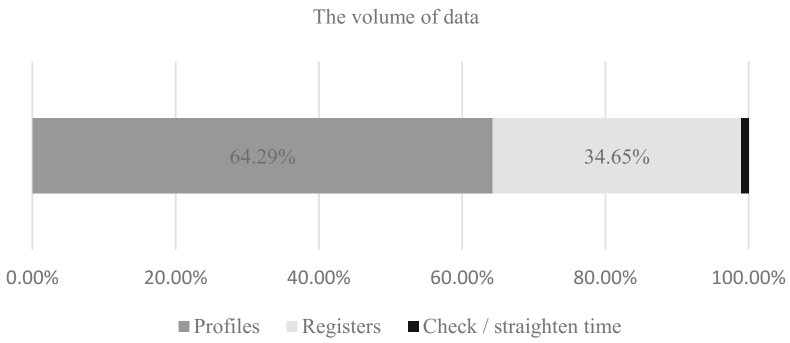

Fig. 2. The average volume data for remote reading

From the analysis of acquired values the time period of individual reading jobs was discovered. In the Fig. 3 reached times during observed period are depicted. There is a distinct difference between the time of profile and register readings. In this relative small test the differences do not seem to be very essential from the practical point of view, however, in the general use these transition time parameters play an important role. SL7000 type electro meters need the longest and with a distance the ZxD is the same which is given by DLMS communication protocol use. ZxD type electro meters were read by two types of communication protocols (DLMS and VDEW) and because of that the time difference was shorter in average. FCB type device and FAG do not feature registers and therefore they are not mentioned in the graph. Very similar time came from profile values reading because there is not a great difference in the data volume. All older devices had higher time demand at the beginning and also the end of connection. From all tested meters E700 electro meters had the greatest problem with establishing and terminating the connection. On the other hand, LZQJ, SL7000 and ZxD had the least difficulty with establishing and terminating the connection. All three electro meters fall in the group of newer devices than E700.

3.2 Operation Evaluation According to Data Readings

In Fig. 4 average data readings of every day remote collection are depicted. Successful electro meter reading includes transferring of all necessary telegram values such as profile data and electro meter register including time unit control with data central. In partial readings data transition was not successful in one or two items. For example, register values were read and time control was successful. However, profile reading failed etc. Errors are best analysed on the basis of interrupted telegrams during the communication. In a case of telegram interruption data central initiated new transfer after 30 s. Five tries in total were set and if used up the transfer was evaluated as failed. The highest percentage of successful data reading had FAG and FBC coders because this device does not feature registers therefore lowering the possibility of problems with data reading. Despite a high percentage of successful data collecting in several cases the readings were successful after new transfer. DC3 and E700 types showed higher number of interrupted telegrams during the testing. During data registers reading interruption of connection with data central came about and with that time delays connected with repeated transfers. ZxD, SL7000 and LZQJ electro meters have similar values despite using different communication protocols. Communication results showed that GPRS technology is problematic. Data readings in GPRS mode have worse readings than GSM or PSTN. Main reason for this was bad signal. Problems did not happen during the whole testing period, they came in irregular and unexpected intervals. However, when the connection in GPRS mode was established it was stable during the whole data reading. Between 1.9.2017 and 31.12.2017 there were only few occasions when the GPRS data collection was not possible. When the communication technology was unavailable the readings were done manually in data central through GSM Backup Line tool. Because of this possibility LZQJ, ZxD and SL7000 electro meters have average data reading over 80%. During this testing the cascade (multi-master operation) connected group of meters was added. Readings of ZxD meters group was influenced minimally by this.

