

The Evolution of Electrical Energy Measurement in Brazil

Ana Maria Ribeiro Franco ¹, Rosane Moreira Debatin ¹

¹ *INMETRO, National Institute of Metrology, Quality and Technology*
Av. Nossa Senhora das Graças, 50 – Xerém – Duque de Caxias, Brazil
phone: ++55 21 26799074, fax: ++55 21 2143236, e-mail: lapen@inmetro.gov.br

Abstract- This paper shows that the increasing complexity of new equipment for the power grid, mainly transmitted through processes of additional software, is an important issue and needs to be quickly assimilated by the metrological controls to prevent the emergence of problems in the way of smart grid. This paper aims to describe all relevant aspects of this particular experience revealed in Brazil, discussing the real scenario and its challenges opposites.

I. Introduction

The measurement of electric energy began over 100 years ago with the electromechanical meter popularly known as "clock". This type of meter made it difficult to carry out different tasks other than the measurement of electrical energy such as different rates, load profile of consumers, prepayment, etc. The first movement was developing in the early '80s with hybrid versions of electromechanical and electronic energy meters. Finally, the paradigm is completely changed with the adoption of the fully electronic meter.

The current models of electric energy meters are provided with computational logic and communication capacity and bring new possibilities for the measurement process, dissemination and collection of electricity consumption.

The integrated circuit incorporated in the electronic meters was fundamental in developing the concept of centralized measurement. This innovative concept is recognized in Brazil and abroad. Invention patents were granted in Brazil (1992), the United States and several European countries.

The traditional electronic meter is a device that includes the sensor, the indicator (display) and data logger in a single device or box. The Distribution System of Measurement of Electric Energy (SDMEE) presents these elements distributed throughout the installation, being communicated through a dedicated communications system and managed through dedicated software.

The main change from the traditional systems is the separation between the unit responsible for measuring and the element responsible for the dissemination of consumer information, either to the energy distributor, or to the consumer. Such separation is accompanied by the need to exchange information between units of measurement, central billing and query terminals, making it a complex communications system.

There are numerous possibilities brought by SMDEE, among which we emphasize:

- Tax and automated billing;
- Turn off and turn on of energy on distance;
- Mapping of energy theft;
- Reducing the electrical power supplied to certain clients (known as "Social cutting ");
- Differential tax using the time.

The fundamental concept of SMDEE is the preservation of the individualization of the measurement of energy consumption associated with the centralization of information consumption, allowing the sharing of common parts and offering a significant reduction in physical space.

II. Work Motivation

Some projects for the use of SDMEE were implanted in Brazil with the main purpose of combating the theft of electricity in regions with high rates of non-technical losses. The distribution companies have identified that most fraud happens for user intervention in their own energy meter, therefore, proposed the implementation of a SDMEE to combat fraud by placing the measuring point outside the residential unit at the medium voltage network. Below is a brief description of this system.

19th IMEKO TC 4 Symposium and 17th IWADC Workshop
Advances in Instrumentation and Sensors Interoperability
July 18-19, 2013, Barcelona, Spain

A. Description SDMEE installed in Brazil

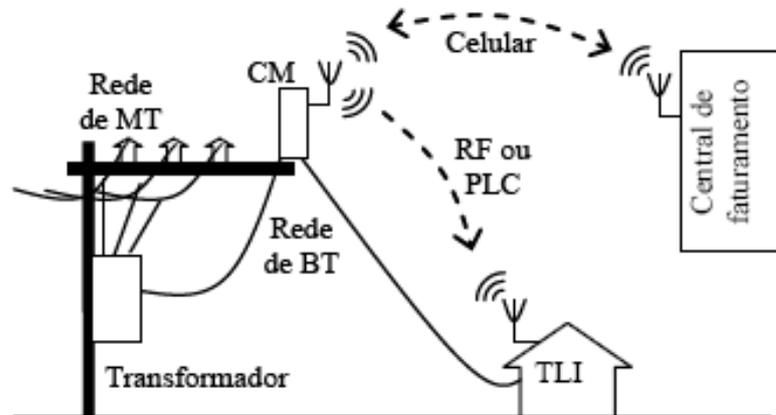


Figure. 1. - Configuration SDMEE installed in Brazil

Figure 1 presents a summary of the operation of SDMEE installed in Brazil. This figure is shown the medium voltage network - MT ($1 \text{ kV} \leq V \leq 100 \text{ kV}$), powering a transformer that distributes energy to low voltage - LV ($V \leq 1 \text{ kV}$).

In Brazil was created a new standard for the BT network, in which compact concentric cables share the same support structure that the network of MT. A concentrator of measurement - CM is installed in the support structure from which the branches come out of power to the customer's energy distributors. The CM contains several single-phase measurement modules, which can be grouped to compose three phase customers.

The number of measurement modules, supported by the CM varies from 9 to 12 modules depending on the manufacturer's SDMEE. In the houses of the clients terminals are installed individual readings - TLI where they can view a description of their measurement module. Depending on the manufacturer, communication with the TLI can be through radio frequency - RF or using their own supply line to BT as the carrier technology (PLC - Power Line Carrier) [1] [2]. Communication with the central billing occurs in a hierarchical manner due to the large volume of information resulting from the measurements of all customers that belong to the energy distributor. A summary of the hierarchical structure of communication implies the existence of the data concentrators where the information converges to the CM, for transmission to the central billing through mobile phones. Some manufacturers use the data concentrator to forward the information to read both the central billing (by phone) as the TLI (by RF). It is also possible to perform the cutting and reconnection of customers through a bidirectional communication between the data concentrator and the CM.

