A METHODOLOGY FOR EVALUATING THE ENVIRONMENTAL IMPACT CAUSED BY THERMOELECTRIC GENERATION

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Abstract. *Recently, changes in the energy matrix of developing countries, driven by regulation and strong market competition, has caused substantial impact to the environment due to problems associated with atmospheric pollution, noise in the neighborhood of densely populated areas, contamination of water resources, damage to soil and natural systems, mismanagement of natural resources, etc. In particular case of Brazil, the use of natural gas and other fossil fuel for producing electricity has been fostered by the country's government causing unavoidable impact to the environment. This paper discussed the shift of the Brazilian energy matrix towards a thermal character. It evaluates the potential social and economical impacts that such a change will eventually cause. The current incipient legislation is reviewed and mitigation of environment damage are reviewed.*

Keywords. *Thermal Power, Fossil Fuel, Environment Impact.*

1. INTRODUCTION

The ever-greater demand for power production in modern society is mandatory for keeping high standards of modern life, including housing, health, transportation, food processing, etc. Today, all of those aspects of contemporary life are sought in light of environmental issues demanding a continuous search for environmentally satisfactory actions, without compromising the effectiveness of productive processes. Geo-processing and Remote Sensing are here refereed as instruments to efficient Environmental Management, leading to the proposal for models for diagnose, monitoring and production.

Worldwide environmental impact studies have covered a wide range of power production systems, including fossil power plants running on a combined-cycle [Corti and Carnevale (1998)] or small cogeneration systems [Makarytchev (1998)], nuclear plants of the fission [Fisk (1999)] and fusion [Atkinson (1989)] types, geothermal [Bargagli et al (1997)], tidal [Marfenin et al (1997)] and wind [Cole (1993)] power production plants in addition to hydropower stations [Rashad and Ismail (2000)]. Other factors impacting on the environment have been investigated such as power transmission lines [Jackson and Hudman (1978)] and fuel exhaustion in urban transportation [Corbo et al (1998)].

For the particular case of Brazil, studies on mining of uranium [Fernandes et al (1995)], gold [Weisberg (1991)] and sand [Santo and Sanchez (2002)] have been published, in addition to analyses of the impact on land use [Fiorio et al. (2000), Eve et al (2000)] and fishing [Diegues (1998)]. Hazards caused by hydropower plants in Brazil have for a long time been the subject of several studies [e.g. Mozeto et al (1990)], and the relatively new shift in the energy matrix of the country towards a more "thermal" characteristics will demand studies on such specific impacts also for thermal power plants.

Therefore, acknowledging that generation of thermal energy is being one of the viable alternatives of electricity production in Brazil, and noting the absence of systematic literature surveys in the national literature dealing with this particular matter, the objective of this work is to focus attention on air quality issues, one of the few impact factors that can be preliminarily diagnosed.

2. AIR QUALITY

The quality of air is defined as the state of the main atmospheric variables in relation to a group of norms and pre-established patterns. It is used as a reference value for the process of environmental control.

Air pollution refers to situations where some materials or some forms of energy occur in great amounts, implying in harm to men, plants, animals and materials. The main pollutants generated by combustion processes are particulates, SO_2 and SO_3, hydrocarbons, NO and NO_2.

For treating issues of air quality, it is necessary to know meteorological data such as wind direction and speed, temperature, visibility, relative humidity and precipitation.

Air pollution, as far as its concentration if of concern, can be classified as *acute*, when occurs in specific periods of time and areas, and *chronicle*, when it happens daily, although causing smaller immediate impact, presenting late and very harmful damages to the atmosphere and to men.

According to Mendes (1998), for evaluating pollutant concentration in exhaust gases, it is necessary the use of adequate equipments for extraction of representative samples as well as additional equipments (devices) for its collection and capture of the chemical component to be analyzed. To do a sampling of certain pollutant, it is further necessary to first identify the activity-source in order to determine the equipment type and the pollutants that may be generated. The final process consists of the analysis of the mass of particulates kept into the equipment, allowing for evaluation of adherence to legal limits of atmospheric emissions. The quality of the atmospheric air should be analyzed taken into account the cycle of pollution, which consists of emission, transportation and diffusion of pollutants, because it is possible that accidents or collateral effects occur in quite distant places from the generating sources of pollution.

