DSM THROUGH TIME-OF-USE TARIFFS

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SUMMARY

This paper describes the experience that has been held, by the Power Utility of Minas Gerais, CEMIG, at the city of Juiz de Fora, in order to achieve load curve leveling through Demand-Side-Management using time-of-use tariffs.
The methodology to chose the customers , the metering system and the rates adjustments that had to be done are also described as well as the results obtained with the changes on customers habits, that led to transference of load from peak-time to off-peak-time.

INTRODUCTION

Companhia Energética de Minas Gerais – CEMIG has been considering new tariffs for low voltage, with the purpose of providing for a rational utilization of the electrical system, and at the same time achieve a reduction of the costs for operating and expanding the production, transmission and distribution of electric energy.

Such new differentiated tariffs are intended for modulating the demand curve during the peak hours of the Electrical System. During this period, most of the transmission lines are subjected to heavy loads, raising the need of investments in order to accommodate new and increasing demands.

Thus, a means of easing the load on the lines must be sought, for example by promoting the shifting of part of the peak-hour load and spreading this load throughout the rest of the day.

So, concerning the establishing of a new mode of differentiated tariffs, CEMIG is evaluating the application of a binomial tariff (Demand and Energy), which in principle will offer a more effective guidance to the customer about the best way of using Electric Energy. The experience is being held witch 432 low voltage customers (residential, industrial and commercial) in the city of Juiz de Fora, MG, Brasil

This will require:

- extensive in-depth knowledge of the low-voltage market;
- knowledge of the costs and the establishment of the tariff;
- development, suggestion and testing of various types and features of metering/reading equipment;
- evaluation of the costs of implementation;
- evaluation of investment savings;
- performance of cost/benefit analysis in each consumption class and range.

METHODOLOGY OF THE PILOT PROJECT

The project of "Differentiated Tariffs for Low Voltage" of CEMIG has been structured along the following main activities:

a) diagnostics and identification of the problem;
b) knowledge of market behavior, with the view of calculation of marginal costs and establishing the tariff;
c) proposing, testing and selection of a metering equipment for billing, which complies with the requirements of the proposed tariff;
d) application of the differentiated binomial tariff to a sample of customers;
e) monitoring of load curves of distribution transformers to which the sampled customers are connected;
f) monitoring of customer load curves to evaluate changes in behavior;
g) **research** to determine which equipment the customer stops using during higher price periods (peak) and the changes involving consumption habits;
h) production of a report on the findings and recommendations;

The major phases of the pilot project are detailed below.

Determination of the Problem

- Figure 1 shows CEMIG's overall energy load, where one may see that the distribution load curve peak is the one responsible for the total load curve peak.

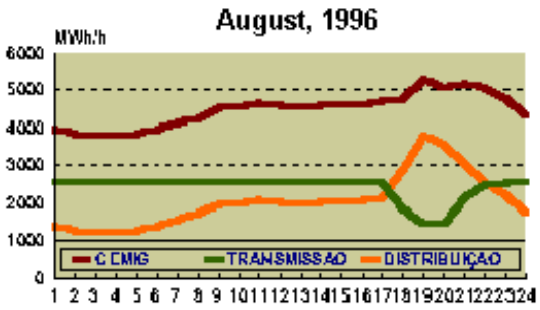

Figure 1

- Figure 2 shows the distribution aggregate load curve, showing that the critical problem concerns low voltage.

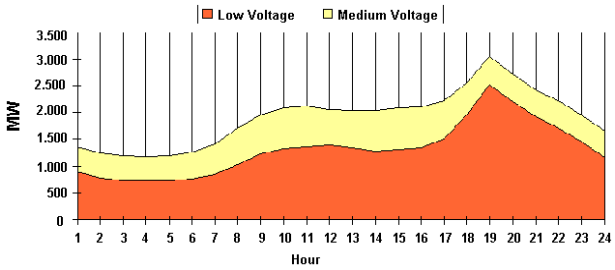

Figure 2

- Figure 3 shows the low-voltage aggregate load curves, showing that the critical problem concerns residential customers

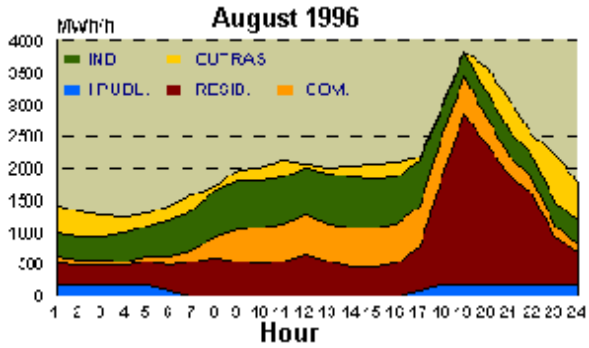

Figure 3

Knowledge of the Market for Calculation of Marginal Costs and Determination of Tariffs

