

SMART GRID PRODUCT TESTING AND QUALIFICATION

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ABSTRACT

The introduction of smart meters in Europe had a significant impulse with the publication of Directive CE/2006/32 about energy efficiency.

Besides this regulatory imposition, utilities under competition have to manage their business in the best possible way to give their customers services that they appreciate.

This means a differentiation factor that can be offered to customers, complementing the electric energy supply with services supported by the information given by smart meters, allowing a more efficient use of electrical energy, due to the remote on-off switching and monitoring of home electrical appliances consumption.

In this strong technological change, with several different technical options offered by the market, it is very important for EDP to have Labelec's laboratory support. Labelec helps EDP with the decision process regarding the most competitive technological options and cooperates in the definition of specifications that are more suitable to ensure the equipment conformity.

INTRODUCTION

The Qualification and Inspections (Q&I) Department of EDP Labelec (The laboratory company in the EDP group) has had a growing participation in EDP projects associated with smart grids, such as INOVGRID, smart grid mini-pilots and re:dy. The work done includes mainly testing (in laboratory and on the field) and technical consultancy activities.

EDP Distribuição, the distribution system operator, launched in 2008 the implementation of the INOVGRID project that is much more than a simple metering project since it integrates many features very important for a correct management of smart grids.

EDPBOX is a smart meter that, besides its basic function of measuring the energy consumed by the customer, integrates additional features that provide a substantial improvement in the quality of service associated with the supply of electricity (such as: voltage measurement at the client's home, record of the number of energy interruptions and their duration, possibility of remote parameterization of the contracted power, tariff programs, etc.).

EDPBOX includes an RS-485 port, allowing the client to access consumption data along the time (load profiles). The project re:dy of EDP Comercial, the Portuguese Electrical retailer, collects information from EDPBOX, via RS-485 port.

SMART GRID PRODUCT QUALIFICATION

Under Smart Grid Products Qualification, EDP Labelec, in the Q&I department supports EDP Distribuição on INOVGRID project.

INOVGRID project aims to provide means to adapt society life styles more sustainable and lower consumption of resources. In this project the electrical power grid is provided with smart equipment (smart meter, data concentrator) that are able to automate the energy management, to present value adding services to the consumer (for instance, real-time analysis of their consumption). In this case, the consumer can interact with power grid in a simple and effective way.

To ensure the functional uniformity and interoperability of equipment from different manufacturers it is necessary to elaborate a document where it is present the minimum requirements that the equipment must comply.

These requirements are described in a document - functional specification - developed by EDP Distribuição (in partnership with EDP Labelec), covering approximately 250 functional requirements. These requirements not being covered by any European or International specification are not checked for correct implementation in the product certification process by a notified body.

For this reason, EDP Labelec prepared, based on the functional specifications, 34 test procedures to test compliance of the product with all the 250 functional requirements. As an example, among the 34 procedures the Circuit Breaker test procedures, Tariff Setting, Billing, Demand Management, Quality of Service, Load Profile, HAN port, Local and Remote Communications can be highlighted. These procedures, apart from ensuring that all requirements are tested, have the advantage of ensuring uniformity and equal criteria between tests of the same requirement, independently of the manufacturer and the tester.

It should also be highlighted the participation of EDP Labelec in the preparation of a procedure to test the DLMS [1] data model that was defined by EDP Distribuição, the *test book*. Being a very extensive procedure, a software tool for the automation of DLMS tests was created in partnership with an external entity.

Thus, the qualification of smart devices, namely EDP Box, lacks functional tests described exhaustively in functional procedures and tests performed by DLMS software tool according to the test book.

Both, the functional specification and the test procedures, are subject of ongoing updates, to ensure a

continuous improvement. For every change made to the documents it is published a new version of the documents, being recorded all changes made since version 0 (document release) to the current version. This method ensures the traceability of the document.

So far, during the INOVGRID project 8 EDP Boxes manufacturers have already begun the Qualification Process. Each manufacturer may have different versions of EDP Boxes: single or three phases or also Public Lighting equipment. In each of the versions, manufacturers may also have different communication technologies between EDP Box and the data concentrator: PLC or GPRS.

EDP Labellec has already conducted Qualification Tests on 14 different models of EDP Boxes. Obviously, the solutions provided by the manufacturers are extensive, which emphasizes the importance of very specific and rigorous testing to ensure functional uniformity and interoperability of systems.

