LIFE MANAGEMENT OF ASSET FROM HIGH VOLTAGE SUBSTATION

Sorina COSTINAŞ[1]

Rezumat: *Companiile reinventează continuu propriul model de afaceri iar mentenanța poate juca un rol cheie pentru profitabilitatea pe termen lung. In România, după liberalizarea pieței de energie, companiile de electricitate sunt obligate să identifice şi să coordoneze o multitudine de procese şi să promoveze competivitatea. Este necesar să se lucreze în siguranță și cu responsabilitate față de mediul ambiant, respectând obiectivele stațiilor electrice. Lucrarea va prezenta strategiile de mentenanță şi aspectele informaționale (tehnice, financiare, sociale, politice, legale, de risc) ale procesului de decizie. Metodologia propusă pentru mentenanța stațiilor electrice se va concentra pe ISO 9001/14001.*

Abstract: *Companies have to reinvent continuously their business model. Maintenance can play a key role in the long-term profitability of a company. In Romania, especially since the liberalization of the energy market, the electrical companies are forced to identify and coordinate a lot of processes and to promote competitivity. It is necessary to work safety and be environmentally responsible in order to achieve electrical substations obiectives. In this paper will be presented maintenance strategy (replacement, upgrade or repair) and informational aspects of decisional process (technical, financial, social politic, legal and risk aspects). Proposed methodology regarding the maintenance of electrical substation will be focused in how to improve the decisions for improving asset maintenance performance through ISO 9001/14001.*

Keywords: maintenance, electrical substation, decision process.

1. Introduction

In Romania, large parts of the 110kV, 220 kV and 440 kV electrical substation was designed with the aim of reducing transmission losses. Many electricity distribution companies find themselves struggling to power a 21st century world using the technologies and management concepts of the 20th century.

Especially since the liberalization of the energy market, have been facing new challenges. As increasing demand pushes aging grids to the breaking point, electricity distribution companies around the world face a dilemma. On one side, demand for high-quality, uninterrupted service continues to grow. On the other, regulators are loath to allow utilities to raise rates to pay for dearly-needed infrastructure improvements.

[1]Title: Assoc. Prof., PhD, Eng., affiliation: Power Engineering Faculty, University "Politehnica" of Bucharest, Romania, (e-mail: sorina_costinas@yahoo.com).

When an electrical equipment failure incident occurs there is a consequential loss of profits and amassing of costs. Therefore a new approach is required to achieve the goal of increased network efficiency for minimized prices.

A general definition of *Asset Management* is: "The set of disciplines, methods, procedures and tools to optimize the whole life business impact of costs, performance and risk exposures associated with the reliability, availability, maintainability, efficiency, longevity and regulatory, safety, environmental compliance of the company's physical asset". The definition states that it affects all areas of the business (operations, production, projects, engineering, safety, maintenance etc.). Management, engineering and information related aspects creating the complex structure of asset management have to be simultaneously considered in order to create fully operating and efficient managing instrument.

2. Technical Aspects in Maintenance Management Decision Process

Industrial and technological progress has been always related to an increase in energy consumption. Enlarging the capacity by modernization of the existing networks is quite a challenge because of many different aspects that need to be considered.

