Ergonomics Aspects in Operators of the Electric Power Control and Operation Centers

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Abstract. The activity of the operator of the electrical power control centers is the prevention of incidents and errors that disrupt the operation of the electrical system. They have to do it by mobilizing knowledge and reasoning for which they have received training, which from the point of view of the existing rules are adequate. However, there are some factors that need to be improved, because there are still accidents and incidents, caused manly caused by fatigue, lack of concentration or due to inadequacy of human Computer Interface. This article aims to analyses ergonomics aspects and human factors in the electric power control centers and contribute with a methodology of studies including the topics of Human; Machine; Interface IHM; and critical factors.

Keywords: IHM in Electric Power Control Centers, Workload in Operators, Fatigue.

1 Introduction

With technological advancement the operator in Electric Power Control and Operation Centers tasks and are more complex and automated [1, 2, 3]. Similarly to the systems developed for other industries, the automation in electric power sector resulted in more sophisticated equipment and demanding more attention from operators, who now control and operate a growing body of equipment. This results in increased the cognitive load and hence fatigue and environments more conducive to error [4]. Electrical systems can be categorized as critical systems, where failures can result in significant economic loss, physical harm or threats to human life.

The activity of the operator of the electrical power control centers are the prevention of incidents and errors that disrupt the operation of the electrical system, or when it is no longer possible, the process of trying to return to normal, which is called recovery. There are some factors that need to be improved, because there are still accidents and incidents, caused manly caused by fatigue, lack of concentration or due to inadequacy of Human Computer Interface (HCI) [5]. His activities are extremely complex with numerous variables and the technician has a high degree of uncertainty.

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It is essential to make decisions and process information continuously, with a frequent request mental due to the necessity of maintaining attention, memory and reasoning request.

Among the factors involved in the decision-making capacity can be cited: the postural requirements, existing facilities, the status of ongoing attention that the task requires, fatigue, health, the difficulty in interpreting the information, the issue of shifts work [6,7].It is also emphasized environmental conditions such as noise, temperature and lighting inadequate. Also influencing the response of operators, there are also those related to media like visual signals and verbal information and human-machine interface [8] and workload NASA - TLX [9].

This article aims to analyses ergonomics aspects and human factors in the Electric Power Control Centers and contribute with a methodology of studies including the topics:1-Human (Operators: Work Characteristic, Experience, Life Quality, Personal Data); 2-Computer (Control Centers: Work Organizational, Organizational Culture, Work per shift; attention, Information Safety); 3-Interface IHM: (Tasks, Monitoring, Supervision, Planning, Operation, Equipments, Monitors, Computers, Panels Supervisory System); 4-Critical Factors: (Amount of information, Information Quality, Workload Fatigue, Work Environmental Factors, Noise, Lighting, Thermal Comfort).

2 Electric Power Control Centers

The electricity sector is characterized by a set of processes, tools and equipment, focused on generation, transmission and distribution of electricity [10]. The electric power goes a long way to reach the end consumer as in figure 1, where is produced in the power plant, goes through a voltage substation and it is transported over long transmission lines to areas where there is need for consumption. Here goes through another substation, this time, step-down voltage being delivered to end users through distribution systems [11]. The monitoring system is in electrical power control centers. There are used techniques distance automated commands that allow decisions together in one place [12].

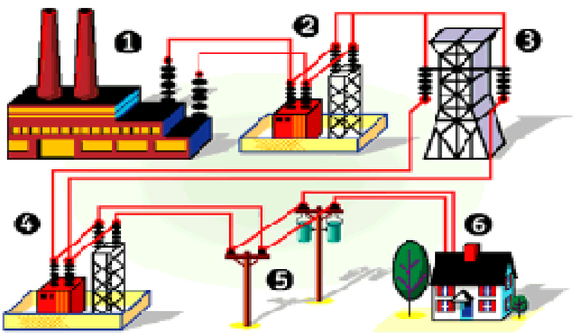

Fig. 1. Transmission and Distribution of Electricity-source [11]