To perform the Qualification Test, several testing tools are needed. For instance, voltage and current sources able to generate current values up to 100 A, capacitors, and LV cables up to 100 meters length (tests for Circuit Breaker requirements), voltage and current sources liable to remote control for automation either time-consuming tests and tests that require a repetitive action (tests for Tariff Setting requirements), digital oscilloscope and the voltage source generating voltages up to 1 kV (the requirements for testing of the HAN port).

In Figure 1, it is shown a picture of some of these equipments which have been used to perform the Qualification tests.



Figure 1 - Equipment needed to perform the Qualification tests.

After finished each set of Qualification tests, test reports (one for each test procedure) are released. In these reports it is registered the version of the functional specification subjected to testing and the version of the test procedure used.

It was experienced that generally when manufacturers have equipment for qualification tests, they are not compliant to all the functional requirements, implying the existence of several rounds of tests.~

In Figure 2, Figure 3 and Figure 4 are shown graphs where the number of nonconformities in each test round are indicated. It can be seen that in the first test round there are a large number of non-conformities, decreasing dramatically in subsequent rounds.

In some cases the first round has less nonconformities than the second round, because during the first round critical nonconformities were found, and the tests have been canceled. So, in these cases not all the tests procedures have been performed.

Once again, based on the results shown, the importance of these Qualification Tests performed by the utility is reinforced to ensure that “what you want is what you get – WYWIWYG”.

We can also conclude that further rounds of testing will be needed to ensure that all manufacturers are qualified to INOVGRID project.

Once the Qualification Process of the first manufacturers of EDP Box has been completed, EDP Labellec will focus on the Qualification of other smart devices, for instance, data concentrators, routers, communication modules, sensors and actuators, just to name a few.

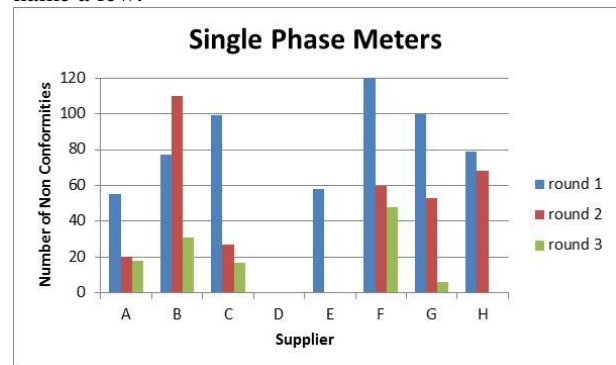


Figure 2 - number of nonconformities found in each test round – single phase meters

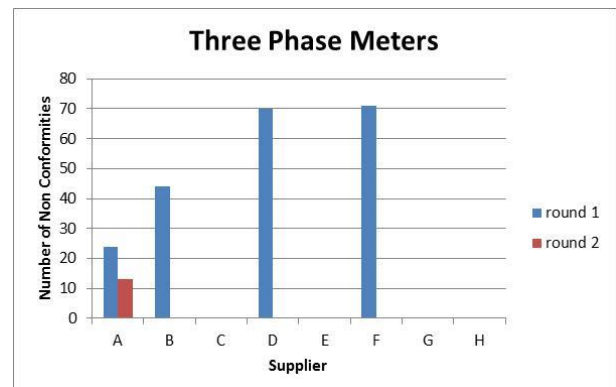


Figure 3 - number of nonconformities found in each test round – three phase meters

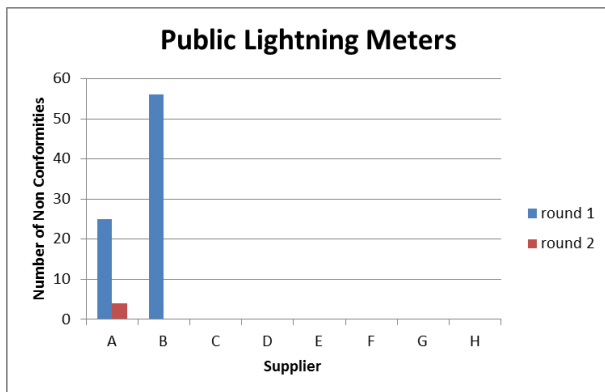


Figure 4 - number of nonconformities found in each test round – Public Lightning meters

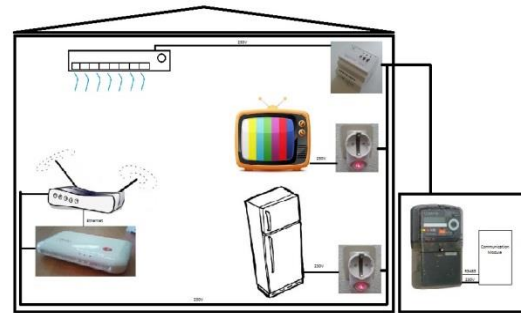


Figure 5 – Interaction between all re:dy devices.

