DEMAND MANAGEMENT TO REDUCE THERMAL LOADS TO TRANSFORMERS AND VOLTAGE LEVEL PROBLEMS

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ABSTRACT

This study presents the considerations made over the management on the demand side of hourly-seasonal customers. The proposal presented consists of the optimization of systems in the context of the electric energy network of the border region of the state of Rio Grande do Sul, specially during full load as of rice harvesting. The phases of the implementation of special peak times are described. The paper also discusses the results of simulations and measurements that show the uniformity of the load curve and the respective benefits in reducing the thermal requests of transformers

INTRODUCTION

In Brazil, incentives are offered to the development of rural activities. One of these benefits comprises discounts in electric energy bills, when power is used exclusively for irrigation purposes. These conditions were initially defined in 1992 by the Federal Department of Water and Electric Energy, DNAEE, Resolution 105 [1]. In the west border of the state of Rio Grande do Sul, rice is extensively grown in farms, causing a strong seasonality as regards electric energy demands. This fact imposes high demands over the electric energy network at short periods in the year, while for the rest of the time the network is under low demands. In this sense, it is worth mentioning that the region answers for around one third of the country's rice production, which results in a high load demand during the wet season, from December to April. Such features imply a considerable severity in demands placed to the system. Load curves produced by substations that feed rural customers using irrigation are significantly similar, with high loads throughout the day and a subsequent drop between 7 pm and 10 pm (peak times), when a substantial reduction in demands over the system is observed.

Aiming to smooth the loading curve of power transformers operating in the region's substations, thus diminishing overloads during high loading periods, a load transfer study for peak times as caused by irrigation, practiced by hourly-seasonal customers, was conducted. These special peak times in the wet season afford the alteration in these systems' load curves, so that the demand by customers served does not concentrate along the whole day, when higher environment temperatures are measured and power transformers are under greater demands. Considering the inherent characteristics of the regions electric energy system, the actual benefits generated by the approach are verified: likely overloads are avoided, voltage levels are improved to fulfill load demands, and possible voltage fluctuations are diminished. Thus, the adoption of a load transfer strategy was suggested and submitted to the country's regulator agency for electric energy (National Electric Energy Agency, ANEEL). The load transfer plan reallocates peak times to manage demands more flexibly.

The present study shows the results obtained with the implementation of the plan, whose strategy comprised the distribution of loads throughout the whole day, except for the reduced fee periods as established by Resolution 105.

The plan was implemented in three substations in the region, and implied the definition of 5 different times (between 6 am and 9 pm). The objectives were fully reached, both in terms of thermal requests to equipment and in the improvement of the load curves across feeders.

Based on the evaluation of results, this operational alternative is under study to be adopted also in the remaining substations of similar characteristics within the region. After the recent invalidation of Resolution 105, which had defined the hours when electric energy fees were given a discount for irrigation purposes, it became possible to improve and expand the load transfer plan, ultimately rendering load curves at peak times more uniform during rice harvest. This change in the legislation, enforced through ANEEL Resolution 207 [2], meets the objectives of the plan proposed as the electric energy company is free to establish the start of the reduced fee time, thus improving the system's flexibility against significant seasonal demands.

The adoption of the complete load transfer plan, with 8 different peak times, also affords a reduction in voltage variations caused by alterations in the larger load blocks in the system, without nevertheless bringing any losses to the customers served.

With the management of the system's demand and full load transfer plan operating in peak times, the benefits and results concerning a better distribution along a load curve are expanded. As a consequence, energy supplies are improved until the system expansion works are implemented, with the real system's actual needs being more appropriately addressed. Also, an estimate of the impact of feeder loading management and flexibility on the substations' global demands is presented.

Side by side with the loading results, an assessment of the rise in transformer temperature was carried out due to the behavior observed as of loadings with and without load transfer, which characterizes the optimization of the system's operation.

SYSTEM CHARACTERISTICS

The plan was put to practice in the west border region of the state of Rio Grande do Sul, in which one third of the country's rice production is grown.

Noteworthy seasonality is observed in the region in the period between November and April, due to the irrigation of rice plantations. Thus, considering the characteristic configuration of radial feeders with relatively significant extensions, a strong impact on voltage drop is observed across the system as of intensified irrigation in the area.
Figure 1 shows the behavior of the load curve typical of feeders that supply power to consumers ranked as users of rural irrigation [3]. By analyzing figure 1, a considerable potential toward uniform loading is observed, according to the aims of the demand management plan as introduced.