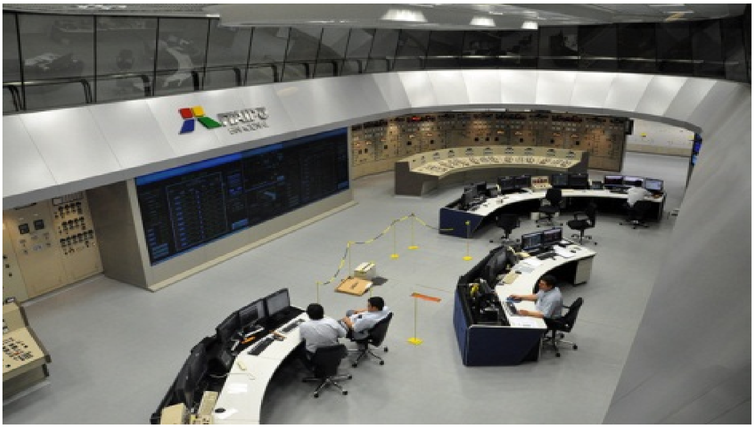

Fig. 2. Typical Electric Power Control and Operation Cnter

2.1 The Operators: The Work and Tasks

The work carried out by operators in control centers occurs through monitoring screens, communication systems and specific programs (specific software) designed to meet the needs of this type of activity [13]. His routines involves receiving information gathered from the previous turn in an application, check the functionality of other applications and planned interventions for hours.

In case of failure, it is essential that the control centers operators act to make the process returns to normal. Generally, in these situations, the amount of information received is very large and generated from various sources. It is a fact that during the period of a contingency, even under stress, the operator needs to analyze and interpret this information list of failures quickly and safely, separating the important from those that are secondary, preventing further damage. Therefore, it is up to the operator to decide whether or not reconnection of equipment, and may be at risk of causing accidents due to misinterpretation of events or flagged by the notices of deficiency [14, 15].

The tasks of operators in control centers are associated with hazardous processes and systems. Implies supervision systems where some critical events occur infrequently and regularity, but requiring monitoring and decision making continuously.

The main tasks of operators are to execute: monitoring the substation equipment; power measurement; substations equipment and transmission line protection; protection supervision; automatic restart; location of line fault; power remote controls; overload on transformers; control voltage; reactive flow; selective cutting loads; alarms in general; Print reports; Interface with the Distribution Operation Centers (DOCs);

2.2 Interface in the Electric Power Control Centers

The interface of the human-operator with the control rooms (Computer) occurs through several monitoring stations. The screens of the computer must be positioned to facilitate the handling of operators, both for normal operations and for preventing accidents. One of the factors that can influence the decision-making is the difficulty of interpreting the information provided by the system. Due to the large amount of information available to the operator, there is a decrease in the ability of maneuvering and understanding of the tasks to be performed. A fundamental problem in this type of system is that agents (human or machine) must understand what the other is doing. If the operator believes that the system is in a way, but is actually in other conditions, situations can arise very dangerous [16].

The number of alarms is high when changes occur in electrical systems, which means that the operator has difficulty in determining the causes of these disorders and to determine the actions to be performed. People in controlling such systems must often pay attention to a large amount of information from a variety of sources in order to acquire knowledge of the situation in question. They must be able to identify at all times the state of the system to power on a contingency informed decisions.

One of the major studies that should be performed for about HMI- Human-machine interface is the cognitive ergonomics. These studies contribute to research on Human-machine interface as well as decision-making at work [17]. These studies have the following objectives [18]: 1-Decrease the time needed to accomplish tasks; 2- Reduce the number of errors; 3- Reduce learning time; 4- Improving people's satisfaction with a system.

May [19] says the complexity of Human-machine interface (HMI) in Operation Centers and Control for the following reasons: 1-Greater integration and increase the size of the national and regional networks; 2-Increased level of automation involving distributed measurements and automatic decisions; 3- Increased complexity of coordination arising from the implementation of optimal power flow, market-based