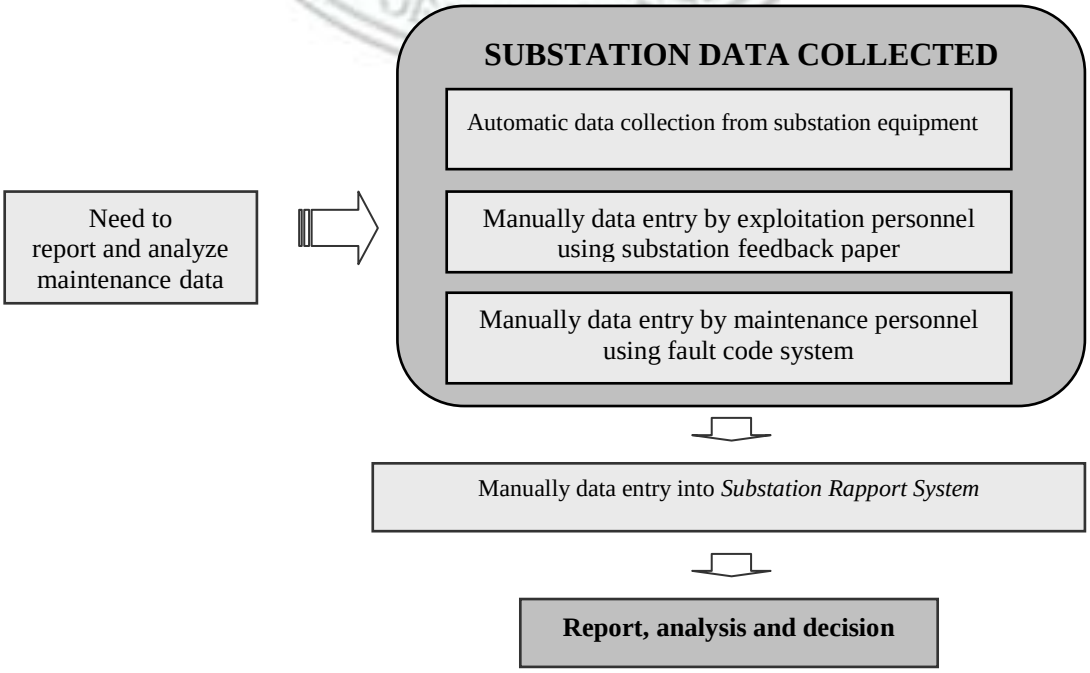

Fig. 1. Equipment Reliability Reporting, Analysis and Decision.

The technical point of view cover amongst others condition assesment, aging, history and failure probability, but also information on the equipment inventory,

the network structure, the available spare parts, the current maintenance procedures, the history of failures and the operating conditions of a substation component (Figure 1).

Electrical equipment consists of several modules, due to the construction of the equipment. These modules consist of several components. There is an advantage to define equipment classes, which enclose comparable type of components. It is very important to know asset hierarchy levels (substation, group of equipment, single equipment, parts of equipment, components) [1].

Considering supply voltage, we need information about where are affected circuit types (for example switched busbar breaker, distribution line, power transformer, line of supply for customers, power station connection line).

All incidents are evaluated as a function of: the cause of the failure; affected circuit type; consequence; unavailability duration; undelivered electrical energy; costs etc. A combination of diagnostic tools for condition assessment is chosen and applied, depending on the different types and locations of insulation defects induced degradation sites. In order to decrease the probability to a failure, condition assessment can be used [2].

From a technical point of view, many scenarios can be found to influence the asset performance [3-7]. Potentially, equipment that is referenced in the *EMS* will include any item whose failure or improper operation or repair may result in release of hazardous or toxic materials into the environment. This may be a significant number of equipment items.

Companies operating in a reactive management mode may see the cost associated with such failures as an opportunity to establish a toehold on moving toward the preventive, predictive, or proactive modes (Table 1).

Such a strategy can address two problems simultaneously. First, since reactive organizations are most likely to be responsible for environmental aspects, exposure to environmental penalties can be reduced. Second, operational efficiency can improve due less unplanned downtime.

Companies implementing *QEMS* will adress specific attention to: maintenance programs and activities; maintenance planning, scheduling and backlog management; additional tracking in the *Computerized Maintenance Management System* (*CMMS*), *Root Cause Analysis (RCA)* procedures and records.

Creation of an effective maintenance algorithm requires two aspects to be considered: maintenance strategy (replacement, upgrade or repair) and order of maintenance (priority).

Table 1. Maintenance strategy evolution process in parallel with medicine evolution [2].

MAINTENANCE STRATEGY AND NEEDED TECHNIQUES/ TOOLS			**MEDICAL ACTIVITY ASSOCIATED**	
Breakdown maintenance	Replacement or repair is performed only if a failure occurred.	The spare parts and equipment themselves.	**Emergency medicine**	Heart attack or stroke / by-pass or transplant surgery.
Preventive maintenance	Time based maintenance, recommendation from manufacturer and experience with same type of equipment. It has been practiced as the usual mainte-nance strategy in electrical power systems for many years.	Substation data sheets; Periodic component replacement.	**Prophylactic medicine**	Periodic medical testing; Diagnosis; Prescription
Predictive maintenance	In accordance with condition and importance. Concept of Availability & Reliability and RCM; Power supply monitoring.	Vibration monitoring; Spectrographic oil analysis; Thermographic analysis; Infrared thermography; Ultrasonic inspection; Use computers for analysis and trending.	**Diagnosis through medical imagery**	Detection risk of heart disease using EKG or ultrasonic; Computed Tomography; MRI; Positron-Emission Tomography.
Proactive maintenance	Proactive approach could be suited for equipment associa-ted with the organization's significant environmental aspects.	Monitoring and correction of failure root cause; Root cause analysis; Failure Mode Effect and Criticality Analysis.	**Family medicine**	Cholesterol and blood pressure monitoring with diet control.

