CHARACTERIZATION OF DECENTRALISED MICROGENERATION IN PORTUGAL

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ABSTRACT

The foreseeable increase of interest by the public on the micro-generation of electric energy to be injected in low voltage grids of all Distribution System Operator (DSO), has led EDP Distribuição (EDP Group) to take some measures on the management, control and operation of its low voltage grids in order to accommodate the additional amounts of power suddenly available by the owners of microgenerators (µG). This paper gives a brief account of what has been made in Portugal in this area and shows the results of a special Power Quality (PQ) campaign launched by EDP Distribuição (EDPD) to estimate the effects of this new decentralized power on some of the main PQ indicators of its low voltage grids. In addition, a reference is made to the InovGrid Project EDP Distribuição has in operation to implement in a first step of grid modernization the technology of smart-metering in selected portions of low voltage grids as a means to achieve a more secure and flexible grid towards a different concept of electric network known as smart-grid.

INTRODUCTION

The continuous effort for the search of new sources of energy, in particular for those reputed non-pollutants or more environment-friendlies, has determined a world-wide interest by citizens for the so called microgeneration of electric energy.

To correspond to such vast interest, all countries have developed specific legislation (in Portugal, Decreto-Lei n.º 363/2007) in order to facilitate the connection of microgenerators, up to 5,75 kW (excepted condominiums) to the low voltage (LV) distribution networks and limited to 50% of the power contracted for consumption.

This sudden increase of microgenerators injecting power into the Portuguese LV grids has posed some problems of operation, management and control of the whole Power System.

The present document has been elaborated to give an overhaul account of EDPD experience in dealing with this power contribution from common people, clients as well as consumers from EDPD LV grids.

This experience forced some special attention and sometimes some modification of established rules and modes of operation from EDPD, namely to assure a balanced geographical distribution of microgenerators in the LV grids.

Apart from the fundamental previous legislation – Quality of Service Regulation and NP EN 50 160 – EDPD has added some basic rules to prevent overcharge of grid transformers designed to accommodate this new available power, presumably due to increase as the cost of this sort of equipment is becoming more appealing to the general public.

A special PQ monitoring campaign was launched by EDPD to estimate the effects of this power being injected in the LV grids, by solar microgeneration units.

The results of this PQ monitoring campaign will be shown and its influence on the grid duly explained, in particular the effects on some of the main PQ indicators, such as Supply Voltage and its variations, Harmonic Voltage Distortion and Voltage Flickering phenomena.

In addition, a reference is made to the InovGrid Project EDP Distribuição has recently initiated to build a more accurate and flexible control and management of the grid, by installing in pre-selected portions of its low voltage grids the technology of smart-metering to pave the way for the concept of smart-grid to be effective in the near future. This Project will allow for an easier control of the whole low voltage grid, a better quality of service and a reduction of power losses, in the context of an increasing diversification of energy sources.

CHARACTERIZATION

Portugal is one of the European countries with great potential for harnessing solar energy, with an average annual solar exposure 8h/day, getting a solar incidence of 1kW/m2. In Portugal, the average annual number of hours of sun, varies between 2.200 and 3.000h. Therefore, the main renewable energy source of the microgeneration is solar (92,3%), followed by the wind, hydro and combined.

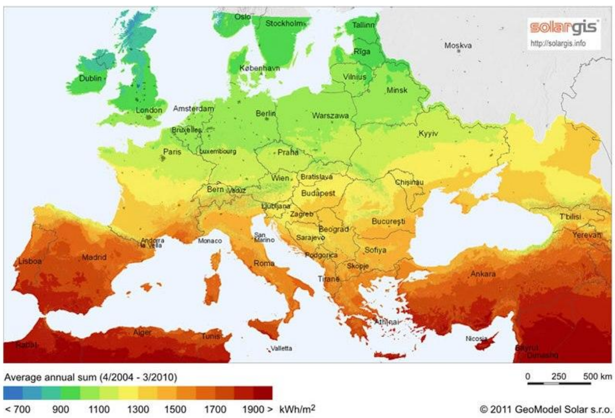

Figure 1 – Europe - Annual global irradiance
(http://www.greenrhinoenergy.com).

