ALS: A NEW APPROACH TO ASSET LIFE CYCLE MANAGEMENT

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ABSTRACT

Many electrical energy distribution concessionaires in the world operate a growing park of aged equipment and near to the end of their useful life. Growing operational costs with the increase of the medium age of the equipment are consequences of this situation. On the other hand, the demand for better quality in the electrical energy supply by clients, and increasing profits by share holders create the need of new methodologies and criteria development for asset management during all the asset life: since the planning and creation of the new projects portfolio up to the asset replacement.

AES Eletropaulo is an electric energy distribution concessionaire founded 107 years ago that works in the metropolitan region of Sao Paulo city and it has a big amount of electric assets. Approximately 500 power transformers 15 to 90 MVA, 1,000,000 concrete poles, and 1,000 km of underground and overhead transmission lines at 88 / 138 kV voltages, are part of this collection. Some of these assets are over 60 years old. Beyond that, the electrical system energy demand grows at an average rate of 3% per year in this region.

Like others distribution companies in the world, pressed to reduce operational costs to attend the demands of stock holders and at the same time submitted to the increasing costs due to the ageing of its assets and the client demands for better energy quality, AES Eletropaulo has developed new methodologies to manage its assets during all their life cycle.

This article presents the experience of AES Eletropaulo in the development and usage of this new approach for the asset management during the life cycle of the equipments and installations.

INTRODUCTION

The AES Eletropaulo is a company controlled by AES Group and it is responsible for electrical energy distribution in the metropolitan area of Great Sao Paulo City, Brazil, involving 24 municipalities.

It has around 5.5 million clients and supplies a population of approximately 16 million inhabitants. Its electrical system is formed by a grid of 1,700 overhead primary distribution circuits at 3.8, 13.8 e 34.5 kV class tension; 95 underground primary distribution circuits at 20 e 34.5 kV; and 160 transforming, switching, capacitor banc, and overhead to underground transition substations. It is the biggest electrical energy distribution company of South America.

It is a 107 years old company, it has an average annual load growing rate of 3% per year, and faces up to the following questions that must be correctly answered to maximize the investment effectiveness, achieving the entrepreneurial objectives of maximize the return over investments and attending the client expectations of quality of services / products and fair costs:

Increase or reduce investment?

Increase or reduce O&M expense?

Keep investment and expense?

The formula found to answer properly these questions was the development of several methodologies and criteria that form the asset management system of AES Eletropaulo.

ALS: ASSET LIFE CYCLE MAINTENANCE

ALS – Asset Life Cycle Management System is a system, developed by AES Eletropaulo, to manage assets and formed by a set of methodologies and criteria applied in the life period of the different assets that compose the electrical system of an electrical energy concessionaire.

In the next items these methodologies and criteria are presented.

SYSTEM EXPANSION

In 2004 AES Eletropaulo began the studies and the implementation of a new methodology to optimize its project portfolio.

The tools employed up to this time were those normally used by the totality of the electrical sector companies and based on financial analysis: cash flow, net present value – NPV, internal rate of return – IRR, pay back.

The main objectives looked for with this new methodology are: optimize the projects portfolio improving benefits value achieved with the projects implementation, and to develop a defensible logic for valuing and prioritizing AES Eletropaulo projects.

The first segment where the implementation of this new methodology began was the portfolio of Research and Development Projects.

The prioritization criteria were established to three dimensions: Strategic Relevance, Complexity, and Regulator Agent Criteria. To the R&D projects segment the dimension of Regulator Agent is important because the company is obliged to invest a percentage of its gross operational revenue in this kind of projects. To all other projects the other two dimensions prevail: Strategic Relevance and Complexity.

