THE NEED FOR CHANGES IN ELECTRIC DISTRIBUTION NETWORK FOR THE USE OF THE MINI AND MICRO ON GRID GENERATORS

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THE NEED FOR CHANGES IN ELECTRIC DISTRIBUTION NETWORK FOR THE USE OF THE MINI AND MICRO *ON GRID* GENERATORS

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ABSTRACT

It is expected that with the diversification of utilization rates, the increased demand for electricity and the difficulties encountered in hydroelectric generation, promote the acquisition of more renewable energy generators connected to the network. There's no way to keep a nationwide system of interconnected components and mini-generation connected to the network, effectively without the deployment of the smart grid. Through studies carried out in some inverters used in solar generators, it was verified the existence of harmonics that are injected in the distribution network, creating fluctuations of voltage and current. Rectification of the sine wave inverter, and the connection of multiple network generators cause oscillations in both voltage and frequency, making necessary a network that not only identify these fluctuations, but to interpret, going further, as should take measures to mitigate the effects of these oscillations. This requires an intelligent, interconnected network to the central data processing, intuitive and with a certain degree of autonomy, reducing response time to problems, directing and compensating voltage spikes and rectifying the quality of electricity injected by miscellaneous generators connected to the same.

Keywords: waves, *on grid* generator, harmonics, *smart grid*.

. INTRODUCTION

The advances brought about by RN482/12[1] are noticeable, but *on grid* inverters emit when in low power, harmonics that penetrate into the distribution network. The concessionaires have standards for the acceptable limit of harmonics in the network, when we *on grid* generators, but the connection of several generators can cause a wide variation of harmonics, which may lead to voltage fluctuations and change in frequency, causing damage to the connected equipment, such as RLC[2]-based circuits, detectors such as televisions and radios, in addition to measuring devices that require a certain sensitivity.

There are studies of a smart grid (*smart grid*) that may solve the problem, analyzing power quality that permeates the network, and even with a certain autonomy, rectify it, with frequency filters. These changes are necessary if conceive the possibility of a large number of generators connected to the distribution network.

THE CONNECTION OF GENERATORS TO POWER

After RN482/2012, which rule the credit of electrical power connection of generators in power distribution network has revolutionized the way consumers saw the concessionaire and sale of electric energy.

If the only problem was the definition of what was regarded the relationship between concessionaire and consumer consumption, product sales, namely, electrical power, or provision of services, or the provision of energy to the user.

[1] RN482/12: Regulamentary Norm number 482 of 2012 - ANEEL (Electrical Energy National Agency).
[2] RLC: Resistor-Inductor-Capacitor

According to the standard, the only requirement is that the generator has character of renewable energy, such as wind generators, photoelectric, biomass, etc. In addition, it is necessary that there is an access procedure and analysis of energy generated, in order to be authorized to connect the generator to the distribution network, [1].

It is expected, therefore, that many generators are connected to the distribution network, the system to be viable it must wait a number of connections. And are also expected to be various types generators, as shown in the graph below (Figure 1), there are already a variety of generators connected to grid by RN482/12, and the standard is relatively new.

Similarly, it was found that, apart from the fact that several connected generators create special needs electricity injected quality analysis to the distribution network, the inverters can be unable to regulate the voltage and frequency in a satisfactory manner, creating the need for studies in this area to suit the inverters to Smart grids.

