European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)

International Conference on Renewable Energies and Power Quality (ICREPQ'10)
Granada (Spain), 23th to 25th March, 2010

The economic crisis and the urban electric power curve demand

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Abstract. The economic crisis is usually studied from points of view of economic growth evolution, of employment creation / loss, etc.

This paper is oriented from a technological perspective. In it, the evolution of several of the most significant variables in the load curve is studied, before and during the crisis of the Spanish economy. So, the aim of this paper is to identify the economic crisis throughout the analysis of the power curve demand of an urban low voltage (LV) substation. The analysis is centred on the most representative characteristics of the profiles which have changed, comparing the load curve of days with similar meteorological variables.

All the conclusions are extracted from the study of a real database, generated from the measures taken by means of a power quality analyzer, in a "representative" LV substation, from the year 2000 until the present. The main conclusion is that the economic crisis has been reflected in the power curve demand.

Key words

Economic crisis, load curve, urban electric power demand.

1. Introduction

An economic crisis implies the adaptation of consumption habits to the new situation. Recently these habits are extended to all aspects: economic, technical and social. Among others, the habits of electric power consumption have also suffered variations. Some consumers have adapted their own demand values, changing accordingly the evolution of some representative values of the power curve demand (average values, peaks, etc.).

In the international literature we can find some papers where the authors explain or predict the new values for the trend evolution in power curves demand [1]-[4]. But only an analysis on power curve demand measurement values can verify these studies.

We have created a wide database composed by actual measures of electric variables of the power consumption in an urban MV/LV substation by means of a power quality analyzer. These measures have been taken for ten years, and the registers correspond to peak values and average values. The registered data are voltages, currents, powers and disturbances whose average values have been recorded in an almost uninterrupted way with samples every minute.

The LV substation is located near the centre of Logroño, a medium town in the north of Spain, with a population near 160000 inhabitants. This LV substation supplies electric power to almost 450 consumers. Among these there are customers of the third sector (hostelry, shops and other services); in addition, there are consumers from several blocks of flats corresponding to people of different social groups. That is to say, the studied LV substation shows a representative consumption of the whole town, which has been considered as a group.

In this article the previously mentioned database is analyzed to discover the most significantly changes in the evolution of the power demand load curve.

2. Methodology

The methodology used in the work described in this paper, with the manage of database, is very simple. The characteristics of the electric load curve have been checked, Fig. 1, before and after the beginning of the economic crisis.

In Fig. 1 are shown the electric power demand of the three phases and the total power demand (in Watts) corresponding to the second week of January 2005.

It is not easy to establish a temporal reference that marks the beginning of the economic crisis in Spain, since the dates are slightly different depending on the person and his/her activity sector; a good reference could possibly be the second half of the year 2007. About what are the most significant electric variables for this study, the references are the peak and average values of voltages, currents and powers. Although current and power are variables intimately linked to the customer's demand, voltage is related to other factors apart from the consumers (take into account that the voltage regulation in urban LV substations is carried out by means of a combination of the operation in external substations with superior voltage levels, the configuration/reconfiguration of the system and the evolution of the consumptions in other LV substations).

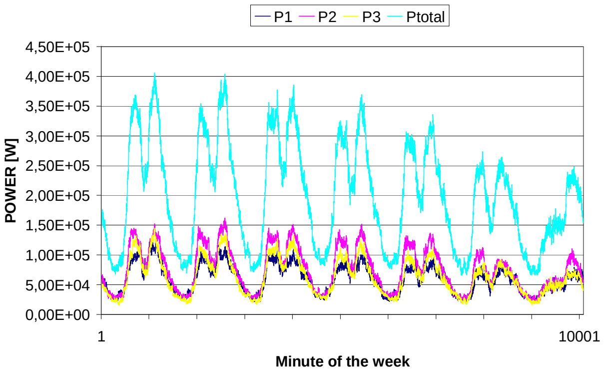


Fig. 1. Load curve for a week (sampled every minute).

In our power demand study, we have be used the normalized values for power using the peak value as the reference one, Fig. 2. This normalization helps to analyse the variations in the consumption schedules and the moment in which the peak values take place. Besides, the average and peak values are studied to observe their temporal evolution. Table I shows the data associated to the registers of the total power shown in Fig. 2, normalized with respect to the weekly peak value (on Monday with a value of 405.98 kW).