The microgeneration program that started in 2007, had a significant success, being already installed about 22 thousand microgeneration units, corresponding to

78,20 MW of power connected, as shown in Figure 2.

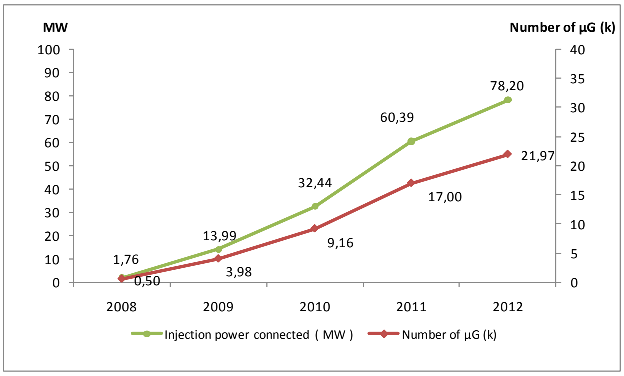

Figure 2 – Number of microgenerators connected and corresponding power connected

Figure 3 shows the microgeneration geographical distribution, by municipality in Portugal.

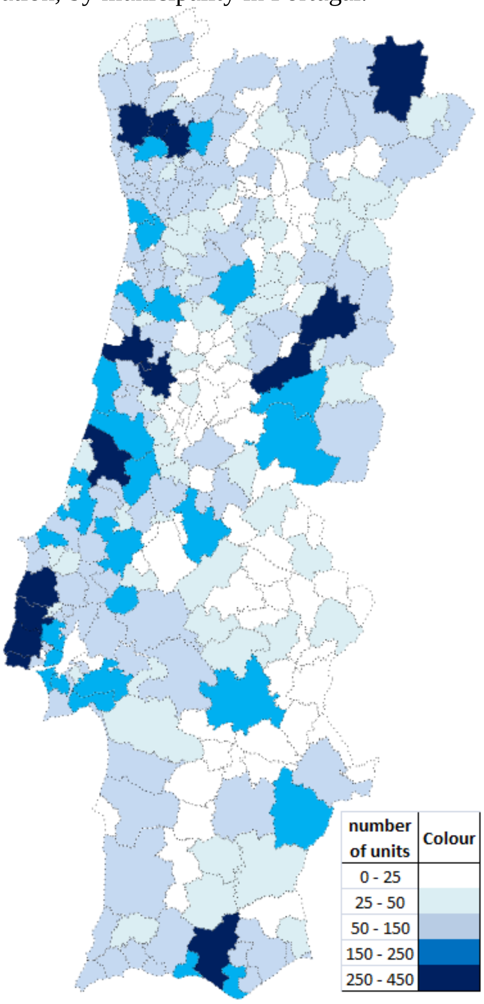

Figure 3 – Microgenerators geographical distribution

The main microgenerators developers are Water Companies, City Councils, Council Companies, Property Development and Real State Companies, Telecommunications Companies and Banking.

CASE STUDIES: POWER QUALITY MONITORING RESULTS

Some Power Quality (PQ) monitoring results (continuous phenomena and voltage events) are presented, from some microgeneration case studies. EDPD has been systematically monitoring its grids, in particular the MV and LV. EDPD power quality monitoring campaigns have been done according to NP EN 50160 recommended standards and also according to a national quality of service regulation. The main surveyed power quality parameters are:

- voltage frequency
- rms voltage values
- voltage flicker
- unbalance of voltage three phase system
- voltage harmonic distortion

Furthermore, EDPD measures the magnitude of all voltage dips or sags occurred in the networks, as well as swells and interruptions both in number and duration, which occur in the regular periods of power quality monitoring.