After the definition of the criteria weight, it was defined the adherence level of the project to each criterion, that was validated to the Research and Development Committee of AES Eletropaulo.
The three categories of criteria evaluated were:
1) Strategic Impact: criteria related to the strategic impact of the R&D projects according to the strategic objectives of AES Eletropaulo.
2) Complexity: criteria related to the difficulty level to implement the projects.
3) Regulator Agent: criteria related to the requirements of the regulator agent that impacts on the project selection.
The first decision was to use all the Strategic Policies of AES Eletropaulo to prioritize the R&D project proposals. The Strategic Policies were: Clients First, Safety Always, Operational Excellence, Self Esteem of the Employees, Corporate Image, and Financial Strategy.
To each one of the Strategic Policies it was given a formal definition and it was created criteria and sub-criteria. All of then received a precise definition to clarify their meanings to be easily understood for every person.
The AES Eletropaulo strategies and the criteria and sub-criteria were compared and their weights were defined to the project selection.
The system compared the criteria two by two and verified the consistency step by step.
Nine levels of importance were considered during the comparisons: extremely; strongly, moderately, slightly, equally, slightly, moderately, strongly, and extremely.
It is compared Clients X Safety, Clients X Operations, Clients X Image, Clients X Self Esteem, Clients X Finance, and this procedure is repeated to all others policies.
The results of the process of weighting the policies is an structure showed at figure 1, where it can be seen the criteria for each considered policy.
The same process was repeated for all the criteria of the other dimensions – Complexity and Regulator Agent.
The difficulties to perform each project under the point of view of financial, technological, regulatory, interdependencies, and implementation aspects are verified in Complexity dimension. In Regulator Agent dimension it was verified: proposal quality, project results and qualification of the team.
After the discussions about each one of the criteria and their sub-criteria, their definitions and descriptions, it was defined the levels of each sub-criteria and they were compared two by two. Finally it was created a questionnaire that defines the punctuation of each project based on the answers to this questionnaire.
In 2006 it was initiated the expansion and adaptation of this methodology to be implemented to all the other company projects. An additional value of benefits of about US$ 90 million per year is expected to be achieved with this new tool.

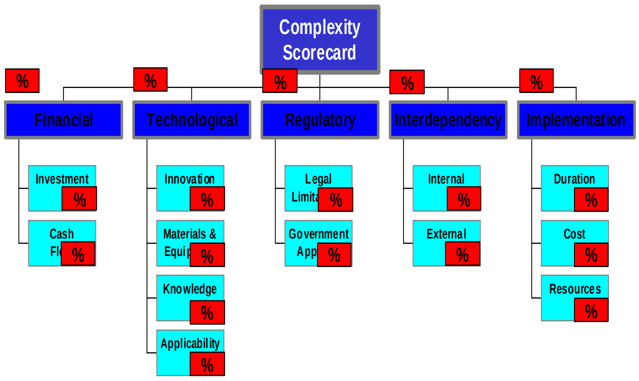

Figure 1: Complexity, Criteria, Sub-criteria and Weight

SYSTEM MAINTENANCE

The methodologies and criteria developed to electrical system maintenance can be divided in three major groups: RCM – reliability centered maintenance, prioritization criteria to substation maintenance investments and prioritization criteria to distribution circuits maintenance investments.

RCM - Reliability Centered Maintenance

The development and implementation of the RCM methodology was initiated through pilot projects in four systems that were studied between January and April of 2005. The implementation ended during the second semester of 2005. The chosen pilot systems were:
System 01 – Overhead Distribution: Overhead Distribution Primary Circuit 13,8kV GNA-106
System 02 – Overhead Distribution Secondary Circuit ET52591
System 03 – Underground Distribution Network Centro V
System 04 – Subtransmission: Distribution Transforming Substation 88/13.8 kV ETD Nações.
The theoretical base to RCM is found in the reference [1] book and this methodology objective is to assure that the system performs what their users want it to do into its operational context. It differs to the usual maintenance concept that focuses on the equipment or installation trying to maintain the equipment or installation using tasks that "can be done". RCM focuses on the system, maintaining its basic functions using tasks that "need to be done". Beyond this, it emphasizes data collection and the continuous failure analysis.
Seven basic questions need to be answered during the implementation of this methodology:
Which are the functions and performance standards of an asset into its present operational context?
How it fails fulfilling its functions?
What causes each functional failure?
What happens when a failure occurs?
How each failure matters?
What can be done to predict or prevent each failure?
What can be done if none proper proactive task could be