SMART GRID PRODUCT TESTING

In addition to the qualification tests of smart meters for EDP Distribuição, the Q&I department of EDP Labeltec has taken an increasingly active role within the EDP group in testing smartgrid related products. One sufficiently relevant example to be referred is the participation on the re:dy project of EDP Comercial, having EDP Labeltec helped in different tasks throughout all the phases of the project with its expertise and testing tools.

The Re:dy service launched in 2013 by EDP Comercial, is a set of Home Automation devices - essentially a central module or gateway and smart plugs - which allows the user to control and monitor the consumption of its electrical equipment installed in-house. This service allows through a mobile phone/tablet application to switch on or off electric circuits, a lighting circuit, equipment plugged in a smartplug, and also to monitor local and total consumption in real time. To make this possible the Home Automation devices use communication protocols to communicate between them, usually the Zigbee and PLC broadband.

Additionally, by using a re:dy device called re:dy modem that it is connected to the smart meter, the customer can know and control their consumptions by gathering the information recorded by the smart meter specified and installed by EDP Distribuição. In Figure 5 it is shown the interaction of all re:dy devices.

The smart meter in Portugal has a HAN port (RS-485) that allows the re:dy system to access the meter information. Currently, re:dy clients can access:

- Imported/exported Power consumption – real time;
- Power contracted and tariff information;
- Load profile – Stored on the meter

The Smart Meter is the link between the electrical utility and the customer.

Benchmark studies and tests

Because some of the technologies intended to be used in smartgrid projects are not yet mature enough, the need of a laboratory support is essential, to support in the decision-making process. This also happened in the re:dy project.

The project started in 2011 and since then there have been a series of evolutions on the devices that allowed the re:dy service to exist. Several prototypes were tested in order to identify the best technological solutions. In Figure 6 it is shown the evolution of re:dy devices across the time, since 2011 until today.

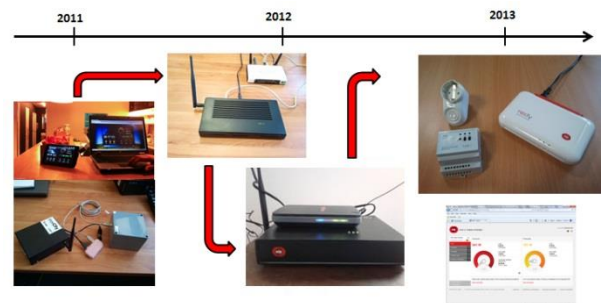


Figure 6 – Evolution of re:dy devices across the time, since 2011 until today.

Benchmark studies of wireless communication technologies (for instance ZigBee, EnOcean and ZWave) to define the best solution for application in smart plugs were made, tested various versions of hardware components, made communication and functional tests in the laboratory and in the field which endorsed EDP Comercial with valuable information described in about 60 technical reports.

All studies and tests conducted in the pre-development phase proved to be absolutely essential to determine the best technological choices and support for the specification phase of the system to be developed by EDP and respective selected partners for the re:dy project.

Development of smartgrid products

To the phase of product development, the experience, technical expertise and tools available in EDP laboratories have also been an important asset to the success of SmartGrid projects underway in EDP group.

The evaluation phase of the several prototypes in re:dy project provided EDP Comercial with all the information needed to easily specify all the re:dy devices and its functional capabilities. But the work did not ended at this point; it was not considered sufficient to specify, adjudicate the project to an external entity and wait for the final solution implemented because this option has associated risks that did not match the importance of the project and its limited budget and severe timeframe. For this reason the project plan included several checkpoint tests performed by EDP Labelec. This decision had advantages not only for the project management – closer monitoring of the technical project evolution, periodic review of the developments, performance evaluation of the developed prototypes along the project – but also for the manufacturer; acting has a facilitator and helping to find errors in an early stage of the project. In Figure 7, it is shown the software used in one of these tests, in order to verify the Zigbee communication between devices.

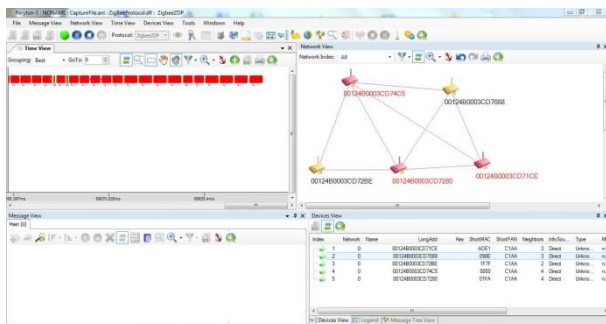


Figure 7 – Software to test communication requirements on re:dy devices.