<u>MV/LV transformer with the highest number of microgenerators connected</u>

The first case study is from the MV/LV transformer with the highest number of microgenerators connected to them. This MV/LV transformer, with 630 kVA of rated power, is located in the centre of Portugal, close to the cost, with 39 microgenerators, corresponding to 141,22 kW of power connected. The PQ monitoring campaign was held between July and September 2011.

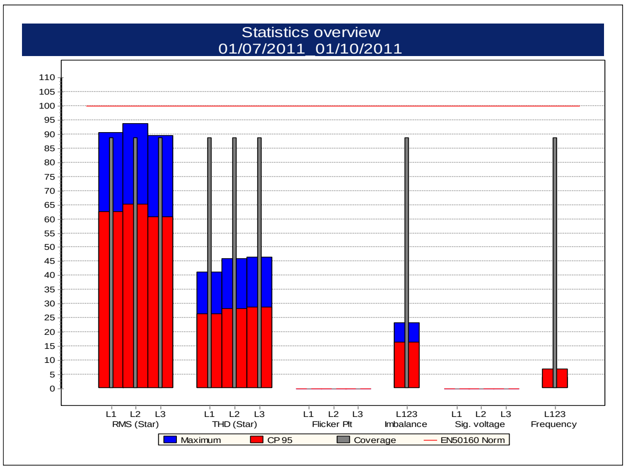

Figure 4 – Analysis of voltage accordance with NP EN 50160

Having as reference the admissible levels recommended by the NP EN 50160, it can be verified in the Figure 4, the voltage on LV side of MV/LV transformer is perfectly on agreement with the requirements of the above mentioned norm.

MV/LV transformer with the second higher number of microgenerators connected

The second case study is from the MV/LV transformer with the 2nd higher number of microgenerators connected. MV/LV transformer, with 630 kVA of rated power, is located in the south of Portugal (Algarve), with 27 microgenerators, corresponding to 96,37 kW of power connected. The PQ monitoring campaign was held also between July and September 2011.

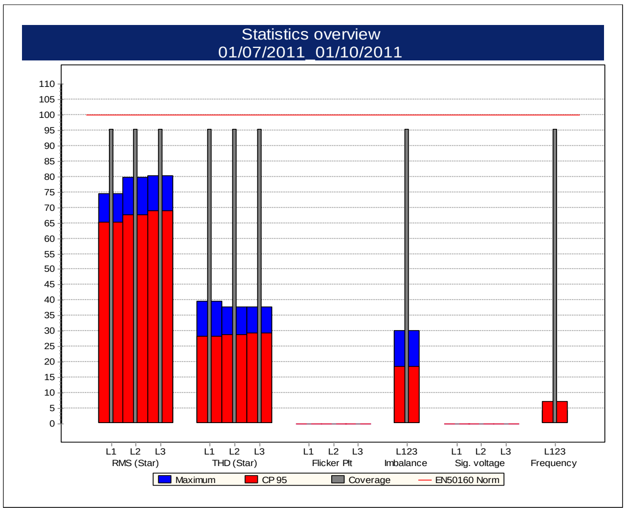

Figure 5 – Analysis of voltage accordance with NP EN 50160

Having as reference the admissible levels of the NP EN 50160, it can be verified in the Figure 5, the voltage on LV side of MV/LV transformer is perfectly on agreement with the requirements of the above mentioned norm.

Complementing the previous paragraph, the analysis period profile for the rms voltage values and the magnitudes of voltage harmonic distortion in the three phases (average values) are shown in Figure 6 and in Figure 7, respectively.