3. Financial - Economical Aspects in Maintenance Management Decision Process

The deregulation could have a positive effect in reducing outages number and maintenance costs. Every technical aspect mentioned above will have its financial aspect. There are cost of maintenance, replacement, service, or inspection, but also the cost of condition assessment and the investment costs for equipment and spare parts. One of the most important evaluation criteria for comparing different maintenance strategies is the investigation of *Life Cycle Cost* (*LCC*). This goal can only be achieved by a detailed knowledge about the influence of the different parameters, which have a changing impact on the life cycle cost (Figure 2).

In case of major failure, professional solution is needed to restore the energy supply as quickly as possible. Outages can result in customers' compensation (penalty costs from customer contracts, possible claims from customers and the costs of undelivered energy). All informations will be processed amongst financial staff-members.

4. Social, Political and Legal Aspects in Maintenance Management Decision Process

Technical and financial informations are not the singles important aspects. The public image and the feeling of safety determine the social impact of utilities industry. The society impact can have very strategic consequences. Assessment of the substation impacts upon the environment and setting up measures to reduce them through impact studies and environmental balances are in use. All studies and balances are prepared by specialized and agreed entities. These documents are particularly required to obtain environmental agreements permits.

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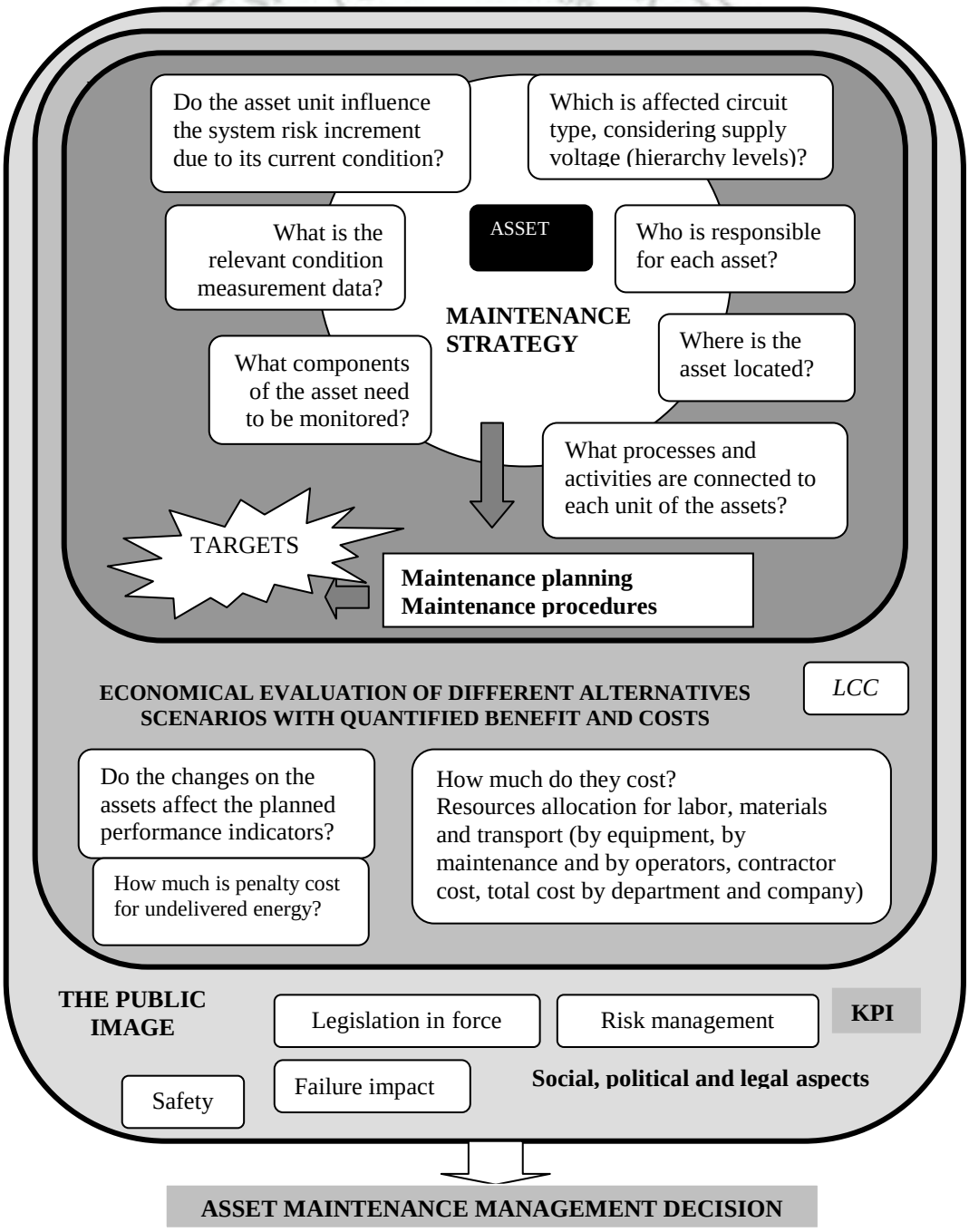