During the development phase of the re:dy devices, it was performed:

- Laboratory tests
 - Metrologic tests – Smart Plugs and panel module (error <2%);
 - Functional tests;
 - Safety tests – pre certification tests;
 - Communication tests.
- Field tests
 - Communication tests;
- Analysis of all malfunction devices;
- Support the manufacturer on the development of the final product;
- Support the manufacturer on the certification process – Safety and EMC tests.

Before the execution of the laboratory tests, EDP Labelec prepared a set of procedures according to the specification and executed them at the checkpoints and also performed acceptance tests in the final prototype delivered by the manufacturer. Simultaneously EDP Labelec performed a set of pre-certification tests that also helped the manufacturer to identify all the issues that were needed to be rectified to get the CE marking of the devices, according to the requested by EDP Comercial.

Deployment of smartgrid products

For the installation and operation phase of Smartgrid equipments, EDP Labelec also makes an effort to ensure that the EDP group is prepared with the necessary know-how and testing tools.

For the roll-out phase of smart meters it was estimated the need for performing diagnosis tests, to check the presence of communication problems, to simulate communication conditions, to measure signal attenuation and electromagnetic fields associated with these technologies.

Regarding this last issue, EDP Labelec acquired an isotropic antenna, which allows field measurements for frequencies between 30 MHz and 3.6 GHz, a spectrum analyzer FSH4 that allow frequency range selection and a tripod and has already performed for EDP an extensive study on EMC fields generated by smartgrid appliances.

Throughout the years the electromagnetic fields have been a big concern for EDP. These concerns were initially focused in the Extremely Low Frequency fields (50Hz), but now, with the new smart grid technologies, it is necessary a larger approach. Technologies such as PLC, GPRS, ZigBee, RF-mesh and others, will be used in the future by all the electrical utilities, and now before the mass rollouts, it is the time to study the electromagnetic implications of its uses. With this purpose, EDP Labelec measured for EDP Distribuição, the EMF in multiple locations with InovGrid technologies and Re:dy equipment installed (distribution transformer site, near the installation site of smart meters – see Figure 8 - and inside the customer's houses), to verify the compliance regarding the Portuguese legislative request, namely the Portaria 1421/2004. The main technologies measured were PLC and the wireless technology (GSM/GPRS, ZigBee and RF-mesh) used by the equipment to communicate.

The data resulting of the measurements showed that the electric field generated by the technologies (ZigBee, RF-mesh, GSM/GPRS and PLC), have a very small intensity.[2] The values recorded are always much lower than the limits set by ICNIRP. [3]



Figure 8 – Measuring EMF near smart meters.

Concerning the re:dy project of EDP Comercial, EDP Labelec already has the tools and testing procedures prepared to support EDP in all kind of interoperability tests, specially ZigBee (EDP Labelec is since 2013 member of the ZigBee Alliance), to ensure the compatibility of newly developed products and devices or devices from other entities that would like to join the re:dy project of EDP. In fact, this is one of the goals of the project, enabling it to continuously increase the range of available services possible to offer to EDP customers.

The list of possible future appliances and services to offer is unlimited; the following are just some possibilities already being explored:

- Illumination control –not only turn on and off;
- Security services;
- Heat/cold control;
- Demand management (dynamic control by turn on and off a series of devices to control the power consumption);
- Warning system (for example: SMS or email);
- Window shutter remote control and programming

Additionally, the existing testing tools on EDP also assures the possibility of testing future new releases of the re:dy devices and supports EDP Comercial with all the know-how acquired over the project to keep abreast with the latest market trends.

CONCLUSIONS

Conducting these tests in laboratory is very important because smartgrid technologies are not yet mature enough. If abnormal performance is not detected before installing the equipment on the field and severe problems arise later, this means high costs for the utility. The need of laboratory support will be even greater when the INOVGRID project enters in its roll-out phase. Then, it will be necessary to perform diagnostic tests to check the presence of communication problems, to simulate communication conditions, to measure signal attenuation and electromagnetic fields associated with these technologies, etc. That's why the laboratories of EDP, EDP Labelec, is focused on increasing its know-how and getting new test equipment and other necessary materials for this purpose, aiming to add value to EDP Group.

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