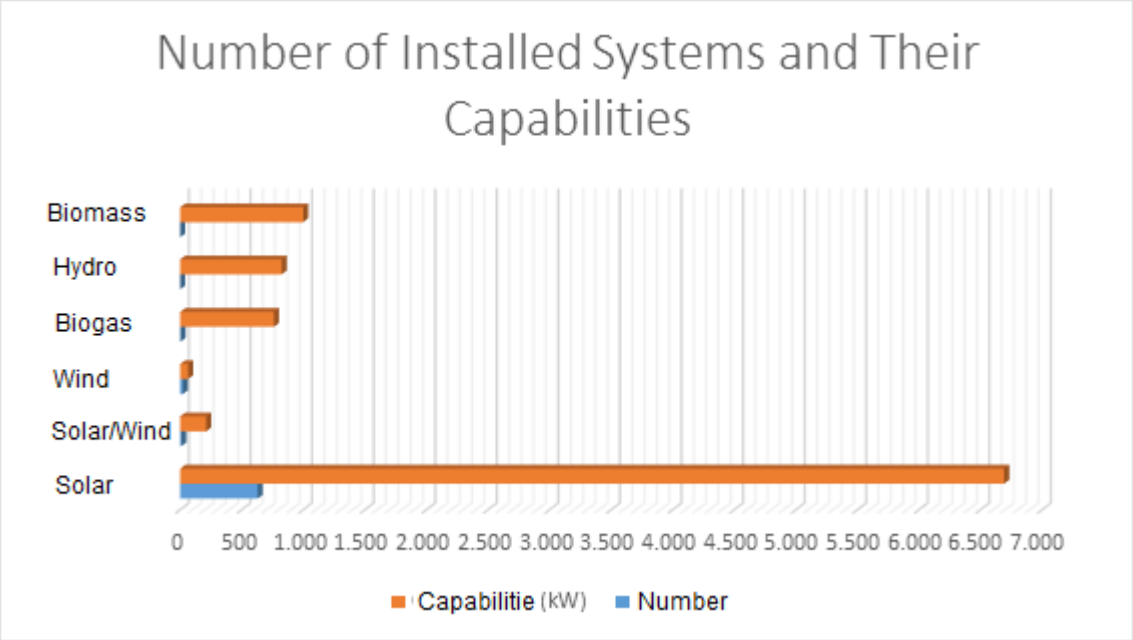

Figure 1 . Analysis of installed systems and their capabilities [1]

THE HARMONICS GENERATED BY DC/AC INVERTERS

For the electric energy generated by photoelectric cells to be injected into the mains, it is necessary that this energy is of such quality that does not cause disturbances in the network.

The inverter converts and rectify the signal obtained by solar panels, including taking care of peak voltage obtained, and optimizing the frequency of the signal. However, according to the doctrine, the signal from the inverter is a square signal.

"Static inverters use semiconductor devices to perform switching and work only in two modes: mode (off) and saturation mode (on). So the signal output is switched. A square signal can be converted to a sinusoidal signal by power filters. The process to filter out the harmonics near the key requires large capacitors and coils that reduce the efficiency of the system, " [2].

In tests the increase in harmonics with power variation by the inverter SMA Sunny Boy 2100 (Figure 2), [2].

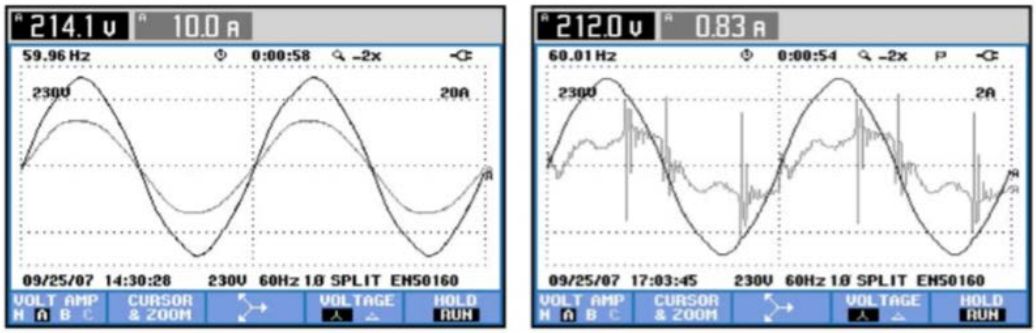

Figure 2 . Chart output voltage and current of the inverter SMA Sunny Boy 2100 with 100% power (left) and 10% (dir.), [2]

In the chart, the major change in the current wave, due to the existing harmonics. In a spectrometric graph of harmonics, existence quite relevant at low power (Figure 3), [2].