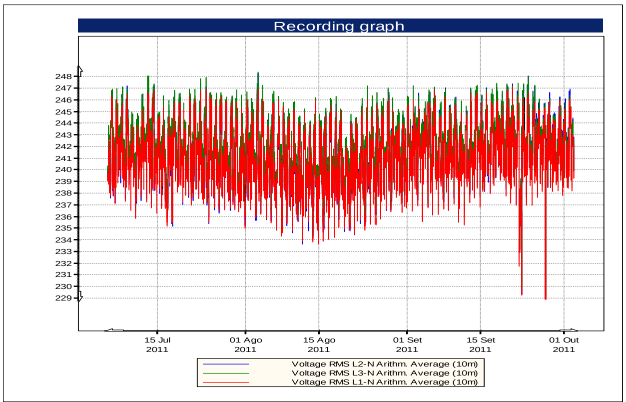

Figure 6 – RMS voltage values

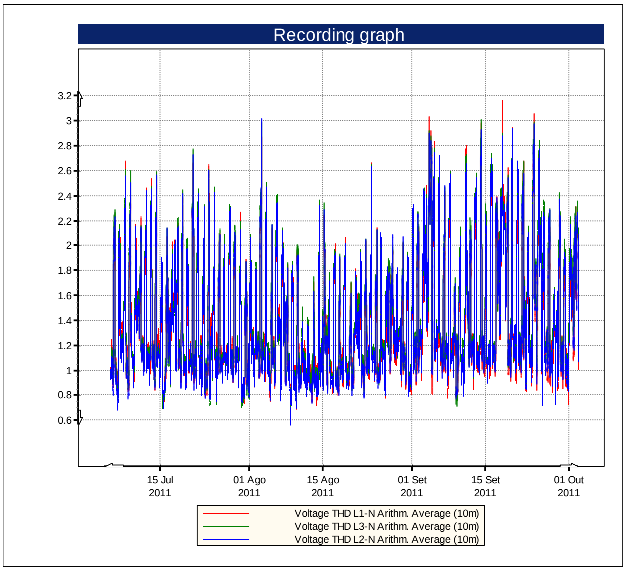

Figure 7 – Total harmonic distortion

A Set of solar microgeneration units and its respective MV/LV transformers

The third case study is from a set of 8 solar microgeneration units and its respective MV/LV transformers. This set in particular was chosen due to its characteristics, location and kind of load, which are a good representation of the typical behaviour of this type of generator, when inserted in a low voltage grid. In addition, the tests were also conducted to evaluate the possible effects of these amounts of energy on some specific power quality indicators, namely the supply voltage, the harmonic voltage distortion and the flickering phenomena.

Based on the monitoring data, it can be concluded the following [1]:

- For the rms voltage values, Total Harmonic Distortion (THD) and voltage flicker (Plt): (1) up to 200 meters between microgeneration units and its respective MV/LV transformers, the rms voltage values, THD and Plt are imposed by the MV/LV transformer, regardless of the local short-circuit power; (2) for greater lengths, the microgenerators may impose voltage rms values locally and it was found in situations with greater distance to MV/LV transformer and low short-circuit power, some increased voltage levels during periods of operation of microgenerators. It was also verified that the load imposed THD and Plt levels of magnitude, the microgenerators having no influence on THD and Plt levels.

- Voltage events (dips and swells) are usually felt in the same way in the microgenerator and its respective connected MV/LV transformer; whenever one voltage dip occurred, the microgenerators stopped.

PQ monitoring results, after a microgenerator complaint

The last case study is based on results from a PQ monitoring campaign, after a microgenerator complaint. In this situation, it was found that each time the voltage values exceeded 257 V, the microgenerator's inverter acted and the production was interrupted. This has been the situation that occurs rather frequently: microgenerator connected at the end of LV network, with distances greater than 800 meters from MV/LV transformer and/or microgenerator connected in branches with low load.

