Load Shedding Scheme for a Large Pulp Mill

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Abstract—UPM Fray Bentos Pulp Mill, is one of the largest single line ones in the world, producing 1.1 million tons per year Bleached Eucalyptus Kraft Pulp. The mill has cogeneration capacity covering in excess its own need of electricity and steam. Excess electricity is sent to the Uruguayan utility UTE grid through a dedicated 150 kV tie line. In normal mill operation, more than 96% of the time the mill exports electricity to the grid, and rest of the time is importing, particularly in contingencies and mill start ups taking into consideration that the mill has no black start up capability. In order to assure that the tie line capacity is not exceeded, a Load Shedding scheme has been implemented. In case contingencies the mill is able to work isolated from the grid. There is a Load Shedding scheme in case of loss of the tie line, and an under frequency Load Shedding for island operation. This paper discusses the development of the scheme and its operational experience.

Index Terms—Cogeneration, Load shedding, Pulp and paper industry.

I. INTRODUCTION

At Fray Bentos pulp mill [1] in Uruguay, electricity supply is assured by two turbogenerators, using steam coming from a Kraft Recovery Boiler. At nominal mill capacity, average power is 122 MW, and 30 MW excess electricity is sent to the utility UTE grid. Mill loads are connected through a 48 bay 33 kV GIS switchyard, and an additional one comprising 13 bays is used for the integrated chemical plant. The tie line to the grid is at 150 kV level, connected through a 65 MVA transformer to the mill 33 kV busbar.

II. LOAD SHEDDING SCHEME

Scope of Load Shedding [2]-[9] is to assure that critical loads of the mill, basically those related to power generation, stay connected in case of contingencies, mainly related to trips at generators, boiler or tie line, or process related restrictions in own electricity supply, which may overload the tie line, regarding protections or contracted power. Additionally, the load shedding in case of island operation has to avoid unacceptable underfrequencies [10], which may end in total mill blackout.

A. Fast Load Shedding

This function is used in case of mill own generation trips. It has three modalities, one generator trip and boiler or two generator trip. Generator trips are detected by directional overcurrent function in tie line 33 kV relay, by setting overload levels coordinated with overcurrent protection ones. Boiler trip is a digital information coming from boiler DCS with a backup of a higher directional overcurrent signal. These signals are calculated by a dedicated VAMP 255 relay and wired to every feeder relay. Additionally, according an
operational priority set at SCADA, the SCADA regularly calculates the amount of load to be shed, and sets flags in feeder relays to assure that after the most loaded generator trip, or boiler trip, enough load is disconnected in order to avoid tie line overload and further actuation of its protection, or eventually to not overpass contractual limits. The VAMP 255 relays used at HV, MV and LV allow complex logic settings, in this case a digital input coming from the wired link between MV bays. An AND function at each relay between the wired signal and the logical signal set by SCADA, allows an instant opening order going to feeders chosen to be shed.

B. Slow Load Shedding

A PeakShaving function has been implemented in case of slight tie line overloads, which may appear after industrial process contingencies which have as a consequence a steam and further power production reduction, or after a fast Load Shedding Trip. This function is implemented totally in SCADA, and it sequentially with a 20 second cycle, opens one MV breaker up to an established level of imported power through the tie line. This level is set over the contracted level. The final adjustment to the contracted level is approached manually by the operator after Load Shedding function actuation.

C. Island Operation

In case the tie line is open and the mill is importing power from the grid, the Load Shedding function trips enough loads in order to keep the mill in balance. This is done by an Island signal wired to feeders’ relays, and a flag set by SCADA. Island detection is done by 150 kV and 33 kV breaker supervision. Additionally over and under frequency protections are used to detect island situation, in case that the isolation from grid is out of the mill.

Then for Island Operation, a Load Shedding scheme is implemented at feeders relays level, by means of underfrequency function.