In order to achieve an in-depth knowledge of the low voltage market, a survey of CEMIG's market (consumption and number of customers) was required, involving its stratification according to the classes (residential, industrial, commercial, rural, etc.) and range of consumption, further separating into single-phase, two-phase and three-phase. Such data is vital in deciding which market segment should be targeted with the differentiated tariff and in which segments the tariff would be economically feasible.

Then, between July and September, 1997, a campaign involving metering of low-voltage customers was performed in order to provide knowledge regarding load curves of low voltage customers. For this purpose, 250 metering sets with electronic equipment equipped with mass memory were employed over a metering period lasting one full week (9 days) at each customer. 10,000 metering events were filed.

Based on the metering results achieved during the campaign, a load typology was developed for each range, within each consumption class. Studies were performed covering the diversity, load factor, behavior during work days, Sundays and holidays in addition to all information required for calculation of the marginal costs of the supply and building of the tariff. The survey included the determination of the prevailing economic activities in each type of the commercial and industrial classes. Below are shown the typical curves for low voltage at CEMIG:

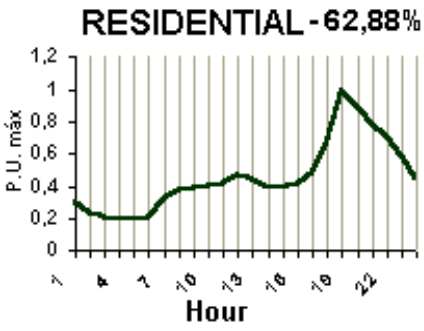

Figure 4

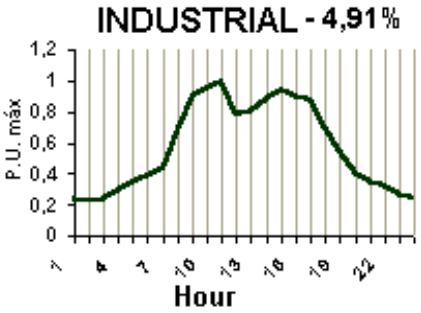

Figure 5

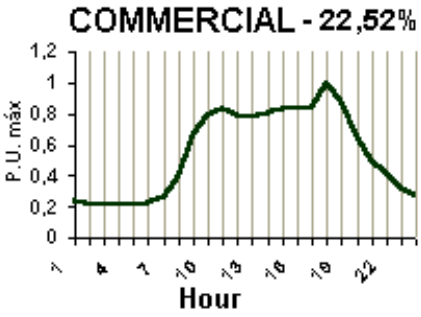

Figure 6

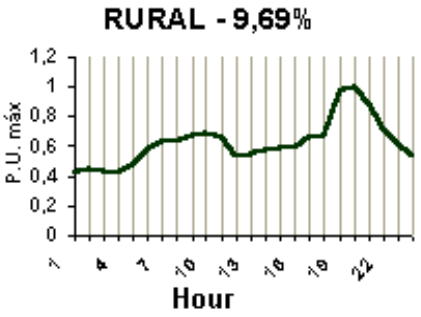

Figure 7

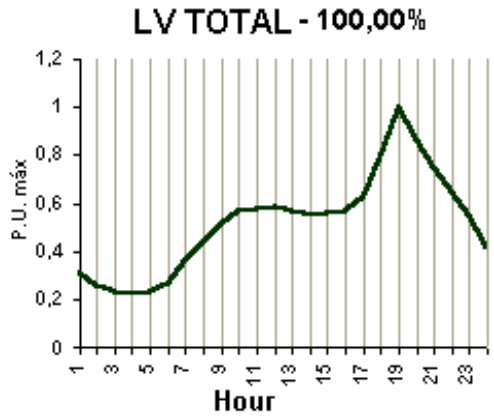

Figure 8

Plans have also been made for two researches covering consumption habits; one before the application of the tariff and another after the application. Such research work is intended for a preliminary identification of the current consumption habits and profile of the behavior of the sampled customers within the current tariff system. At a later stage, the changes in these habits shall be evaluated, as a result of the application of the new tariff. During the research, the constumers were queried for the following topics:

- Who are they?
- income bracket
- degree of schooling

- How do they live?
- type of dwelling
- number of people in the dwelling
- size of the dwelling (number of rooms, area in m^2, number of bathrooms)

- What measures are adopted to save electric energy?
- What are the possessions and habits involving the use of home appliances and domestic lightening

Differentiated Binomial Tariff ("Yellow Tariff")

New consumers are constantly being added to our electric-energy system and those already connected are increasing their consumption.