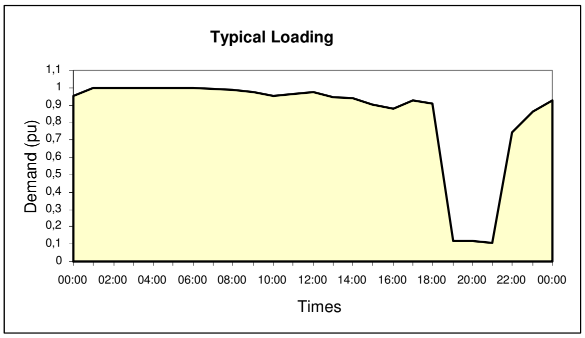

Figure 1 - Typical Load Curve for Border Region

DEMAND MANAGEMENT

The actual feeder load curves show distinct characteristics as regards the composition of load blocks and the use of electric energy. In the context of demand side management (DSM), in terms of system efficiency and rationalization, the ideal answer would be a constant value in accordance with the system's technical specifications. Actions taken such as load transfer and smoothing of valley segments of the curve are some of the possibilities observed in terms of adaptation of the demand. All in all, the proposal aims to transfer demands to the original peak time, thus improving the load factor of feeders. The following secondary sections describe each stage executed toward improving the quality of the energy supplied and of the transformers' thermal conditions.

Partial Load Transfer

The loading management was proposed to the regulator agency and implemented during the 2005/2006 rice harvest in three substations. Five different 3-hour-long peak times were considered, distributed from 6 am to 9 pm for the hourly-seasonal customers grouped according to address, identification number and position of the consumer units across the feeders that took part in the initial stage of the proposal. The low demand at each peak time was considered as the sum of all demands, as ruled by contract, of the consumers for each period with a 10% tolerance margin. Figure 2 shows the load curves predicted for the partial load transfer. In this particular study, the main target was the reduction of technical costs due to transformer overloading. The substations served were Uruguaiana 4, Alegrete 3, and Quaraí, including the 6 feeders in rural areas in the adoption of load transfers at differential peak times. In the light of the existing regulation, reduced fee times were observed as defined by Resolution 105 [1].

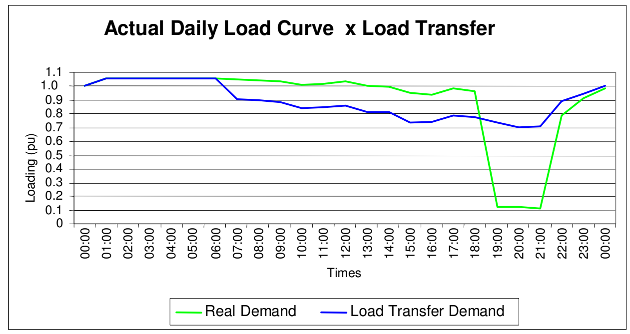

Figure 2 - Simulation of Partial Load Transfer

Measurement data are presented to prove the results obtained after the adoption of differential peak times. Figure 3 shows the comparison between curves for feeder AL 43, Uruguaiana substation 4, with and without partial load transfer.

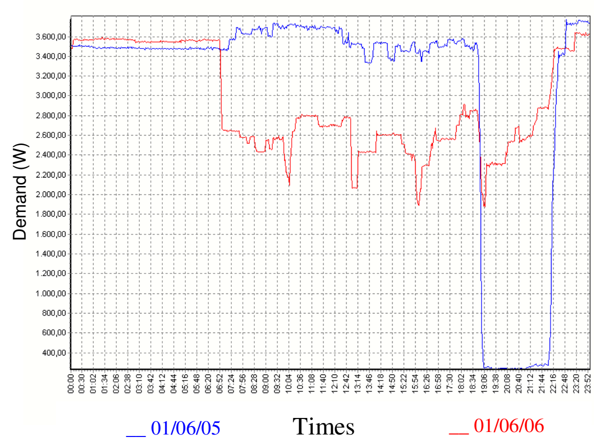

Figure 3 - Measurements with Partial Load Transfer (AL 43)

It is observed that the result expected was obtained in consonance with the proposal implemented. Figure 4 shows the comparative analysis of the demands over the transformer (17 MVA), including the other feeders, with and without the demand management proposal. Satisfactory results were also obtained in terms of the reduction of the demands over the transformer. An increased demand was observed due to the overriding of the demands contracted as of the period when load transfer was not practiced (demands rising up within the 10% tolerance margin and even going beyond maximum demand values), and to the growth of the actual demand by rural customers. Yet, even under such conditions, with the most critical environment temperature, loading remained below the 2005 value [3].