Fig.2. Main Aspects for Decision Process.

The environmental policy targets are aims on short and medium term to mitigate the negative impacts of substations upon the environment up to the limits of our norms and on long term, within the limits of the *EU* norms. The environmental management program is drowning up according to the *ISO* procedure. While *ISO 9001* is concerned about establishing and maintaining controls to ensure process quality, *ISO 14001* requires organizations to plan their activities, including maintenance, to prevent the occurrence of significant environmental impacts. International standard *ISO 14001* [8] has helped many companies to improve their Environmental Management System (*EMS*).

The operational control element of *ISO 14001* ensures that organizations plan such maintenance and carry it out under controlled conditions. Another element of the standard requires the organization to maintain records to demonstrate that it meets the requirements of its *EMS*. Maintenance activities subject to operational control would fall in this category. The *EMS* could be integrating in the Quality Management System (*QMS)* which was certified by *ISO 9001*. The main orientations addressed the following topics:

- waste water management (rehabilitation of waste water collection points and transmission grid in all electric substations and inspection or installation of oil separators at the electric transformers tanks);
- air, soil and climate protection;
- ecologically overcoming the harmful natural phenomenon: wind, rain, atmospheric overvoltage, hoarfrost, sea salt, earthquakes etc;
- noise and vibration (coming from the blast air units in the electric substation) level reduction;
- reduction of electromagnetic pollution;
- waste management according *GD 155/99* (sanitation building and waste collection, transport, disposal and discharge).

The environmental policy includes a commitment of compliance with the legislation in force. The key activities are:

- repair, rehabilitation and modernization of the equipment owned;
- get out of operation the obsolete and polluting equipment (for example, electric capacitor types which contains synthetic oil with *PCB* exceed the admitted limits);
- design and build new substations at international standard level;
- take specific actions to mitigate the substations impact upon the environment;
- develop ecologically oriented training for operators.

Predictive Maintenance actions (vibration monitoring, oil analysis, thermal imaging, predictive electrical testing, power supply monitoring, materials thickness testing, predictive electrical testing, ultrasonic inspection, visual inspection) are focused on more critical equipment and this proactive approach

may be suited for equipment associated with the organization's significant environmental aspects. They can be used to demonstrate proactive compliance with *QEMS*.

Backlog management is an important tool for determining maintenance department resource, making budget and workforce staffing decisions, evaluating department performance and analyzing alternatives. Backlog is the list of work generated as work order requests. Taking advantage of opportunities created by job planning requires coordination and cooperation of production and maintenance to use job planning in ways that actually reduce the time it takes to complete each job.

Key Performance Indicators (*KPI*) for assessing whether the organization is complying with its operational controls and achieving its objectives for environmental performance: Substation Surface (m^2); Oil amounts in Equipment (*tones*); SF_6 in Equipment (*kg*); *PCB* Power Capacitors (*pieces*); Noise Level (*dB*); Electrical Field (*kV/cm*); Reused Wastes (*tones*) etc.

Table 2 Relationship between Input and Output in Substation Activities

Input\ Output		**Produc-tion**	**Quality**	**Cost**	**Delivery**	**Safety**	**Environment**
M O N E Y	Man/ Manpower Allocationx	x	x	x	x	x	x
	Equipment/ Substation Engineering & Maintenance	x	x	x	x	x	x
	Material/ Inventory Control	x	x	x	x	x	x
Management Methods/ Productivity		Produc-tion Control	Quality Control	Cost Control	Delivery Control	Safety Rules	Pollution and Human Resources

The *Computerized Maintenance Management System* (*CMMS)* is a great tool for tracking environmental compliance.

Adding an equipment classification for those items associated with significant aspects is in obvious change to make. There may will be new equipment items to include in the hierarchy. *QEHS* may even use the *CMMS* as its basic environmental data tool.