Strategy to island detection is to disconnect from the grid when the system is out of regulatory limits of frequency and voltage. This has to be coordinated with generators’ settings in order to avoid generator trip due to grid disturbance. Criteria have been chosen from Uruguayan [11] regulation, and complementary one from Argentina [12]-[13], a system who is running in parallel with Uruguayan one:
Island detection is mainly based in breaker and disconnector position in HV and MV tie line. Additionally, in case of an island produced upstream the mill, as it is a highly improbable event, it is set based on the accomplishment of frequency and voltage regulatory ranges. If these are outside limits, it is assumed an island condition and the mill goes to island operation, opening the tie line and frequency controlled by one of the turbogenerators. These settings protect the mill to have generation loss because of grid underfrequency.

Additionally, one undervoltage step taken from Argentinean regulation has been set to detect island formation. In both cases, this island detection scheme is enabled when energy flows from mill to the grid.
Underfrequency settings for feeders are set in a way that they operate only in island condition. This is done by means of wired signal from Load Shedding VAMP relay, which looks at tie in lines breakers and disconnector positions. Additionally they are enabled from Load Shedding in Scada, and coordination is assured with generators' underfrequency settings. Five steps of underfrequency are defined in order to assure smoother load shedding in island condition, and they are coordinated with generator's settings.

These underfrequency protections additionally work as a backup for the tie line trip load shedding function.

### III. OPERATING EXPERIENCE

Most of the Load Shedding actuations occurred during mill first year operation, and they were related mostly with boiler trips and process related tie line overload. The case of single generator trip was not so common, and in most cases did not reach tie line overload. The original concept did not have the slow load shedding, what became in some cases of more load shed than needed.

Island situation are related normally to HV lines short circuits nearby the mill, and normally stands for some minutes after operating checks with grid operator. As the mill is more than 96% of the time exporting energy, there have not been Load Shedding trips from tie line opening.

### IV. EQUIPMENT SUPPLIERS

Original studies were conducted by Jaakko Pöyry [14] from Finland following operational experience in Finnish pulp mills from Metsä Botnia and Finnish utility Fingrid [15].

Load Shedding scheme and MV automation was supplied by Vaasa Engineering using as main equipment VAMP 255 relays and ABB MicroScada. Studies for the connection to the grid have been conducted by UTE [16]-[17].

### V. CONCLUSIONS

Most of this scheme has been developed and fine tuned after mill experience. It has allowed improving mill availability, fast failure recovery and an adequate integration with UTE grid.
VI. REFERENCES


VII. BIOGRAPHIES

Bruno Yuan was born in Zárate, Argentina, on December 14, 1960. He graduated as Electrical Engineer from the Engineering Faculty, National University of La Plata in 1984, revalidating its degree in the Engineering Faculty, Republic University of Montevideo in 1987. His employment experience included the Uruguayan utility UTE, in the field of hydro power between 1987 and 2005. In 2005 he moved to Botnia Fray Bentos pulp mill project in Uruguay, acting as Electrical Manager. His main task was the integration of Fray Bentos pulp mill power plant to UTE Uruguayan grid. Nowadays he acts as Technical Manager at UPM Fray Bentos pulp mill.

Eduardo Hernández was born in Tacuarembó, Uruguay, on April 17, 1982. He graduated as Electrical Engineer from the Engineering Faculty, Republic University of Montevideo in 2008. In 2006 he moved to Botnia Fray Bentos, pulp mill project in Uruguay, acting as Power Plant Engineer. Nowadays he acts as Planning and Development Engineer at UPM Fray Bentos pulp mill, particularly dedicated for the development of HV, MV and LV electrical projects, as well as the activities related to the integration of Fray Bentos mill power plant to the UTE grid.

Mauricio Mattos was born in Salto, Uruguay, on June 11, 1981. He graduated as Electronic Engineer from the Engineering Faculty, Catholic University of Montevideo in 2005. His employment experience included the Electrical Engineering Uruguayan Company Prodie, in the field of automation equipment between 2004 and 2006. In 2006 he moved to Botnia Fray Bentos pulp mill project in Fray Bentos, Uruguay, acting as Project Electrical Supervisor. Nowadays he acts as Electrical Maintenance Manager at Andritz, being responsible in his field of UPM Fray Bentos pulp mill.

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