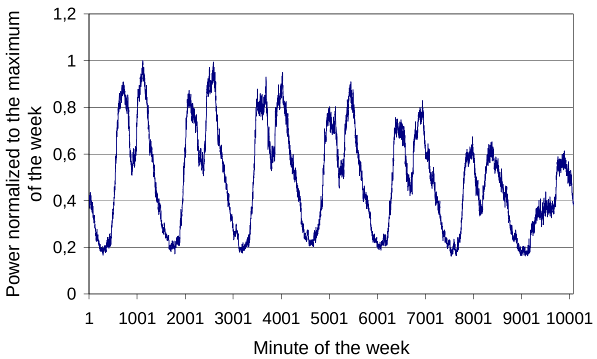


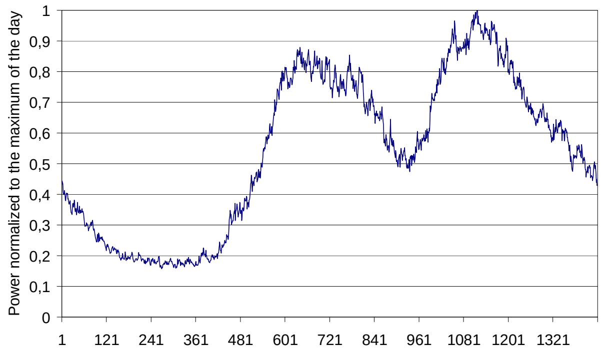
Fig. 2. Power during the second week of the year 2005.

Table I. - Normalized power values before the economic crisis. Second week of the year 2005.

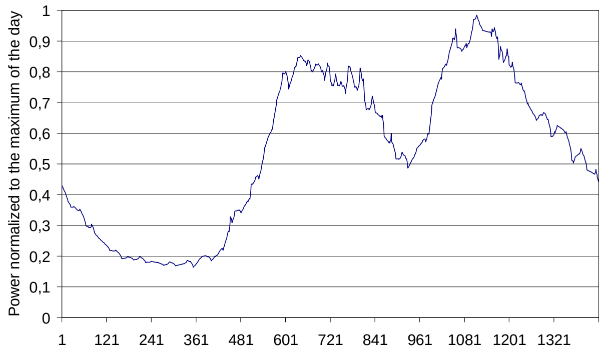
Day	Maximum	Average	Minimum
Monday	1	0.5503	0.1664
Tuesday	0.9942	0.5479	0.1715
Wednesday	0.9495	0.5480	0.1762
Thursday	0.9095	0.5180	0.2012
Friday	0.8278	0.4902	0.1882
Saturday	0.6735	0.4168	0.1622
Sunday	0.6126	0.3543	0.1631

Table I doesn't show the similitude or difference between the load schedule of working days, Saturdays and Sundays. To analyze these it is necessary to process the measured data day after day. Initially, the load curve must be smoothed to avoid confusing the fast power variations with other characteristics and to help the identification of the contour of the load curve; Fig. 3 shows the measured load curve and the smoothed load curve using signal processing tools (denoising techniques). The second step of our data analysis is the measurement of RMS noise, variance and average power from the original load curve, and the measurement of the peaks and valleys of the smoothed curve.

Before comparing two load curves corresponding to two different periods (two days or two weeks), it is required to ensure that they correspond to two periods with similar meteorological conditions. Previously to the extraction of the consumption data, days with a similar meteorological evolution are looked for, with the condition that they must belong to the same period of the year (season) to make sure that they have approximately the same sunlight hours and a comparable schedule, and with the condition that the daily average and extreme temperature values do not differ in more than 2 degrees.



a) Measured load curve



b) Smoothed load curve.

Fig. 3. Power during a working day before the economic crisis.

So, to establish the comparison of load curves of different time periods, a process of chronological and meteorological clustering must be carried out by means of the clustering techniques used in load forecasting [5]-[7] or the analysis of consumption profiles [2]. Later, the values and their evolution are compared and analyzed. The methodology is represented in Fig. 4.

The analyzed characteristics of the load curves have been:

- average Power (Pmed) in kW,

- average Power normalized to maximum of the day (Pmed norm),
- variance (σ) of the normalized data,
- RMS value of noise (Noise RMS),
- absolute maximum Power (Pmax) in kW,
- time of absolute maximum power (Time max) in minutes from the beginning of the day,
- maximum power before lunch (Pmax bl) in kW,
- maximum power after lunch (Pmax al) in kW,
- time of maximum power before lunch (Time Pmax bl) in minutes,
- normalized maximum power before lunch (Pmax bl norm),
- normalized absolute maximum power (Pmax norm),
- normalized maximum power after lunch (Pmax al norm),
- absolute minimum Power (Pmin) in kW,
- time of absolute minimum power (Time min) in minutes,
- minimum power at lunch time (Pmax lt) in kW,
- maximum power at night (Pmin nt) in kW,
- time of minimum power at lunch timer (Time Pmin lt) in minutes,
- normalized minimum power at lunch time (Pmin lt norm),
- normalized absolute minimum power (Pmin norm),
- normalized minimum power at night (Pmin nt norm).