When the atmospheric emissions get to reach urban areas sensibly, the tendency of the problem is to get worse, because the urban space is constituted by aspects, whose organization has origin in the interaction between the social forms and physical forms. In that way, the environmental conservation should assume a role of common goal.

Air pollution is one of the few environmental impacts that can be preliminarily diagnosed, although it will still depend on studies of local and regional climate dynamics.

The climatology study constitutes an important instrument for environmental managers, tends in view the location of the project and the area of influence of the same, if configuring as one of the most important elements of the diagnosis phase.

3. ENVIRONMENTAL VIABILITY

The environmental viability, here understood as the resistance capacity of the environment to certain human interferences and their consequences. The environmental issues, in all of their aspects, must rely on precise data acquisition, which will lead to diagnosis and prognosis, mitigating actions, solutions and modeling for reliable monitoring the environment. A simplified view of ideal phases for a preliminary study of environmental viability is shown in Figure 1 (Mendes (2000)).

4. GEO-PROCESSING AND REMOTE SENSING

As previously mentioned, the characterization of the possible environmental impacts of certain activity will depend on a detailed study of the area, going by a *Check List,* diagnoses, prognostics, among other studies.

One of the most important instruments for Check List elaboration, diagnoses, prognostics, among others, it the use of geo-processing resources and remote sensing for real modeling and database construction with geographical intelligence, giving support to the environmental administration, from the starting phase of data collection to the monitoring phase and control.

Geo-processing has as main characteristic the capacity to manipulate the representation of geographical phenomena in an computational framework, integrating space and alphanumeric information, interpolating primary information and generating secondary information through algorithms, as one can see in researches of the Brazilian Company of Agricultural Research – EMBRAPA, presented in Assad e Sano (1993). Such primary information is acquired through satellite images, Numeric Models of Lands (MNT's), systematic cartography and tabulated data. The application of the geo-processing for linked activities to the generation of energy owes, at least, to consider geographical analysis, numeric models of land, modelling of nets, cartographic production and field topography.

According to Rosa (1989), remote sensing, as one of the phases of geo-processing, consists in obtaining information on an object without physical contact, through the reflectance or emission of is surface, in other words, it generates certain patterns for the ghastly alteration of the solar radiation, allowing for several applications such as the analysis and the environmental monitoring.

The applied techniques of remote sensing to the engineering works, in their phases of viability analysis, project, implementation and maintenance allow the evaluation of the adaptation certain work to the middle, considering the aspects physical, biotic and socioeconomic involved and it also allows the development of monitoring systems during the useful life of the work.

5. THERMAL POWER GENERATION

Natural gas has a high calorific capacity and is one of the cleanest fossil fuels, becoming of significant importance in the accentuated reduction of atmospheric emissions and, consequently, in the concentration of those emissions in the neighboring areas. Although natural gas is highly flammable, the risk of accident is reduced due to its low weight and fast dissipation in the air and due to the fact a stockpiling process. This is one of the best alternatives for producing thermal electricity, so much under technical and economical aspects, as under aspects of environmental preservation.

As for the technical and environmental aspects, one of the great advantages in using natural gas is the fact that its use reduces the time and the number of maintenance stops. This, in turn, has implications so much in the productive process, as in the environmental quality, since some equipment pollute more during start up and shut down than when working in steady state regime.

