AIR POLLUTION AND ENVIRONMENTAL COST MAPPING

Alcindo de A. Maranhão Neto, Marcelo Rebelo Athayde, Antonio C. P. Brasil Jr, Armando de A. Caldeira Pires
Universidade de Brasília – Campus Darcy Ribeiro – Faculdade de Tecnologia
Departamento de Engenharia Mecânica – Laboratório de Energia e Ambiente – Brasília – DF, CEP 70.910-900
alcindom@terra.com.br , brasiljr@enm.unb.br

Abstract. *The growth in the deployment of Thermo electrical Units and their respective environmental impacts as sources of atmospheric pollution warns of a need to limit the emissions of pollutants in the whole national territory, reducing the negative effects of atmospheric pollution on the environment, mainly in the metropolitan areas. The objective of this work is the pollutant dispersion simulation modelling in a certain area, using ISC-AERMOD View, created by Lake's Environmental company, and the environmental costs association and mapping of the main pollutants (CO, SO_X, NO_X and PM) analyzed in the dispersion model. This environmental costs association will be based on the European ExternE project (1998*).

Keywords: *Thermoelectrical Units, pollutants dispersion, modelling, mapping, environmental costs*

1. Introduction

Due to increased electric power demand in the country, Eletrobrás – Centrais Elétricas Brasileiras SA developed an energy supply expansion strategy in the period of a decade. This plan seeks to increase the Thermo electrical Units - UTE participation in the Brazilian energy scenario, decreasing hydroelectric participation.

As consequence, the expansion plan considers that the new configuration of the Brazilian Electric Sector will have an effective participation of private companies, significantly increasing the number of thermo electrical units installed in the next years, due to the smallest investment cost and low risks involved in the deployment of this project type.

In the face of this new Brazilian energy scenario, with the growth of the UTE deployment and their respective environmental impacts of atmospheric pollution, it is necessary to limit pollutant emissions nationwide.

The UTE's are submitted to rigorous Federal and State environmental legislation. The largest Federal legislator is the Conselho Nacional do Meio Ambiente – CONAMA, the Brazilian National Environmental Council, which instituted the Programa Nacional de Controle da Qualidade do Ar – PRONAR, National Program for Air Quality Control, in Resolution no. 05/85, to reduce the negative effects of atmospheric pollution on Brazil's environment, mainly in the metropolitan areas.

The study of pollutants concentration and dispersion in the atmosphere are a fundamental activity in air quality control. All over the world, that study is increasing due to the expressive increase of pollutants emission in the atmosphere, mainly in urban and industrial areas, exposing more and more people to serious health risks. In this sense, knowing exactly how the dispersion behaves and how the main pollutants settle is necessary.

Therefore, it is necessary to estimate and to register, as well as to process the related data in the pollutant sources enabling the development of scientific research with the intention of elaborating local programs to combat air pollution.

With that purpose a UTE belonging to Companhia Hidroelétrica do São Francisco – CHESF was visited. CHESF is a Brazilian company responsible for producing electric energy in the Northeast of the country. The power plant is located in the Industrial Park of Camaçari in the State of Bahia.

Several mathematical models aimed at the most varied situations have been developed, which confirms the importance of this subject worldwide. The models represent different behaviors of the pollutant gaseous plume because of the different meteorological conditions, source characteristics and terrain configuration of each location. Therefore a better understanding of the pollutant dispersion process in the atmosphere makes better control and administration of the air quality possible.

The objective of this work is the modelling of the dispersion simulation of pollutants in a certain area, and the association and mapping of the environmental costs of the main pollutants (CO, SO_X, NO_X and PM) analyzed in the dispersion model.

The modelling simulation is based on the Gaussian dispersion to estimate the rate of pollutant in the atmosphere using the program ISC-AERMOD *View*, created by the American company Lake's Environmental.

The association of the environmental costs will be based on the European ExternE project (1998). The cost mapping was calculated through the program MATLAB version 5.3, using the area coordinates generated by the dispersion program.