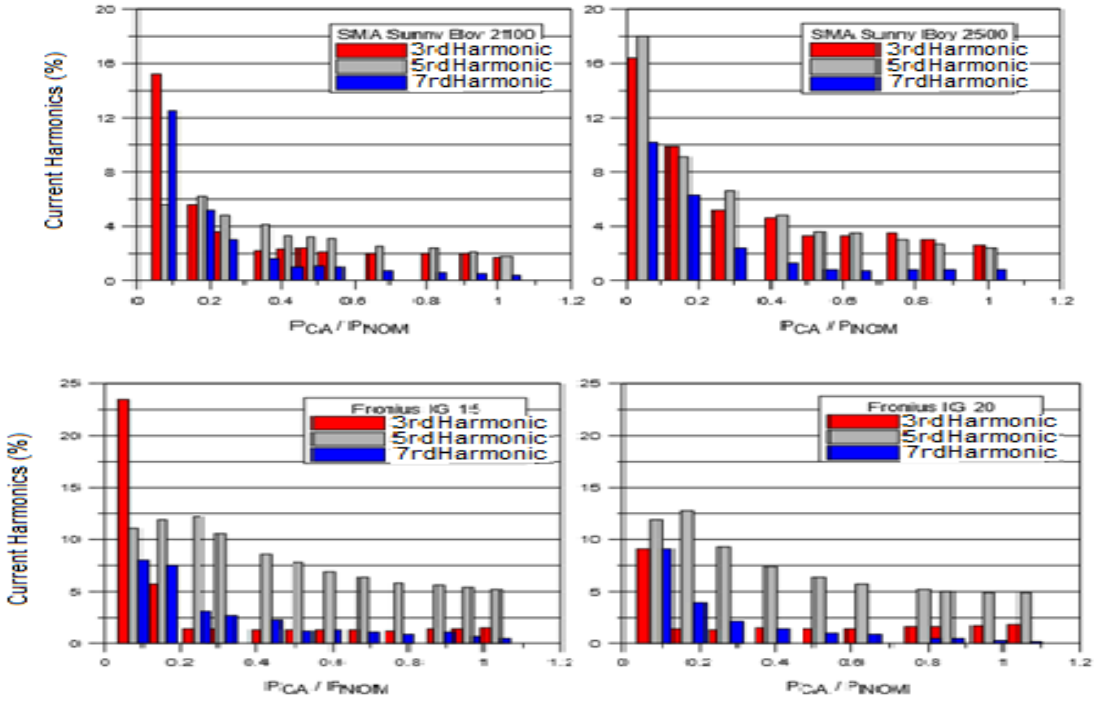

Figure 3 . Harmonics in several tests found in inverters [2].

It turns out that in harmonics, when analyzed, demonstrates that the first pass of the House of 15% in some models of inverters, which are released on the standard, that the harmonics should arrive to 4% at rated power [IEC 61727-/2004[3], IEEE-519/1992, IEEE-929/2000[4]]

Thus, it is concluded that, within hours of low heat stroke, the inverters will send harmonics electrical network, far beyond the desired standards. This diversification of situations requires a smart grid, you can analyze the signals of future several connected inverters.

[3] IEC: International Electrotechnical Commission – Tecnical Norms.
[4] IEEE: Institute of Electrical and Electronics Engineers (Instituto de Engenheiros Eletricistas e Eletrônicos) Tecnical Norms.

CHANGE OF VOLTAGE SPIKES ON THE NETWORK

In addition to the harmonic-related problems, there is the problem of the rise of voltage peaks. It was found on a generator connected to the mains voltage peaks during the day and considerably high harmonics generated in low periods of insolation.

"Entering into the merit of a qualitative analysis of the electricity injected by a small-scale SFCR and their impacts on the distribution network, some specific measurements were analyzed, considering a sunny day, (...) of variables such as: Total harmonic distortion (THDi), power factor (PF), RMS voltage and energy throughout the day, " (Figure 4), [3].