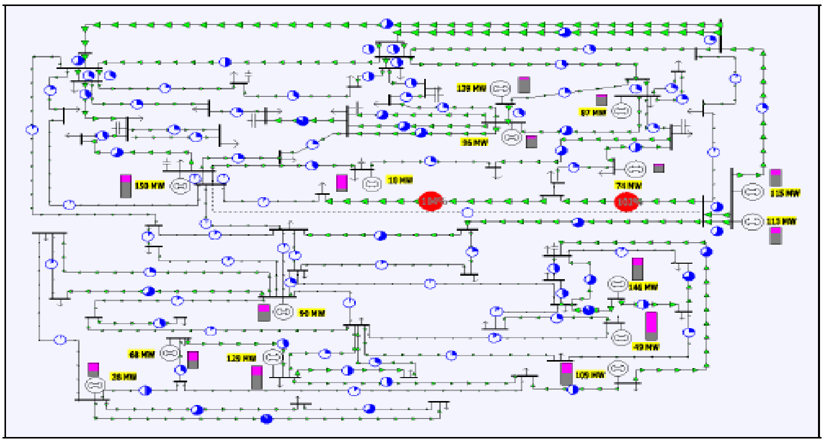

Fig. 3. – Unifilar Diagram of Load Flow displayed on a screen in the control room of the electric power center, source: [20]

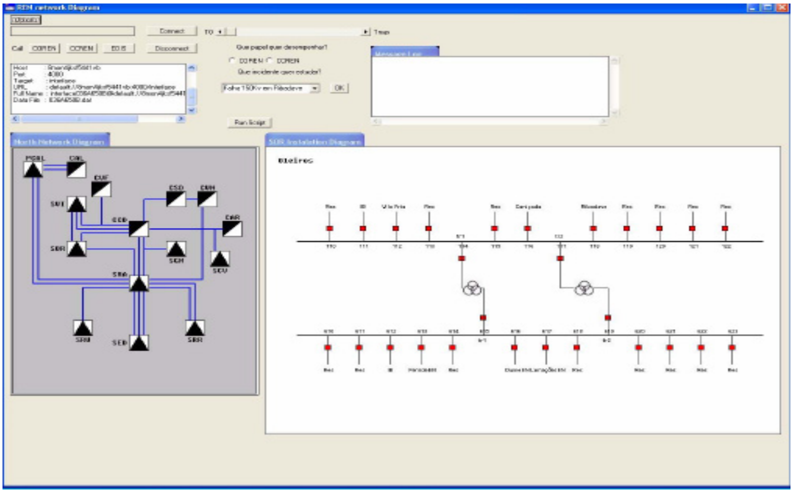

Fig. 4. – Unfiled diagram of substation equipment displayed on a screen in the room of the electric power control center

electricity; 4- Increased demand for power grids resilient in the form of permanent " micro-networks" or "islanded" that can help protect networks from higher voltage instabilities.

Besides the supervisory panels shown in Figure 2, each operator has three to four monitors with screens and information about the electric power system. These information generally has been shown using a display interface with figure two dimensional (2D) according to Figures 3 and 4.

3 Workload and Fatigue in Operators of the Electric Power Control Centers

The mental burden is placed as a hypothetical construct, induced by performance of a task and causing a decrease in the mental activity of other tasks. The aspects of fatigue were analyzed by Ilda [21], who noted that a balance between the demands at work and the ability of workers is needed. This balance can be supported by ergonomics research conducted in the workplace, because ergonomics aims to study the interactions of people and technology, as well as organization and environment to cooperate in an integrated way for the safety, comfort, welfare, and efficiency of human activities.

Many research about work fatigue and workload were analyzed last years [22, 23, 24] classified the main determinants of fatigue in internal and external variables. The following external variables are those that act more explicitly on the subject: Availability of time, equipment, instruments, and securities, for the physical environment (temperature, noise, vibration, and air quality); technical pressures; management; strategies; and organizational policies. On the other hand, internal variables are those intrinsic to human nature, such as the biological aspects of the constitution of the individual worker; psychological aspects characterized by personality style, emotional, and social aspects demonstrated by the level of commitment to issues of work and the service needs of food, shelter, safety, and comfort.

First, there are physiological factors related to the intensity and the duration of physical and mental work; psychological factors, such as boredom, lack of motivation; and finally, the environmental and social factors, such as the lighting, noise, temperature, and personal relationships on site. Fatigue is very common in the workplace and must be understood as a set of signs and symptoms of physical and mental attributes [4, 8], and that, if not properly observed and reversed, it may pass on to several systems of the body, causing changes in the functions and leading to reduced performance at work as well as psychological, family, and social disorders [25]. There will be a contribution to the operation management of the electric utility company a better work quality and consequently a lower probability of operator error.