2. Air Quality Environmental Impacts

Air quality suffers alterations during the deployment and the operation of the power plants. During the actions that are part of the deployment, the emission of gases and particulate material coming from the operation machines and the vehicles that will transport the equipment, the supplies and the necessary personnel for the works of the UTE is foreseen. Also the dust emission is foreseen at the time of the above-mentioned transport, in the case that part of the access highway is not asphalted.

The gases originated from machines and vehicles in generation are especially the carbon monoxide - CO and the carbon dioxide - CO_2 associated to the particulate material - PM (soot).

Dust is another concern, not only the originated dust from the exhausts soot, but also that emitted during the displacement of material transportation vehicles and machines that can provoke the dispersion of fugitive dust along the accomplished course, if highway protection precautions are not adopted. It can be harmful to the workers' health and to the local population and also to the highway border vegetation, which will tend to acquire a dust layer on the leaves, endangering the breathing processes, transpiration and photosynthesis.

In the operation phase air quality suffers alterations of the pollutant emissions from the chimneys and support equipment, such as, cooling systems for bearings using independent machines, among others with low pollutant emission content. Again fuel transport can be mentioned.

The gas dispersion in the atmosphere depends on several factors: the current meteorological conditions, the exhaust gases characteristics, composition, temperature and flow, but also in the form of the release, chimney height and chimney diameter (speed of the gases). The definition of the dimensional characteristics of this equipment can avoid concentrations of pollutant in areas close to the plant.

3. Pollutant Emissions in Thermo electrical Plants

The air pollution level is measured by the constant quantification of the pollutant substances. In a thermo electrical plant, the emission of pollutant gases depends on several factors:

- Turbine used;
- Location and size of the plant;
- Operation time;
- Work ratio;
- Fuel used.

There is a very large variety of substances present in the atmosphere that, depending on its concentration, can make it inappropriate, harmful to health. However, the pollutants are separated in two different categories:

1) Primary pollutant: Those emitted directly by the emission sources, in the case of the chimneys (gas exhaust).

2) Secondary pollutant: Those formed in the atmosphere, through the chemical reaction among primary pollutant and natural constituents of the atmosphere. For instance, the ozone can be mentioned as the product of the chemical reaction of NO_2 + organic compounds + sunlight.

The substances usually considered air pollutants can be classified in the following way:

- Sulfur Oxides (SOx)
- Nitrogen Oxides (NOx)
- Organic Compounds
- Carbon monoxide and carbon dioxide
- Particulate Material

But the pollutant group that serve as indicators of the air quality are: sulfur dioxide (SO_2), dust in suspension, carbon monoxide (CO), Ozone (O_3), total hydrocarbons (HC) and nitrogen oxides (NO and NO_2). This is due to the frequency and to the adverse effects they cause on the environment.

With the intention of restricting the levels of pollutant by atmospheric pollution sources, limiting emissions over the whole national territory, CONAMA, in its resolution n.º 03/90 of June 28, 1990, established the standards of air quality in the concentration of atmospheric pollutants, that, if exceeded, can affect the health and safety of the population, as well as cause damage to the fauna, flora, and to the environment as a whole.

This resolution also establishes fixed values for the primary and secondary pollutants, defined standards for each one as follows:

Primary standards: represent the concentrations that once exceeded, can affect the population health, and can be considered as the maximum tolerable concentration level of the atmospheric pollutants. These were established based on the observation of the relationship between pollution levels and cases of related, registered diseases in the exposed population.

Secondary standards: represent the concentration values that below which, minimum effects in the life quality of the population and damage to the fauna, flora and to the environment are expected.

The same Resolution establishes that, while each State doesn’t define the area zoning, the primary standards should be assumed for these areas. The Resolution also considers that air quality monitoring is the responsibility of each State.

The CONAMA Resolution n.º 08/90 establishes national emission standards for some pollutants, and applications for UTE's that operate with mineral coal and fuel oil. This same Resolution establishes though, that the licensing to define maximum limits of emission for units of external combustion that operate with other fuels falls to the responsible environmental organ .