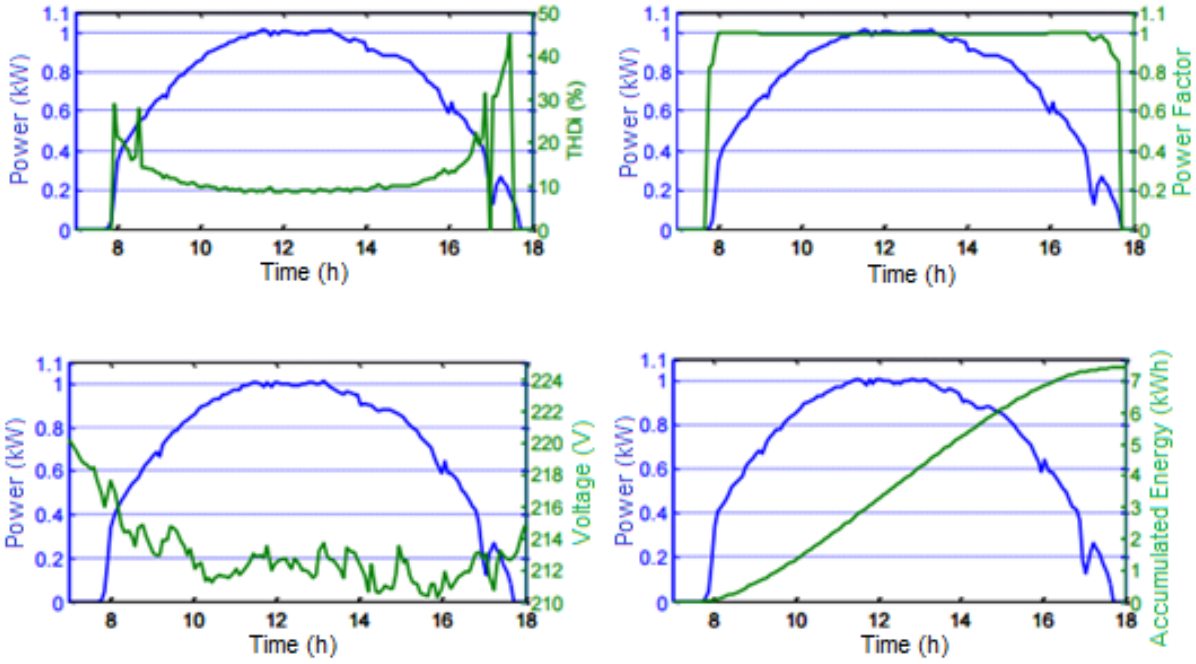

Figure 4 . Photoelectric generator data connected to the distribution network in the Amazon, [3]

The voltage values added to the network, measured at the output of the inverter are of the utmost importance and must be considered, since that change patterns of electric network at that point, for example, the energy balance from that location.

"The quality of energy is a very found in electrical engineering, due to the concern of dealers to provide a stable energy and with the least amount of harmonics. Power quality disturbances alter the characteristics of voltage and current, which result in a malfunction of the power supply. Among the main QEE disorders include harmonics, interruptions, rising and sinking, being these last three characterized as short-term voltage variations (VTCD) ", **[**4].

Similar practical results were verified by Freitas and other authors from the Faculty of electrical engineering and computer science at Unicamp:

"Assuming a indie want to install penstocks on the 50, which is a critical system bar from the standpoint of voltage drop by to meet away from the substation and have a high load, the following studies were performed. In this bar, injects herself active and reactive power supplied by synchronous generators with different power factor adjustments and, in each case, the system voltage profile is calculated. Several simulations were performed to verify the impact of synchronous generator installation in the system voltage profile during maximum and minimum loading, " (Figure 5), [5]