It is this increased consumption that determines the expansion of the existing system and, as a result, new costs for the whole society.

The marginal cost, rather than the average accounting cost of the facilities in service, as a tariff reference, is what correctly tells the customers about the consequences of their consumption events.

A tariff system based on marginal cost will tell the customer, for example, the benefit resulting from the reduction or shifting in his/her consumption.

It should be emphasized that a change in the consumption habit of a customer may allow service to be provided to an additional customer, with no need of expanding the system.

The benefits achieved with a structure of electric-energy prices based on marginal costs are shared among all economic players participating in the process
On the one hand, the supply system becomes more efficient as the tariffs lead to a more rational utilization of the existing facilities and reduce the need of new investments, with the ensuing reduction of costs incurred. On the other hand, the tariffs and the customer bills will also see a reduction.

The differentiated binomial tariff structure developed under the pilot project presents a fixed price to cover the commercial costs and prices for power (R$/kW.month) and energy (R$/MWh) at three tariff periods:

- peak (18:00 to 20:00 hours)
- complementary peak (17:00 to 18:00 and from 20:00 to 22:00 hours)
- off-peak (22:00 to 17:00 hours)

The customers may opt for this mode, under which they will be billed for the power and the consumption recorded and may obtain a reduction in their bills. The customer may freely decide about his/her consumption at any time.
This tariff is more efficient from the standpoint of an economic signal and is of interest for those customers who relish their comfort, but are willing to reduce their bills.

Figure 9 following shows the values and the yellow tariff structure

TARIFFS	ENERGY R$ / MWh			DEMAND R$/kW * mês			CONV R$/MWh
	P	FP	PC	P	FP	PC	
RES	412.62	62.02	109.64	1.44	0.05	0.20	133.02
IND	237.19	76.24		4.41	2.79		124.19
COM	237.19	76.24		4.41	2.79		124.19

Figure 9

Metering System

To atend the pilot project purposes, CEMIG had to join to the manufactures in order to develop low cost equipment system.The metering system adopted allows the utility to interact with the consumer market, by introducing an automated reading system, in order to reduce the demand during the peak period of the electrical system. The system uses programmable exchanges installed on the low voltage side of the distribution transformers, using carrier signals transmitted within a communications protocol to allow

control of modules located at the consuming facilities and/or at load points in general. Such signals are transmitted using an encryption system in order to provide secrecy to the communications. The system operates in a bi-directional mode, transmitting data on the 3 (three) phases and may be assumed as a standalone system, since the modules are equipped with lithium batteries and chips with non-volatile memory, where all data of the consuming units are programmed plus a memory, where the consumption and demand data, broken down into 3 (three) hourly periods (peak, off peak and complementary peak) are stored.

The main advantages of this system are on the aspects of the costs and implementation versatility, which distinguishes the system from other large-size systems that have high fixed costs, requiring them to be implemented in areas with large concentration of consuming units by medium-voltage or high-voltage circuit.

The system also provides for interconnection of the various exchanges through conventional/cellular telephones or radio and the management through conventional microcomputers. The communications can be made during low-tariff periods (midnight to 6 am).

Electronic time-of-use meters equipped with mass memory and punctual reading are also being employed in some of the customers from the sample.

The figure 10 shows the metering system used and its future skills

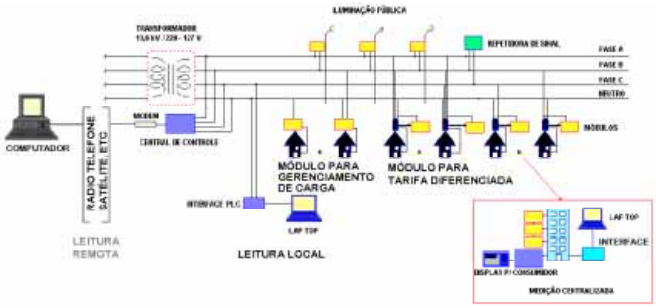

Figure 10

Application of the Tariff

In March 1998, the new differentiated tariff was applied on a sample of customers, at which time the customers were told of the pilot project and the new tariff mode.
A videotape explaining the tariff was produced and presented, showing in a simple form the basics and objectives of the differentiated tariff. Leaflets were distributed among the sampled customers covering the differentiated tariff, containing information about the following topics:

- the project and its objectives;
- clarifications about the tariff and the tariff periods;
- simplified concepts of power and energy;
- procedures which should be adopted to reduce the consumption and demand during the periods of higher cost;
- equipment units with high power ratings;

Subsequently, CEMIG carried out an extensive program involving visits to all players in the project in order to deliver to their dwellings/facilities all the material explaining and divulging the differentiated tariff. Discussions were held with the customers about the objectives of this tariff mode and how to profit from it.