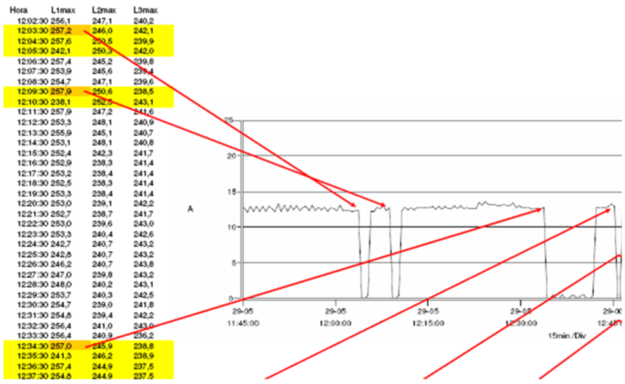

Figure 8 – Current demand curve supplied and rms voltage values

This kind of situations have been mitigated as follows: (1) phase change of microgenerator, since the remaining phases present higher load; (2) to decrease one point from tap changers, providing this change doesn't cause voltage disturbance in the remaining LV network; (3) LV network remodeling; (4) installing a new MV/LV transformer.

INOVGRIG PROJECT

InovGrid is an innovative project that aims to equip the electricity grid with information and devices to automate grid management, improve service quality, reduce operating costs, promote energy efficiency and environmental sustainability, thus increasing the penetration of renewable energies and electric vehicles in the electric networks.

InovGrid is being developed by EDPD with the support of domestic partners in the fields of industry, technology and university research centres.

InovGrid project is organized around three pillars: (1) Smartmetering, designed to implement system-wide Automation Meter Management capabilities; (2) Smart Grids, aimed at improving the efficiency and reliability of the grid through the introduction of a new level of intelligence on its management systems; and (3) Microgeneration, consisting on the adaptation of the grid to the growing demand for the connection of microgeneration units [2].

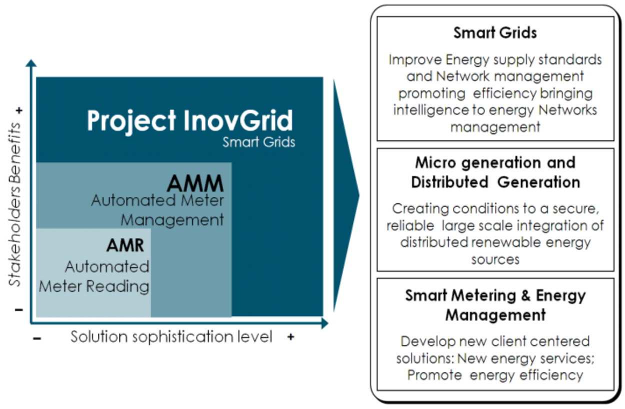

Figure 9 – InovGrid Pillars

CONCLUSIONS

As already mentioned, Portugal is one of the European countries with great potential for harnessing solar energy. With the advent of specific legislation (Decreto-Lei n. º 363/2007, in Portugal) that facilitates the connection of microgeneration units to the distribution network, there was a substantial increase of microgenerators injecting power into the Portuguese low voltage grids. The microgeneration program that started in 2007 had a significant success: approximately 22 thousand microgeneration units are already installed, corresponding to 78,20 MW of power connected.

These special PQ monitoring campaigns launched by EDPD to evaluate the effects of this power being injected in the LV grids, by microgeneration units allowed the conclusion that the effects of the present volume of microgeneration in our grids has not significantly altered the previous levels of PQ indicators However, EDPD maintains a close look on the evolution of this kind of injected power, imposing in some weak points of the network limits of connecting power to the local MV/LV transformers.

InovGrid is EDPD's response to all these challenges and opportunities taking place in its grids and the first step towards a new distribution network paradigm, namely on the adaptation of the grid to the growing demand for the connection of microgeneration units.

Acknowledgments

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REFERENCES

[1] LABELEC (EDP Group), 2009, "RL 09/42 – DED (Internal Report): Monitorização de Redes BT; Avaliação Comparativa do Impacto da Microgeração nas Redes Monitorizadas".

[2] MELO, N., PRATA, R., GONÇALVES, R., MIRA, F., 2009, "Microgeneration in Portugal – EDP experience and future perspectives", *CIRED 2009, 0569.*