3.1 Workload Evaluation: Ergonomics Aspects

There are several methods for the evaluation of cognitive and workload. One is the National Aeronautics and Space Administration Task Load Index known as the NASA-TLX (NASA, 2008), developed by the NASA Ames Research Center in 1986, after 3 years of studies involving over 40 laboratories research and flight simulations. This method works with physiological indicators associated with subjective methods in situations simulated in the laboratory or in real situations and operational work, taking great advantage of being applicable to various operators and activities without the need of change in its structure.

It is a multidimensional assessment procedure that gives an overall score of the workload based on a weighted average of the scores obtained in the six factors of NASA-TLX scale. These six factors are as follows: levels of achievement, effort and frustration, which have strong influence from the characteristics of individual operators, and the requirements of mental, physical, and time factors that are determined by the work situation [9].

With regard to satisfaction with the performance of the staff, the level of effort with respect to how much one has to work physically and mentally to achieve a good performance, as well as the level of frustration, there are factors that inhibit the performance of work, such as insecurity, irritation, lack of stimulation, and setbacks are important. On the other hand, the mental requirement involves mental activity needed to complete the work, and the physical requirement corresponds to physical activity required for the performance of work requirement and time on the level of pressure needed to achieve the same as shown in the Table 1.

Table 1. Factors considered in the NASA-TLX Instrument

Factors	Low Limit	High Limit
Mental Demand	Tasks considered easy, simple, goals achieved without difficulties	Tasks difficult, complex, requiring much mental effort to achieve the goal
Physical Requirement	Light, slow, easily accomplished tasks	Heavy, quick, strong, and lively tasks
Temporal Requirement	Slow and relaxed pace, with low pressure to the termination of activities	Fast and furious pace, with lots of pressure for completing the activities
Level of Effort	You feel very happy and are praised when it reaches the goals	You become no satisfied and almost no one notices your work
Level of Achievement	For the task to be performed successfully, surface concentration, muscle strength light weight, and simple reasoning are required (lack of skills)	Deep concentration, muscle strength, intense, complex reasoning, and great skill are needed
Level of Frustration	You feel safe, happy, and relaxed when you run the task	You feel insecure, discouraged, angry, and bothered with the task

4 Proposed Methodology

The proposed methodology for analyzing human factors and ergonomics, and human-machine interface in the electric power control centers would have the following steps

4.1 Steps of the Methodology

- Step I – Work Situation Characterization

— Human operator (experience, professional activities, age, style and life quality, personal and biomechanical data, anthropometrics).
— Organizational (organizational culture, work per shift; commitment labour; labour requirement, attention and concentration, information safety, automation);
— Environmental (temperature, noise, level luminance, lay out, position of monitors, supervisory panels, furniture especially chairs operators).

- Step II–Activity analysis by systematic visual observations of the work

— -Postural activities
— -Workers strategies to accomplish the task
— -Communications (with the other workers and devices)

- Step III–Worker Perceptions

– -Utilization of collected through questionnaires: (cognitive aspects, mental workload, types of tasks, difficulty of execution, emergency switching). These questionnaires using the methods described above with emphasis on methods NASA-TLX.
– -Interviews with a selected group. It is recommended that the interview be quick with answers structured to provide a better understanding of the factors involved between the work situation and the ergonomic aspects.
– -Data collection for the study with the interview: (software type, colors, symbols, size of the graphics system; modeling of equipment, types of screens, web design and other data).

- Step IV – Data Analyses and Identification of Critical Factors

– -Statistical analysis of data from questionnaires basic and the results of the interview. A correlation study should always be conducted to identify possible associations between the data and the variables collected in the studies.

- Step V – Proposed Solutions

– -Proposed solutions:

5 Results and Conclusions

The activities of the operator are extremely complex with numerous variables and the technician has a high degree of uncertainty. His tasks are associated with hazardous processes and systems. Implies supervision systems where some critical events occur infrequently and regularity, but requiring monitoring and decision making continuously. The Human-machine interface (HMI) are specialized by the many reasons like a greater integration and increase the size of the national and regional networks and increased level of automation involving distributed measurements and automatic decisions;

With this methodology there will be a contribution to analysis of human factors of the operators of the Electric Power Control Centers. This new procedure will improve the few existing procedures with an innovative character and include other topics in cognitive ergonomics and Interface Human-Machine.

There will be a contribution to the strategic planning of electric power companies providing data for a better match of activities of the operators of the electric power control centers, contributing to a reduction in operating errors.

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