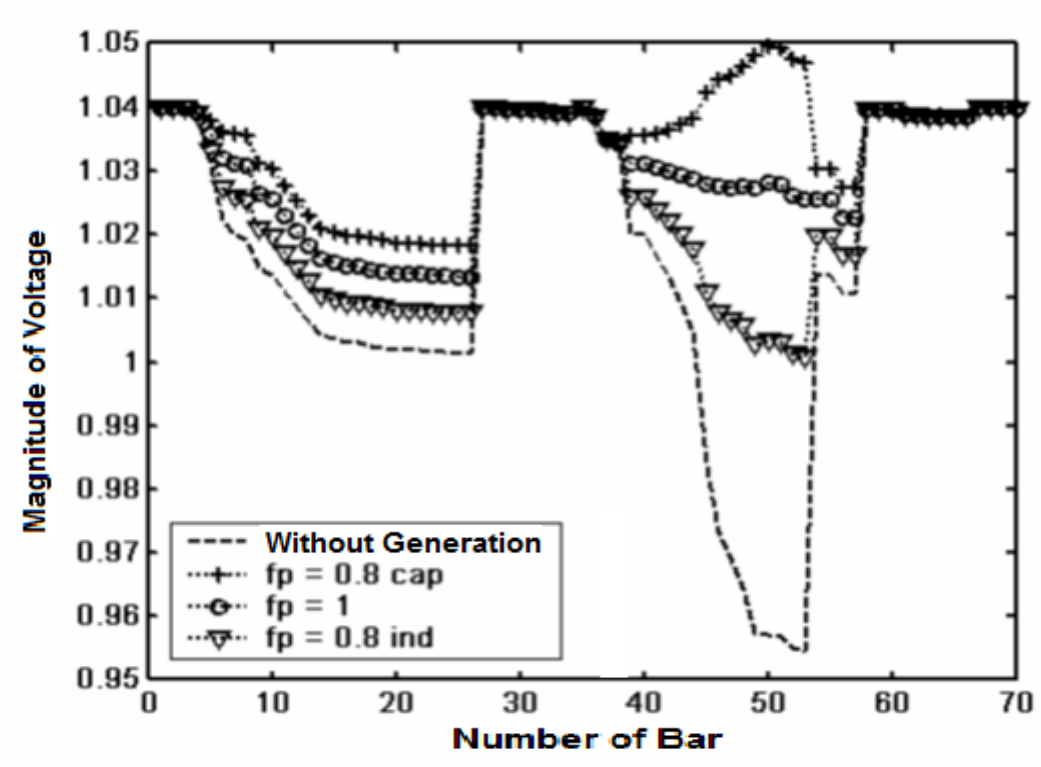

Figure 5 . Maximum loading with tap at 104%-injection of GD in the 50 and 2000 kW power [5]

There is then the change in the power quality of the network. Analytical studies have verified these voltage magnitude changes.

In the experiment, the magnitude of voltage increase quite considerable, almost in every bus, but mainly on the 50, which is a more sensitive to voltage changes (Figure 6).

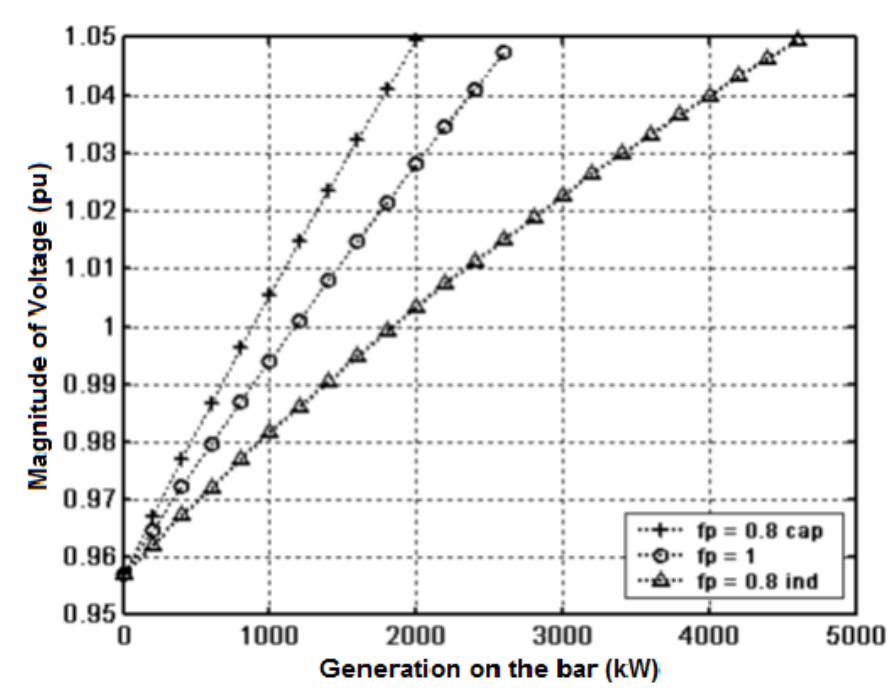

Figure 6 . Voltage variation for each synchronous generators power injection. [5]

On own 50 bar, power changes demonstrate high levels of voltage magnitude, configuring big difference of power quality.