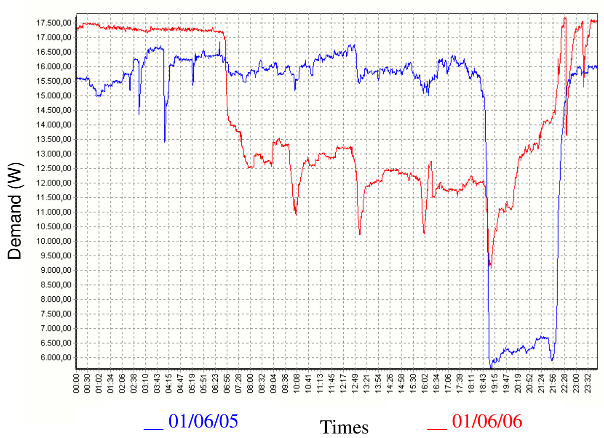

Figure 4 - Measurements with Partial Load Transfer (SS - URU 4)

This contributed to the drop in transformer temperature, thus improving the equipment's working life. Temperature rise was estimated for the conditions with and without load transfer at peak times. In order to comparatively assess temperatures in terms of loading, a standardized methodology was used. Load curves and environment temperatures were obtained every minute, as shown in figure 5, for the winding temperatures [4],[5].

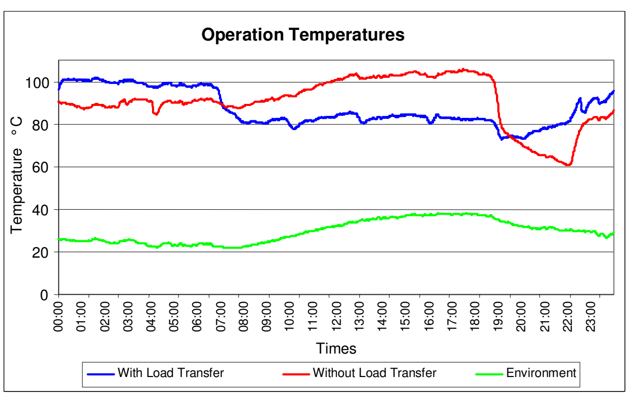

Figure 5 - Comparison between Transformer Temperatures

Complete Load Transfer

Based on the results obtained after the implementation of the partial load transfer, management was evaluated for the whole period. The main target then focuses on the optimization of the distribution system by permanent requirement of peak time management in the border region, expanding the benefits of seasonal irrigation load transfer. In order to implement this alternative, the flexibility of the reduced fee times for rural irrigation becomes necessary, as stipulated with the alteration of Resolution 105 by Resolution 207. Thus, this proposal established 8 different peak times. An example of the simulation of the comparison between partial and complete load transfer is analyzed in figure 6.

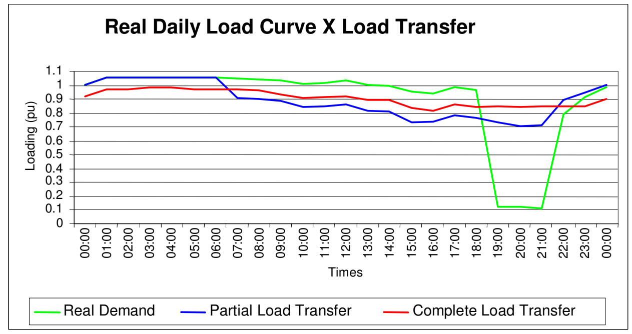

Figure 6 - Simulation of Load Transfer

Apart from the benefits of the reduction of thermal demands over transformers, another direct advantage emerges concerning the voltage curve toward the improvement of the load curve of feeders. In order to illustrate this, the performance of feeder AL 43, substation URU-4 was simulated based on the load measurements and estimates as afforded by the proposal. Figure 7 shows the referenced feeder network, to analyze the most important supply points.

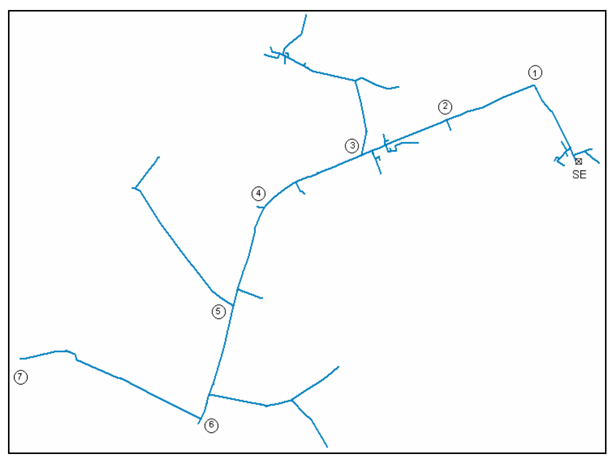

Figure 7 - Feeder Configuration - AL 43

Figure 8 shows the voltages practiced obtained by the simulation of the load flow under two conditions, based on the period of top demand, in which the voltage curve across the system is more appropriate, due to load transfer. For this case in particular, the added benefit of a reduction in losses of up to 15% is observed. Apart from this, the proposal also results in a better answer to variations caused by motor startup procedures, as during demands become less severe as of entering and leaving load blocks.