The tendencies of all these values have been analyzed too.

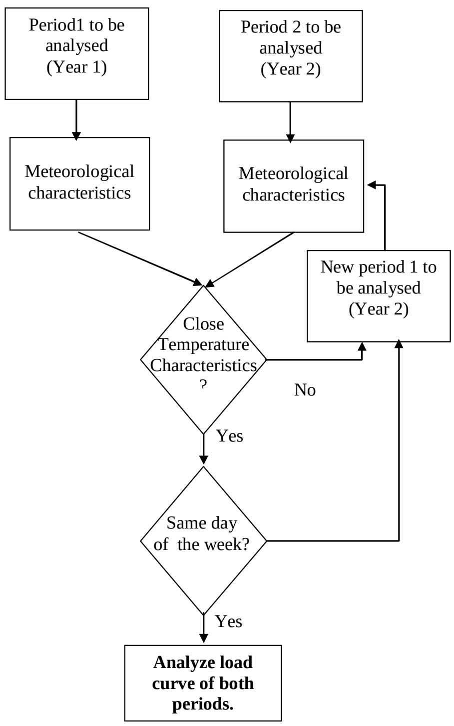


Fig. 4. Simplified methodology.

3. Results

Due to the great quantity of generated and analyzed data, it is difficult to present them. To help this process we have resorted to show them as tables like Table II, where several equivalent time periods of the power curve are compared. In Table II are shown the analyzed data of three days with similar meteorological characteristics, two of them correspond to days previous to the beginning of the economic crisis (years 2004 and 2005) ant the third corresponds to a day affected by the crisis. From the analysis of all the extracted information, it can been deduced that the demand profiles have changed slightly because of the economic crisis.

Table II. - Characteristics of three working days.

	08-XI-2004	10-XI-2005	10-XI-2009
Pmed	175.76	175.96	162.91
σ	0.065	0.056	0.067
Noise RMS	0.014	0.014	0.014
Pmed_norm	0.541	0.531	0.551
Time max	1.062	1.146	773
Pmax bl	268.99	272.50	295.49
Pmax	324.61	331.43	295.49
Pmax al	324.61	331.43	281.37
Time Pmax bl	789	774	773
Time Pmax al	1083	1082	1086
Pmax bl norm	0.829	0.822	1.000
Pmax norm	1.000	1	1.000
Pmax al norm	1.000	1	0.952
Time min	344	347	329
Pmin lt	163.730	138.010	142.110
Pmin nt	50.590	54.620	45.280
Pmin	50.590	54.620	45.280
Time Pmin lt	933	932	936
Time Pmin nt	344	347	329
Pmin lt nor	0.504	0.416	0.481
Pmin nt nor	0.156	0.165	0.153
Pmin nor	0.156	0.165	0.153

One of the main results is the change of tendency of average power (energy per day). Before the economic crisis the average power increased year after year. During the first year of the crisis the power consumption was similar to the last year before the crisis. In the second year the average power decreased (near 3,4%); but the most significant decrease corresponds to 2009 (with a decrease near 8%). That is a bigger decrease (near double) than the energy decrease of the Spanish average. This evolution is showed in Fig. 5

We can see several changes comparing the data before and during the crisis, Fig. 6. The conclusion for winter time is that during the crisis:

- The consumption peak after lunch is narrower.
- The consumption peak before lunch presents maximum values for more time and falls down suddenly.
- The minimum of the night valley is lower.
- The fall and rise of the lunch valley are faster.

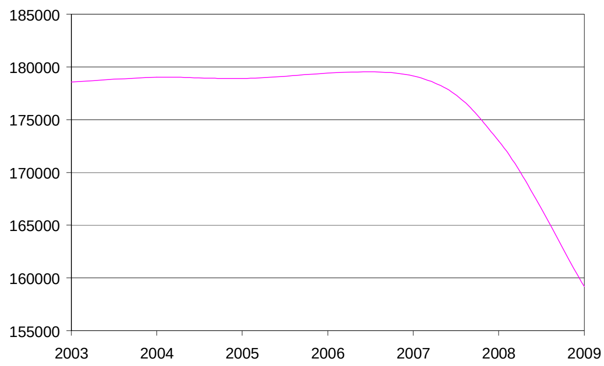


Fig. 5. Evolution of the average power in the selected LV substation.