found?
The RCM key tools are FMEA – Failure Modes and Effects Analysis and Decision Logic Diagram.
The studies were carried out according what is recommended by bibliographical references: formation of work teams with the participation of technicians and field electricians, maintenance engineers, operations technicians and equipment specialists, coordinated by a facilitator to the correct analysis of the systems.
During the studies it was necessary to take decisions that were dependent of more elaborated quantitative analyses. In these situations some risk / cost analyses were performed.
The RCM is a methodology that aims to define a pertinent maintenance program related to risks and consequences of systems and equipments failures.
The methodology follows basically three steps: Functional Analysis, Dysfunctions and Criticality Analysis, and Maintenance Tasks Selection.
The functional analysis objective is to define how the studied system must function and which are the functions performed by him to accomplish its mission into the productive process of an installation.
Once defined how the system operates, it is necessary to analyze how it can stop performing its functions, analyzing the gravity and frequency of the system equipment failures to define its criticality.
After analyzing how the system stops performing its functions it is necessary to find tasks of predictive, preventive or corrective maintenance to avoid failures that cause these dysfunctions. It is necessary to follow economic and effectiveness criteria to choose these tasks.
The RCM is implemented employing forms easy to use that facilitate the analysis and the subsequent comparison between existing tasks before and after the studies.
The RCM methodology used by AES Eletropaulo, that has predominant qualitative characteristics, was complemented with quantitative tools that helped in the difficult decision risk/cost analyses. These difficult decision tasks are in average 10% of the total volume of the analyzed tasks, and they concentrate the tangible source of the investment return of the RCM implementation projects.
The AES Eletropaulo RCM implementation, beyond an increase of the system reliability measured by SAIFI – System Average Interruption Frequency Index, provided a reduction of 17% of the man x hour worked in the substation maintenance activities and 20% reduction on operational expenditures.

Distribution Network Prioritization Criteria

The AES Eletropaulo prioritization criterion to primary circuits considers two aspects that fit the expectation of any electrical distribution business: the circuits performance and the criticality of the region supplied by them.
The performance indicator defines which circuits must be prioritized to achieve quality on energy supply continuity improvements.
The parameter used to performance indicator is SAIFI of each distribution primary circuit.
The criticality defines why to improve certain circuits and not on others and reflects the sensitivity and importance of the clients connected on determined circuit.
To the criticality two parameters are employed. The first one is related to the revenue related to electrical energy consumption of each circuit. The second is an absolute number (AI) related to the type of clients and their sensitivity related to energy supply continuity of each circuit. This grade considers the services and activities that are fundamentals to the society like hospitals, prisons, water and sewer treatment facilities, telecommunication, etc. Also considers clients particularities like self generation installations.
With these two indicators – performance and criticality – a two dimension graphic is defined and clearly points where are the circuits that deserve special attention, those that show low performance and high criticality, showed in “improve area” of the figure 2.