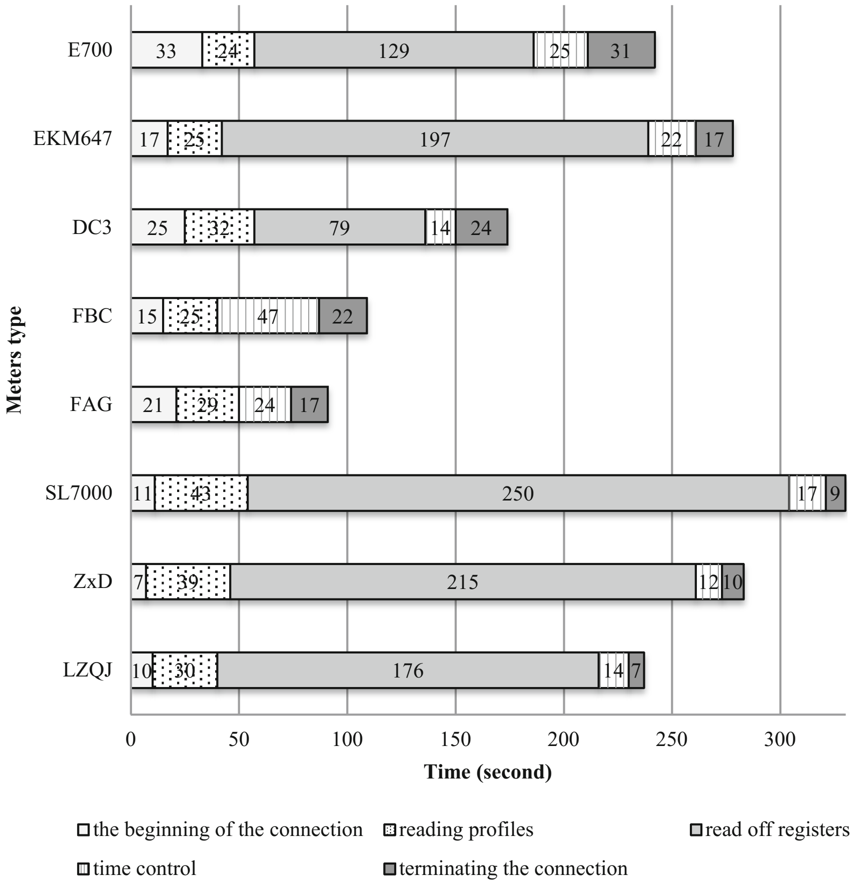

Fig. 3. Times readings for various types of gauges

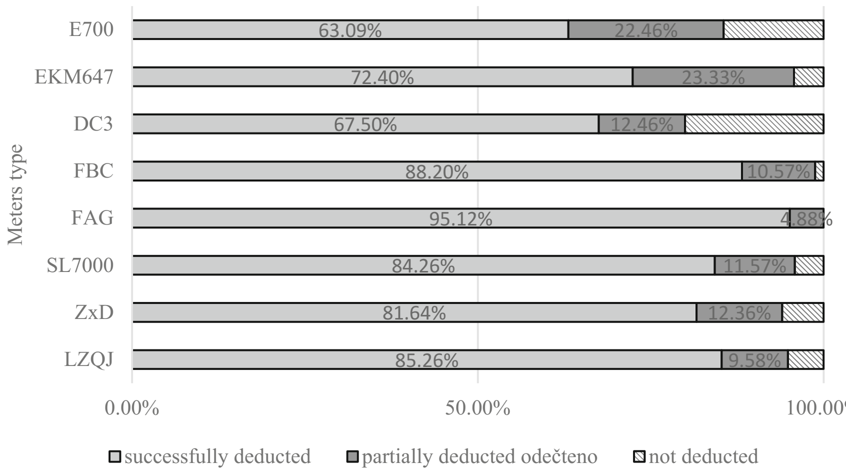

Fig. 4. Total reading of data

4 Conclusion

The aim of this study was to analyse available and used technical devices for remote readings of AMR system electro meters. The behaviour of selected technological devices in AMR operation was tested and analysed in real operation in period between 1.9.2016 and 31.12.2016 focused on reliability, reading effectivity and communication with used protocol and volume of transferred data. Selection of theoretical criteria based on intern data of ČEZ Distribuce, a.s. company was done at the beginning of testing. That was followed by a practical test between meters selected in theoretical part and data (reading) central Converge by Landis&Gyr company. Some meter types do not meet selected criteria and in electro-energetic networks, therefore they should not serve as devices for collecting invoice values. In the future they can be used for example as secondary meters controlling collected data from electro meters installed by distribution companies. This applies to FAG, FBC and EKM types of coders that still can carry out some of the tasks but the only reason they are still used at reading sites or transmitting sites is reluctance of entrepreneurs to change the contract between the customer and the distributor of electric energy. In the current technical solution these coders collect data from electro meters that meet all requirements of the present-day invoice meter. Unlike said coders electro meters DC3 and E700 meet some of the requirements but they are morally old and their next use cannot be recommended due to their unbalanced performance and relatively high error rate. Devices mentioned also do not meet requirements for Smart Metering that will probably replace current remote data collection in the future. Only devices that meet basic standards if the full Smart Meeting system is established are LZQJ, SL7000 and ZxD electro meters.

In the general evaluation it can be said that all electro meters showed very similar results in practical testing. Individual differences were based for example on used communication protocols or technical support. Communication protocol DLMS had advantage during the testing due to missing drivers in Converge central that was by the same producer/supplier as type ZxD electro meters, despite DLMS being thought standard in the world, while his concurrent VDEW is overshadowed and can be found only in older devices or electro meters from Landis&Gyr company that support them. Older meters (except FAG) had higher error rate during the testing mostly in responses and errors in exceeding maximal waiting time for telegram. They also connected and disconnected. The worst was E700 electro meter that had the worst results in all tests. On the other hand FAG coder reached the best results despite belonging in older meters category. FBC devise can be found in load profiles without registers which is in accordance with current legislative that uses load profile for invoice values. It seems like a paradox that only register values undergo demanding testing in metrological testing room. From the register values progress of the electric use reading cannot control unlike in the profile with 15-min intervals. The important aspect is whether during the testing the results were not influenced. An open question for the future is the use of GPRS communication technologies that lacks some qualities and advantages of remote data collecting. During the analysis of real operation problems with availability of this service were recorded and additional reading with GSM technology was necessary. Therefore the demand from the electro meters producer for LTE technology support seems logical. Another possible testing variety is using PLC (also BPL) technologies in distribution companies because they are accounted for in Smart Grid area and Smart Metering area. The main reason for their use is a full control of energy companies such as ČEZ Distribuce over most of the network and minimal expenses when the new network will not have to be built. One of the possible ways to replace the current AMR technology is to unite it with AMM (Advanced Metering Management) or with AMI (Advanced Metering Infrastructure). However, for this realization it is necessary to obtain the long-term analysis of usability of diverse technical devices for remote readings of electro meters because their mass replacement in the short-term is technically and financially impossible. Therefore, the aforementioned implementation of currently used remote electro meter reading technical devices into AMM or AMI systems analysis was carried out. This work and the contribution were supported by project of specific science “Computer networks for cloud, distributed systems, and Internet of Things”, Faculty of Informatics and Management, University of Hradec Kralove, Czech Republic. We would like also thank to students Lubos Mercl and Pavel Blazek.