Customers participating in the project are receiving a monthly statement detailing the differentiated tariff at every hourly period for each electrical component (power and energy). Using this exhibit, the customer will be able to understand what he/she is paying for and will encourage him/her to better manage the use of the electrical appliances.

Evaluation of the Response to the Tariff Signal

The following parameters are monitored and reviewed on a monthly basis:

a) customer behavior in response to price signals through the evaluation of billing data (energy and power) from the various hourly posts and monitoring of customer load curves.
b) The behavior of the distribution transformers, by monitoring the measured load curves.

Feasibility Analysis

A feasibility analysis of the implementation of the differentiated tariff on the low voltage for every class and range of consumption shall be performed. This analysis is performed by taking into account the costs of implementation and network investment savings.

The costs of implementation will assume:

a) cost of the metering equipment/system (investment, depreciation, operation and maintenance);
b) annual revenue loss due to application of differentiated tariff;
c) cost with the new reading/billing system;

The investment savings will assume:

a) reduction of peak and complementary peak power on low-voltage transformers and the amount for all networks;
b) reduction of the peak and complementary peak energy;
c) eventual increase of the off-peak energy;

Report on the Findings and Recommendations

The feasibility analysis will provide input for the report on findings and recommendations with the following topics:

- modulation of energy and power and reduction of the bill
- by class and range of consumption
- by income bracket
- by economic activity
- by distribution transformer

- implementation costs
- analysis of behavior of metering/reading equipment & systems
- proposed tariff
- proposed implementation

CONCLUSION

The measures taken so far show that the customers from the sample have correctly understood the differentiated tariff and are changing their habits of consumption in order to reduce the amounts of their electric energy bills. Below, (figures 11 and 12) we show an example of the modulation of demand of one customer from the sample:

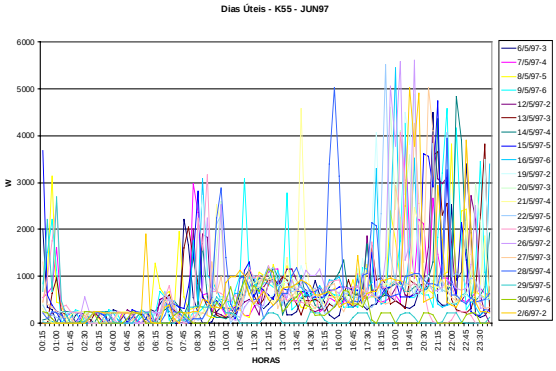

Figure 11

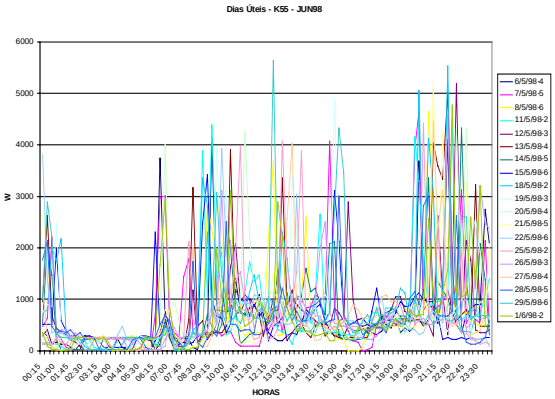

Figure 12

The modulations of energy at peak hour reached 15%.

The gains effectively reflected on the networks and on the transformers will only be known after application of the differential binomial tariffs to a significantly higher number of the sampled customers and as the population is gradually made aware, through educational and publicity campaigns, of a more rational use of electric energy and an understanding of the concept of capacity (demand and energy).

CEMIG expects to extend this measure to a universe of 900,000 low voltage customers, with consumption exceeding 200kWh/month, during a period of 5 years.

ACKNOWLEDGEMENTS

The actions described in this text are, indeed, the results of a dedicated effort made by many people, beside the authors, which have given a significant contribution to make this experiment going on. To this people, including those who don't work for the company anymore, we express our sincere thanks.

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