In event there are environmental aspects, the *Root Cause Analysis (RCA)* procedures, operational control procedures, and record keeping will be scrutinized for their effectiveness in finding and eliminating the source of excursions not only for the specific incident, but extended to all such similar actions and equipment items in the plant. In fact, the *QEMS* will require that specific *RCA* procedure be established, implemented and maintained (Table 2).

5. Environmental Management System ISO 14001 Procedure and Asset Maintenance Management Decision Process

The information about equipment specific risk factors like maintenance cost, enterprise specific risk factors (image or failure response time), customer specific risk factors (power consumption and criticality of supply) as well as sociological factors concerning ecological damages by outage or economical consequences of the latter have to be considered.

ISO 14001 represents a social move toward greater organizational responsibility in protecting and restoring our planet's resources and support systems. It is up to private and public companies to make internal changes to reduce their negative impact. Realizing environmental protection is just plain good business, and profitable for all, too.

Exemple of ISO 14001 Procedure:

- Identify the environmental aspects and assess the significant impacts of the substation upon the environment;
- Identify and record the environmental regulations and other requirements (in order to obtain environmental permit);
- Set the environmental objectives and targets;
- Set the organizational structure, assignments and responsibilities for the implementation of the *EMS;*
- Organize specific training for employees (related to environmental aspects);
- Internal and external communication in the environmental field;
- Develop *EMS* documentation;
- Document control;
- Operational control;
- Emergency preparedness (incidents, accidents) and response;
- Monitor and measure the activities with significant negative impact upon the environment;
- Identification, analysis and working on nonconformities, corrective and preventive actions
- Issuing, filing and eliminating the environmental records;
- *EMS* audit and *EMS* review performed by the management.

Due to the new business environment in Romania, the electrical companies are forced to identify and coordinate a lot of processes and to promote competitively. It is necessary to work safety and be environmentally responsible in order to achieve power stations obiectives and expectations. The equipment maintenance is necessary to meet customer's needs cost effectively in line with *ISO 9001/14001* and *Total Productive Maintenance* (*TPM*) concept. Companies have to reinvent continuously their business model. In this paper, proposed methodology regarding the maintenance of electrical substation is focused in how to improve the decisions for improving equipment maintenance performance through *ISO 9001/14001*.

The environmental policy includes a commitment of compliance with the legislation in force. Failure acceptability can be reflected as the degree in which a failure is acceptable from social point of view. The individual combination of parameters will lead to an individual optimized substation layout in order to achieve minimal life cycle cost and the lowest impact on environment. Identification, analysis and working on nonconformity, corrective and preventive *ISO* procedures for *EMS* are *ISO* Instruction for Maintenance Specification, too.

Conclusions

Conclusion (1). The primary concern of the modern electrical substation is to minimize operating capital investment maintenance and controlling expenditures, development costs etc. while keeping up the desired system reliability and functionality in the same time. Among all electrical systems, electrical substation specific operating conditions demand individual approach. Management brings big changes in the traditional organizations**.** Permanently, new ideas search to optimize maintenance strategies and solutions to save expenses with constant quality of power supply.

Conclusion (2). The scenarios are found by analyzing maintenance strategies and their effects. The selected strategy must be translated into clear targets to become manageable.

Conclusion (3). Maintenance targets can be seen as a combination of:

- *technical information on asset* (mentenance and diagnostic evaluation, search scenarios, evaluation of efectiveness and realibility, quality of power supply, level of personal safety, risk etc.);
- *economical information on asset* (cost of maintenance, cost of spare parts, economical evaluation of scenarios, life cycle costs, cost computation etc.) and *economical information on business* (selection of optimal strategies, company profile, return on capital employed);
- *societal information* (environmental, health, risk profile, public image, legal).

It is necessary to translate the necessary information aspects (Figure 2) into usable data sources. Relevant information needed for equipment management decision support is depending on several equipment-related.

Conclusion (4). Subdivisions of the decision process (Figure1) are:

- *technical control* (lost minutes per customer, quality of services, number of customers complains, number of failures, power lost);
- *financial control* (operational cost, capital costs, resources utilization).

Conclusion (5). There is necessary to collect a huge quantity of data in order to establish a good maintenance program. The decision processes for maintenance management of electrical substation equipment should be designed correctly to facilitate this balancing act using the right information at the right moment. After all, we can not see into the future and we don’t know what it will be. All we can do is to make the best decision possible which will not fail our expectations in the coming times and/or minimize the possible losses.

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