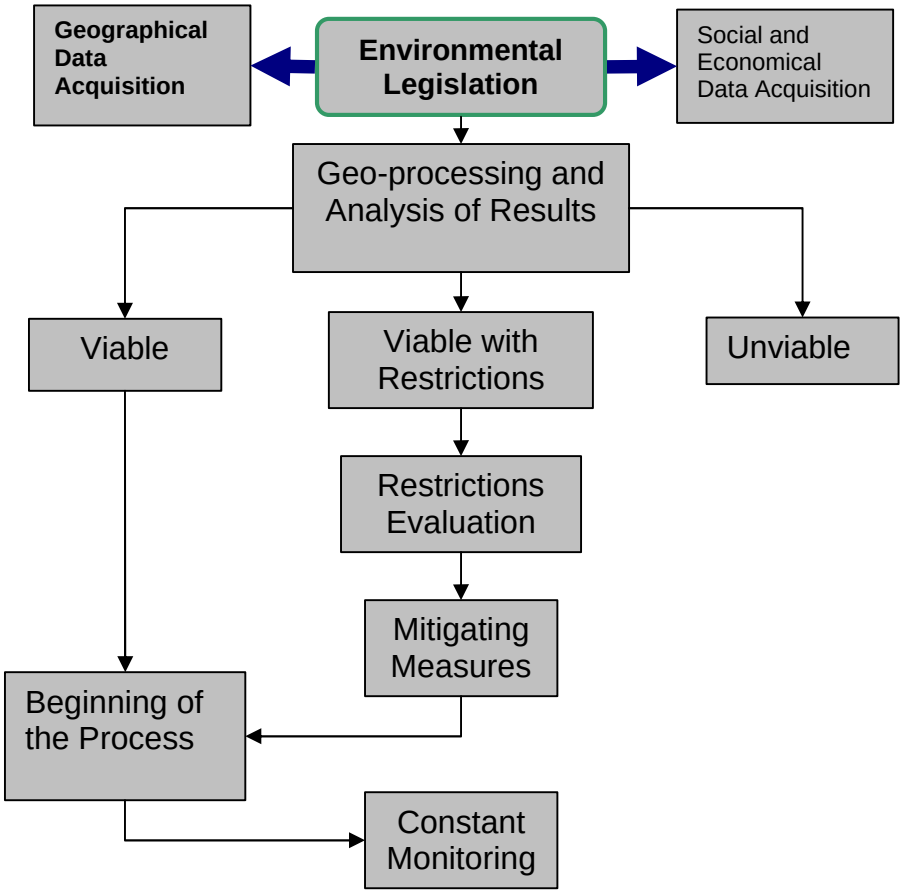

Figure 1. – Analysis phases of Environmental Viability of Project Legislation
(see Mendes (2000) for details)

The environment is the interrelationship between the *natural system* (hydrosphere, atmosphere, lithosphere and biosphere) with the *institutional system*, social and of infrastructure, which composes the basic demands of an entire society. It is for this and other reasons that the environment is one of the subjects most discussed at present times. In fact, environmental protection has already been the subject of some actions and discussions along the century XX, through the so-called *International Environmental Conventions*, which are actually agreements or treaties among some countries seeking the preservation/conservation of natural resources of common interest. (Rocha (2000)).

The risk, as a frequency combination (that is the number of occurrences for unit of time) and consequences (that is the impact of an accident in the man, in the atmosphere and/or in the investment), incurring undesirable events of losses with social and economical impacts, it then should be analyzed by taken into account the concepts of:

- Accident;
- Danger (Hazard);
- Individual risk
- Group of risk
- Social risk

Evaluation of environmental impacts can be done through several methodologies, among the ones as follows:

- The head offices of environmental impact, applied in projects of multiple uses of reservoirs, construction of thermal-power plants, construction of highways, etc.;

- The indexes of environmental quality, that it is the systemization of information collected through monitoring or intensive research of parameters capable to quantify the impact caused by the implementation of projects;
- The physical and mathematical models, that you/they simulate the space and temporary distribution of the environmental indicators addressed to certain problem, as the quality of the air, of the water, the final disposition of residues and emissions in the pedo-geological, geomorphologic, atmospheric and hydrographical media.