III. Legal Aspects SMDEE

Figure 2 shows the SMDEE that were initially deployed in the early 2000s and up to now there was no specific legislation directed to this type of meter. The change from conventional electricity meters to the new SDMEE had major impacts on users. A lot of software failures were observed which led to a fast fix in new versions of the meter's firmware. A second problem was caused by different versions and software embedded in meters, with a small control or no control over it. Such a scenario highlighted the need to control unequivocally the software version that was running on a specific meter.



Figure .2 - SDMEE installed on field

However, the problems mentioned above have generated great uncertainty and discontent in the consumers served by such meters. This situation was exacerbated due to two additional problems:

(i) a large number of wrong billings caused by simple configuration errors, which would be expected, considering the high complexity of SDMEE configuration, especially for technical teams skilled to install conventional meters;

and (ii) the lack of individual devices to display the record for energy consumption. The consumer did not have a monitor to control energy consumption, making their sense of insecurity increase about the accuracy of measurements for which he was charged. At this point, it became clear that it was absolutely necessary to have an indication of each individual within the consumer's residence displaying the accumulated energy consumption.

All problems identified in the first deployments SDMEE confirmed the necessity of creating a specific regulation to address the peculiarities of the new measurement system introduced by SMDEE.

The experience accumulated during the work allowed the preparation of specifications, which incorporate two regulations exclusive to SDMEE [3] [4]. These requirements include the need to provide an indicator of the measurement device in the consumer unit, the specification of update times of reading of the indicator and the need for identification of legally relevant software and hardware [4].

In 2007, a first specific regulation for the SMDEE was developed by Inmetro[3], which requires the existence of a consumer display and takes into account new specific tests, like the influence of self-heating, applied voltage, the influence of temperature and testing for accuracy of limit of errors for the variations of voltage, current and frequency and electromagnetic interference. From this time, new SMDEEs to be commercialized should satisfy regulation 371/2007. In parallel, Inmetro created two different working groups: (i) one for a real assessment of the SMDEEs already in-service, and (ii) one to draw up a new regulation with detailed software requirements.

In 2009, a second specific regulation for the SMC was published by Inmetro[2], which describes all those software requirements. The most controversial aspect of this regulation was the requirement of opening the legally relevant software (source code) to Inmetro. Such an aspect was a decision resulting from a broad discussion with internal and foreign manufactures, influenced by the architectural complexity of the system. An assessment methodology was developed to the SMDEE and includes three main steps: evaluation of architecture, software validation and integrity checking further information about the communication architectures of SDMEE in Brazil can be found in [4] and [5].

IV. Conclusion

The SDMEE installed in Brazil was described succinctly, showing the importance of knowing how this new technology brings challenges for regulators to exercise their legal metrological control of measuring instruments.

The SMDEE provide:

-Utilities:

- Reduction of measurement errors, inhibiting irregularities, allowing remote reading fast and accurate including aggregation of energy by distribution transformer;
- Possibility of automatic knowing of the load curve of consumers / distribution system;
- Turn off and turn on remotely, which allows a better control of frauds;
- Ability to offer new services such as prepaid, differentiated rates;
- Improved operational productivity (greater number of consumers served by the same team).

-Consumers:

- Elimination of reading errors;
- Reduction of time-turn on for cases that occurred turn off by no pavement;
- Better knowledge of the consumer profile, for example, information from your daily consumption;
- Possibility of account with the option of prepayment;
- Staff safety, since there is no need to allow people to access their residence to conduct the reading of energy consumption.

The reality of the Smart Grid must transform the electrical system in a modern network which will allow energy distributors and consumers to change the way we provide and consume energy. The visible part of the electronic energy meters development currently is in use, on a large scale, which will, in a short time, exercise new types of fees and produce new consumer behavior. Telecommunications, sensing, information systems and computing, combined with the existing infrastructure, form an increasingly powerful arrangement that can make the difference.

References

- [1] J.W. Hohn, J.A. Zipp, E.A. Baumgartner, R.O. Burnett, P.R. Drum, D.R. Hemming, J.D. Huddleston, J.W. III Ingleson, J.R. Latham, B.D. Nelson, R.W. Ohnesorge, A.H. Pattman, E.T. Sage, E.A. Udren. "Power line carrier practices and experiences" IEEE Transactions on Power Delivery, vol. 10, No. 2, p.p. 639 – 646 abril 1995.
- [2] W.D. Jones, "Amped Up and Ready to Go", IEEE Spectrum Magazine, vol. 41, No. 9, p.p. 14-18, setembro 2004.
- [3] Instituto Nacional de Metrologia e Qualidade Industrial – INMETRO, Portaria nº 371 de 28 de setembro de 2007.
- [4] Instituto Nacional de Metrologia e Qualidade Industrial – INMETRO, Portaria nº 11 de 13 de janeiro de 2009.
- [5] L. F. R. C. Carmo, E. L. Madruga, R. C. S. Machado, "Aspectos de Segurança da Informação em Redes de Medidores de Energia Elétrica", VIII International Seminar on Electrical Metrology, João Pessoa – Brasil, junho 17 – 19, 2009.