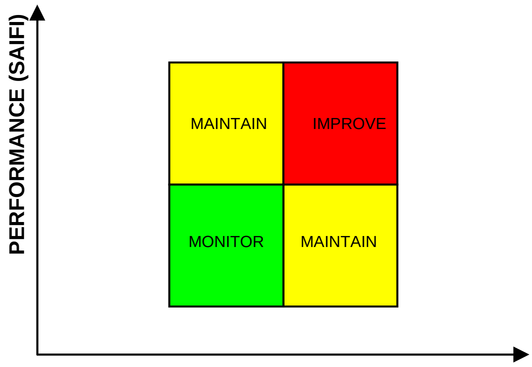

Figure 2: Graphic Performance X Criticality

The reduction or increase of each circuit SAIFI is calculated based on the historical behavior of this indicator to the circuits of each region and it is a function of the improvement, maintenance or monitoring actions implemented in the previous years.
The lines that split and define the quadrants are calculate by a simulator that considers the influence of the increase or reduction of SAIFI of each circuit in the total SAIFI of AES Eletropaulo, in such a way that the established annual goal to this indicator can be achieved.
The SAIFI indicator goal is established observing the restrictions imposed by the regulator agent and the objectives of the business plan of the company. The regulator agent establishes SAIFI limits that must be obeyed or fines can be applied if the limits were surpassed.
With the definition of the lines and the quadrants, the circuits position and the actions that will be implemented during the year in each one of them are established. In this way the budget of the primary circuits maintenance is established and it is assured that the investments will be applied on the proper locals and in an optimized way.
These prioritization criteria have been applied to the

distribution circuits maintenance since 2005. The achieved result was a reduction of 37% in the investments comparing the 2006 and 2005 amounts. In this same period the SAIFI indicator showed an improvement of 2% in the energy supply continuity, obeying the entrepreneurial goals and the regulator agent limits.

Substation Equipments and Installations Prioritization Criteria

To prioritize substation maintenance investments it was developed a methodology similar to the methodology developed to primary circuits.

As technical performance parameter it was utilized an indicator based on SAIFI for each substation.

The SAIFI of each substation is calculated based on the proportion between the number of clients of the electrical cluster and the total number of clients supplied by the substation.

The electrical cluster is defined as the total assets, primary and secondary distribution grid, overhead and underground subtransmission lines, and substations, inside a defined geographic area and all the clients supplied in low, medium and high voltage.

The criticality parameters are the same employed to circuits – revenue and sensitivity of clients to supply continuity – although related to all clients in each substation.

The achieved result with this methodology was a reduction of 83% on the substation maintenance investments comparing 2006 and 2005 budgets. The SAIFI indicators were the same for the both years, according to the regulator limits and business plan goals.

EQUYPMENT REPLACEMENT

To prioritize equipment replacement it is employed parameters related to its operational condition – performance – and the safety and installations security – criticality.

The performance parameter is strongly associated to technological obsolescence, historical failure rates, preventive maintenance costs, remaining useful life and equipment capability.

The technological obsolescence is assessed considering the equipment technology versus the nowadays technology in the market, replacement parts, easiness to adapt parts by others technologically updated and the market service providers with knowledge to repair the equipment under analysis.

The historical failure rates and the maintenance costs come from corrective and preventive maintenance data base.

The remaining useful life is estimated considering the history of the equipment operations, mainly electrical and thermal overloads, and through the equipment condition diagnosis obtained through electrical, physical and chemical tests.

The equipment capability is assessed considering its capability to accomplish the electrical and mechanical functions that it is designed for.

The criticality parameters are related to the amount of interrupted load during equipment failures, probability of explosion and material damages caused by failures, and safety during failures.

The following substation equipments were considered during the studies because its criticality and importance to the electrical system: power transformers, silicon carbonate arresters, high tension breakers, transformers bushing, medium voltage breakers, and cables terminals. The following distribution grid equipments were also analyzed: porcelain top pin insulator, compressed powder and silicon carbonate arresters, one phase fuse switches type A.

The performance versus criticality graphic was assembled, the quadrants defined, and the prioritized equipment to be replaced were obtained in the same way used to prioritize primary circuits and substation maintenance.

The achieved results of this process are into the results above mentioned and related to distribution and substation maintenance.

ACHIEVED RESULTS AND CONCLUSIONS

The main results achieved with the, although partial, implementation of the ALS asset management system were:

1)17% reduction of the man x hour worked in the substation maintenance activities and 20% reduction on operational expenditures,

2) a reduction of 37% in the investments comparing the 2006 and 2005 amounts, and an improvement of 2% in SAIFI indicator in the same period,

3) a reduction of 83% in the substation maintenance investments keeping the SAIFI indicator,

4) an estimated additional benefit value of about US$ 90 million per year with the utilization of the prioritization toll to optimize the project portfolio under implementation.

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