References

1. Tan, H.G.R., Lee, C.H., Mok, V.H.: Automatic power meter reading system using GSM network. In: International Power Engineering Conference (IPEC 2007), Singapore, pp. 465–469 (2007). ISSN 1947-1262
2. Khalifa, T., Naik, K., Nayak, A.: A survey of communication protocols for automatic meter reading applications. IEEE Commun. Surv. Tutor. **13**(2), 168–182 (2011). https://doi.org/10.1109/surv.2011.041110.00058. Accessed 16 Mar 2018. ISSN 1553-877X
3. Geetha, A., Jamuna, K.: Smart metering system. In: International Conference on Information Communication and Embedded Systems (ICICES), pp. 1047–1051. IEEE (2013). https://doi.org/10.1109/icices.2013.6508368. Accessed 16 Mar 2018. ISBN 978-1-4673-5788-3

4. Lin, H.-Y., Tzeng, W.-G., Shen, S.-T., Lin, B.-S.P.: A practical smart metering system supporting privacy preserving billing and load monitoring. In: Bao, F., Samarati, P., Zhou, J. (eds.) ACNS 2012. LNCS, vol. 7341, pp. 544–560. Springer, Heidelberg (2012). https://doi.org/10.1007/978-3-642-31284-7_32
5. Horalek, J., Sobeslav, V., Krejcar, O., Balik, L.: Communications and security aspects of smart grid networks design. In: Dregvaite, G., Damasevicius, R. (eds.) ICIST 2014. CCIS, vol. 465, pp. 35–46. Springer, Cham (2014). https://doi.org/10.1007/978-3-319-11958-8_4
6. Rial, A., Danezis, G.: Privacy-preserving smart metering. In: Proceedings of the 10th Annual ACM Workshop on Privacy in the Electronic Society - WPES 2011, p. 49. ACM Press, New York (2011). https://doi.org/10.1145/2046556.2046564. Accessed 16 Mar 2018. ISBN 9781450310024
7. Verbong, G.P.J., Beemsterboer, S., Sengers, F.: Smart grids or smart users? Involving users in developing a low carbon electricity economy. Energy Policy **52**, 117–125 (2013). https://doi.org/10.1016/j.enpol.2012.05.003. Accessed 16 Mar 2018. ISSN 03014215
8. Roberts, B.P., Sandberg, C.: The role of energy storage in development of smart grids. Proc. IEEE **99**(6), 1139–1144 (2011). https://doi.org/10.1109/jproc.2011.2116752. Accessed 16 Mar 2018. ISSN 0018-9219
9. Wolsink, M.: The research agenda on social acceptance of distributed generation in smart grids: renewable as common pool resources. Renew. Sustain. Energy Rev. **16**(1), 822–835 (2012). https://doi.org/10.1016/j.rser.2011.09.006. Accessed 16 Mar 2018. ISSN 0018-9219. ISSN 13640321
10. Horalek, J., Matyska, J., Sobeslav, V.: Communication protocols in substation automation and IEC 61850 based proposal. In: IEEE 14th International Symposium on Computational Intelligence and Informatics (CINTI), pp. 321–326. IEEE (2013). https://doi.org/10.1109/cinti.2013.6705214. Accessed 16 Mar 2018. ISBN 978-1-4799-0197-5
11. Manual LIAN 98(en): LIAN98. Mayr, Erlangen (2011). http://manuals.lian98.biz/doc.en/manual98en.html. Accessed 01 Jan 2017
12. Protocols: IPCOMM, Nuremberg (2004–2017). http://www.ipcomm.de/protocols_en.html. Accessed 02 Feb 2017
13. Microchip Makes Global Smart Meter Interoperability Easy with DLMS User Association Certified Stack for PIC® Microcontrollers: Business Wire. Lawson (2011). http://www.businesswire.com/news/home/20110719005651/en/Microchip-Global-Smart-Meter-Interoperability-Easy-DLMS. Accessed 08 Feb 2017