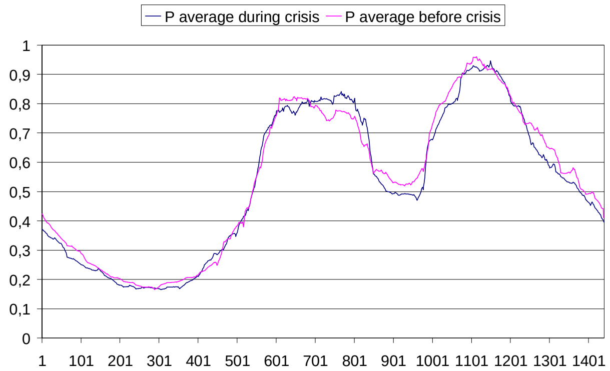


Fig. 6. Normalized load curve in winter.

In Fig. 7 are plotted the changes in the summer load profile. The result, during the crisis time, is the same one that in winter, except that in summer the minimum of the night valley is bigger than its value before the crisis.

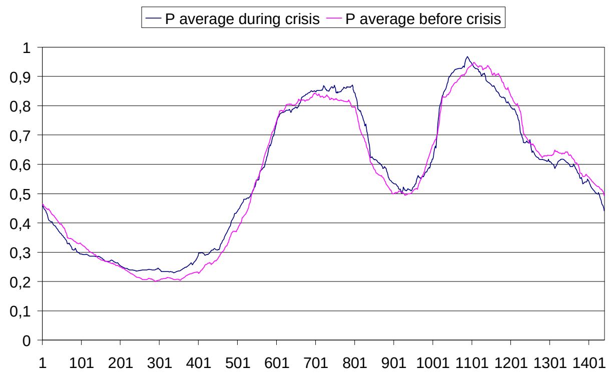


Fig. 7. Normalized load curve in summer.

Fig. 8 shows that the variability of the load curve in spring is bigger during the crisis time. We can see an increase of the valley of night time during the crisis time.

The analysis of the load curve in autumn, Fig. 9, shows a narrower after lunch peak consumption during crisis time. Also it shows a difference of the night time valley (near 2% more during the crisis).

The study of the variance during all periods shows that the value of this variable is bigger during the crisis time. The same happens with noise RMS values.

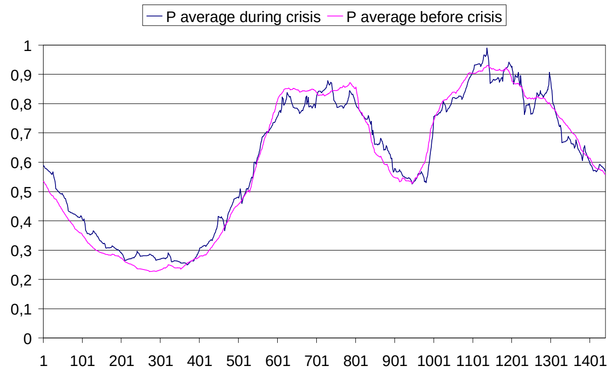


Figure 8. Normalized load curve of spring.

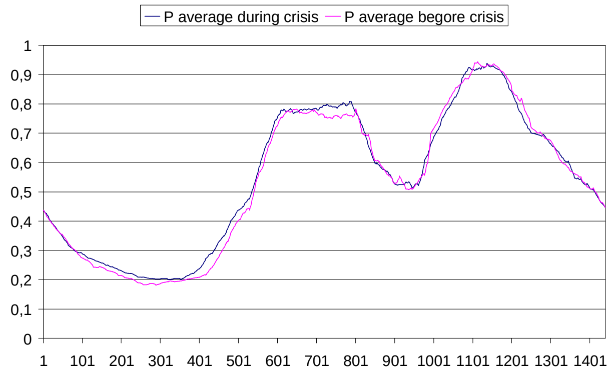


Fig. 9. Normalized load curve in autumn.

4. Conclusions

This paper shows the variations that the electric power curve demand of a representative urban load has suffered before and during the economic crisis of the last years. Load demand data were measured in an urban LV substation during the last 10 years have been analysed and compared in order to identify changes electric power consumption.

The results obtained with the analysis of the power curve demand corresponding to different although comparable days (similar meteorological characteristics) before and during the crisis, reveal a change in the profiles of the urban electric power consumption. The change in the profiles depends on the season of the year. The average power per day has descended, especially in the second year of crisis. The variance and the RMS noise have increased during the crisis time.

Acknowledgement

The authors would like to thank the “Ministerio de Ciencia e Innovación” of the Spanish Government for supporting this research under the Project ENE2009-14582-C02-02, as well as to thank to Iberdrola (La Rioja) for its collaboration in the measurements into the LV substation.

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