Before beginning the study/application of any of these methodological processes, there is a need to conform to a *Check List* method, which is a method in that a list of items is used for comparison or verification. It can be used for evaluation of systems of safety, operational procedures, maintenance practices, evaluation of environmental impacts, etc.

6. THE BRAZILIAN ENVIRONMENTAL LEGISLATION

The legislation concerning environmental aspects obeys a hierarchy that goes by the federal, state and municipal spheres. It is worth to emphasize that the current tendency is the municipalization of the administration and environmental fiscalization.

The Brazilian environmental organs settle down in the following way:

- **SISNAMA** (*National System of the Environment*).
- **CONAMA** (*National Council of the Environment*
- **IBAMA** (*Brazilian Institute of the Environment and Natural Resources*

In agreement with the Brazilian Environmental Legislation, it will depend on elaboration of Study of Environmental Impact (EIA) and respective Report of Environmental Impact (RIMA), the licensing of modifier activities of the environment, among which we can mention:

- Pipelines, gas pipelines, mining ducts, trunks collectors and emissaries of sanitary sewers;
- Lines of transmission of energy, above 230KV;
- Sanitary embankments, processing and final destiny of residues poisonous and/or dangerous;
- Power plants above 10 MW used as primary source of energy.
- Study of Environmental Impact, besides the legislation, he/she should assist to the following guidelines:
- All to contemplate the technological alternatives and of location of the project, confronting them with the hypothesis of no execution of the project;
- To identify and to evaluate the environmental impacts systematically generated in the implantation phases and operation of the activity;
- To define the limits of the geographical area to be direct or indirectly affected for the impacts, denominated area of influence of the project, considering, in all of the cases, the basin hidrográfica in the which is located;
- To consider the plans and government programs, proposed and in implantation in the area of influence of the project, and his/her compatibility.

The Study of Environmental Impact, will develop, at least the following technical activities:

- Environmental diagnosis of the area of influence of the project, completes description and analysis of the environmental resources and their interactions, just as

they exist, in way to characterize the environmental situation of the area, before the implantation of the project, considering:

- Definition of attenuation measures of negative impacts, among them the use of equipment for control and treatment of spills, evaluating the efficiency of each one of them.
- Elaboration of a monitoring program.

The Study of Environmental Impact should be accomplished by at team of qualified multidisciplinary workers and the costs and expenses will run on the proposer of the project. The Report of Environmental Impact (RIMA) will reflect the conclusions of the Study of Environmental Impact and it will contain, at least:

- The objectives and justifications of the project;
- The description of the project and their technological alternatives and locations, specifying for each, in the construction phases and operation, the influence area, the raw materials, the labor, the sources of energy, the processes and operational techniques, the probable effluents, emissions and residues, the direct and indirect jobs the they be generated;
- The synthesis of the results of the environmental diagnoses of the area of influence of the project;
- The description of the probable impacts of the implantation and operation of the activity;
- The characterization of the future environmental quality of the influence area, in their different alternatives, as well as the hypothesis of yours no accomplishment;
- The description of the expected effects of the reliever measures;
- Plan of impact watch and monitoring;
- Recommendation as for the most favorable alternative;
- It should be made available and accessible to the general public.

As for the Environmental Licensing, we have the following phases:

- **Preliminary License** (LP):
- **License of Installation** (LI)
- **License of Operation** (LO):

7. CONCLUDING REMARKS

The objective of this work was to present subsidies to the search of the best administration instruments and environmental analysis, the decision on the best model structure to be used, as well as the aspect to be emphasized in this structure, will depend on the need of solving certain problems.

In any way, before all of the degradation factors, it is important that a head office of environmental impacts is drawn, that it is done necessary to the measure in that it allows the identification of the most significant impacts, demonstrating his/her intensity and where is inserted.

Today, science and technology promote the man's integration and of the middle in a rational way and drifted, on time, I cost and risk reduced. Equipments as satellites of high resolution and sensor radars supply instantaneous and valuable information. Advanced techniques allow the united evaluation of multiples factors, activating the progress of several sections of the partner-economy.

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