The team of researchers at Unicamp concluded the following.

"... the need to assess the impact that the insertion of a DG[5] Park will bring to the system, so that it can stay stable and meet the consumers with an adequate quality standard. Thus, the expansion of DG should not be based only in search of better production costs or a reduction of environmental impact through the use of renewable sources, but also from studies that will ensure the reliability, quality and stability of operation of the system. " [5]

In this way, not only the connection must be prepared for a specialized model of access, but the whole distribution system in that region, what you can achieve with the smart grid (Smart Grid).

MATHEMATICAL TREATMENT

It is not difficult to understand the changes in the quality of the electrical energy distributed in the network by harmonic injection from various generators. Fourier's studies have shown the results of harmonics in the original wave, changing it valuably, raising the voltage peak-to-peak in phase, or causing voltage drops, if the original wave causing lag, a destruction of its frequency and format.

The THD value is an index used for the analysis of the harmonics. The chart in Figure 4, the values for THD prove as wave changes in relation to the sine wave. In an analysis, this indicates how much the wave analyzed differs from the ideal wave.

The index used to account for the amount of harmonics present in a wave, or in other words, how distorted a wave is about a sine wave is the *THD (Total Harmonic Distortion)*. For a purely sinusoidal wave, free of distortion, THD is 0%. Already for some very distorted waves, for example some electronics chains, the THD can reach 100%. The definition of THD is presented in:

$$THD = \frac{\sqrt{\sum_{n=2}^{k} {f_n}^2}}{f_1} \; x \; 100\% \qquad (1)$$

where: , F1 – the greatness in fundamental frequency; n – harmonic order;k-harmonic last considered fn-module of greatness in harmonic frequency [6].

Still, the crest factor (CF), which indicates the change in relation to the peak voltage, since it is the ratio of the peak voltage and the effective voltage.

$$CF_{wave} = \frac{Voltaage_{peak}}{Voltage_{RMS}} \qquad (2)$$

By Fourier series can analyze the resulting wave, realizing the amount of distortion is of major changes. These changes are of the order of 180 Hz, 300 Hz and 420 Hz for examining

Several authors come with the understanding that these harmonics can damage or alter the operation of various electrical and electronic equipment. For example, you can display the understanding of Igor Amariz Pires, in the following sense:

"... we tried to show the main effects the harmonics cause the following components of the electric system: power meters, drivers, lighting, rotating machines, electronic equipment, telephone interference, transformers, capacitors, relays, protection. In addition to these effects, showed the limits of harmonics in accordance with the main national and international standards. Harmonics cause losses for the consumer and for the utility. Despite these losses, the equipment mentioned have a level of susceptibility to harmonics ", [6].

[5] GD: Generation Distributed.

CONCLUSIONS

There was a breakthrough in how the country treats the decentralized generation with RN482/12. A Bill which allowed the connection of decentralized generators to the distribution network. It certainly is the beginning of an evolution and revolution in many ways. First, the way the electric energy consumer facing responsible usage of energy resources and the possibility of generating their own energy. Second, the way the dealers face the relationship with the consumer, focusing on an ecologically responsible consumption. And finally, a moment of broader perception of the State, by ANEEL[6], to enlarge the framework of renewable energy and a certain user's energy independence.

However, major technical measures are necessary. A renewal of distribution networks is necessary, due to the characteristics of the inverters, and the possibility that exponentially, are increasingly connected generators to the distribution network, with the Government and fostering new lines of financing. In this case, several changes, especially during the periods of lowest insolation, will be caused in the power quality in distribution networks, with the need for a smart grid (*Smart Grid*), which not only distribute electrical energy, but some currents generated by the various connected generators, analyze this energy and, in real time, a rectification of the same, mitigating possible high voltage peaks, unwanted harmonics and variations. You can tell that the best option is a change in the distribution network, to adapt it to the concept of Smart grids before thinking about promoting connection of generators to the distribution network.

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[6] ANEEL: National Electric Energy Agency – Brazil. (Agência Nacional de Energia Elétrica-Brasil)