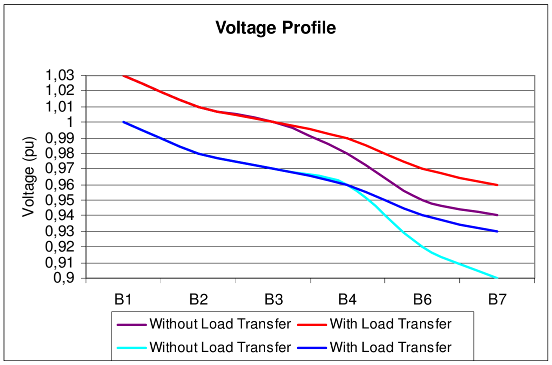

Figure 8 - Voltage Behavior in Steady State

GLOBAL LOADING

The alterations proposed for global load transfer were predicted for the region's remaining facilities. These facilities supply the power predominantly to the operation of water pumping equipment. With the same methodology, a reduction of loading for the other substations was predicted, considering only the load transfer for transformers that supply power to irrigation [3]. Fig. 10 shows the behavior of the active global demand in substations that supply electric energy to the state's border region, whose main characteristic lies in the seasonality caused by the rice harvest. Figure 9 reveals the improvement in global load factor in the region.

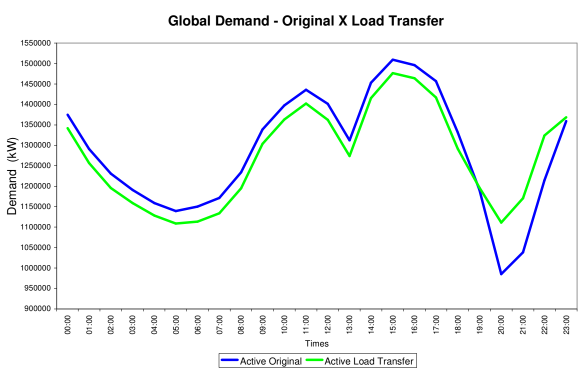

Figure 9 - Behavior of the Region's Total Demand

CONCLUSIONS

This study presented a proposal to manage demand in the Rio Grande do Sul border region, focusing on the energy supply to irrigation of rice plantations during the season. The load transfer for hourly-seasonal customers of the system presented permitted the adaptation of the loadings of transformers installed in the substations that serve loads of significant seasonality. Peak times were evaluated to obtain a better load distribution in the system. Due to the legislation, in the period when the study was conducted, load transfer was partially carried out in 3 substations, with the observance of defined peak times in the proposal initially submitted to the regulator agency, ANEEL.

As expected, even under this limiting condition, the results were fully satisfactory, as proved by the simulations and measurements of loading before and after the adoption of demand side management. The results for rise in transformer temperature were predicted by classic equations. The system was also analyzed focusing on the improvement of voltages by load flow analysis. For the period 2005/2006, the main objective was to conserve transformer temperatures during the hot summer in the region. The study was expanded with the proposal of the permanent management of peak times for the border region of the state of Rio Grande do Sul. It was then that the flexibility of times as stipulated in resolution 105 by DANEE became necessary, that is, the alteration of the reduced fee period as defined between 9 pm and 6 am, according to the objectives of the load transfer proposed. This possibility is already explicitly addressed, making possible the definition, together with the customer, of the start of the reduced fee period. Once the critical irrigation stage was finished, the proposal as implemented also improved the quality of the voltage delivered. With the expansion of the main substations of the region, the measures implemented refer to the best voltage curve in terms of the optimization of the load curve. The proposal was given a good reception by the regulator agency and is at its final stages of evaluation before full implementation. The proposal was evaluated and understood as viable, and opens the way to the possibility to postpone investments, as the load management brings about the direct reduction of the marginal expansion costs. The adoption of load transfer also results in reduced voltage fluctuations, produced by changes in large load blocks in the system, without nevertheless any negative effect to the customers served. With total load transfer and system demand management, the results concerning the better distribution in transformer load curves are expanded. As a result, transformers' service life is enlarged, with the general improvement of voltage levels within the system.

REFERENCES

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