3.1. International standards of Air Quality and Emissions

Many industrialized countries have established some relationships in order to adopt standards with the goal of reducing the discharges of pollutants in the atmosphere. The relationship used by the USA and other countries is given by the ratio between the emission rate of the pollutant produced in a unit of burned fuel and the energy produced by this unit.

The most advanced legislation in energy in the USA concerns the prevention of the significant deterioration of air quality (Prevention of Significant Deterioration - PSD). This legislation establishes the increment to a thermo electrical plant installed at a certain location.

For instance, even considering that the pattern of air quality in a certain non-protected area is 365 μg/m3 of SO2, a UTE can only produce 91 μg/m3 to the existing concentration for a 24-hour sampling period. In terms of annual average, the allowed maximum increment would be 20 μg/m3. For particulate material these values would be 27 μg/m3 and 19 μg/m3, respectively. In the areas surrounding environmental conservation units these values would be even more restrictive.

3.2. Fuel

Petroleum derivatives, natural gas, coal or biomass are burned in UTE's .

At this moment, the most widely accepted fuel to operate in a UTE is natural gas. Besides its countless economical advantages, natural gas stands out for its huge contribution in the improvement of environmental standards. Natural gas is a fossil fuel, found or not with petroleum, composed basically of methane gas .

It has a low presence of pollutants providing a cleaner and uniform combustion, lacking sulfur and ashes, which makes the elimination of ashes that is required in the thermal units using coal and oil unnecessary.

When substituting firewood, for instance, natural gas reduces deforestation. The problem of acid rain is minimal in a thermal plant using natural gas, and the contribution to global warming, by generated kW, is much smaller than in the correspondents using coal and oil for best thermal efficiency. Since natural gas is rich in hydrogen when compared to the other fossil fuels, the production of carbon gas generated by its burn is significantly lower. Still, in relation to other fossil fuels, natural gas presents more flexibility, both in transportation and usage.

On the other hand, the most common environmental problem in the facilities using natural gas is the emission of nitrogen oxides, known as "NO_x", and CO.

In the use of thermo electrical plants operated by coal, two types of environmental aggression happen: they launch gases into the atmosphere and hot water is released into the environment. There are several gases produced, like CO_2, and in smaller amounts, CO (carbon monoxide) and pure carbon.

The industrial gas turbines can operate with several fuels, liquids and gaseous, but due to the high temperatures of the process, all the fuels should have low levels of pollutants. Liquid fuel should have a low viscosity, like diesel oil and kerosene oil, as well as having a low level of pollutants (such as metals, sodium, potassium, sulfur, etc.) that require special attention in the supply of liquid fuel.

Besides, natural gas possesses other important characteristics such as its fast dispersion (in case of gas leaks) and its low odor indexes.

Diesel oil as the main fuel or fuel used in an emergency has a high rate of sulfur emission into the atmosphere, together with solid residue production in the generation process and is less efficient.

Biomasses are constituted of wood and pulps and they are the least used when talking about generation of large-scale electric power.

3.3. Pollutant Dispersion

3.3.1. Physical Phenomenon Associated to the Dispersion

The dispersion of the pollutants emitted by a chimney type point source depends on the meteorological conditions present in the area where the formed plume disperses. The wind speed and the intensity of the atmospheric turbulence determine the height that the plume will reach and the speed with which the pollutants will be dispersed.

The term atmospheric stability is associated to the group of meteorological factors that determine the largest dispersion of pollutants in the air. In function of the turbulence intensity, the atmospheric state can be classified as stable, unstable and neutral.

3.3.2. Gaussian dispersion

The models commonly used are denominated "Gaussian dispersion models ", because they use the Gaussian distribution, (Cornwell, 1991) to estimate the rate of pollutant, coming from an initial plume, that is mixed with the ambient air. The main structure of the equations that form the estimate base of the pollutants dispersion in the atmosphere is usually denominated Gaussian Plume model, or Gaussian dispersion model.

The Gaussian dispersions models of pollutant in the atmosphere are based on the premise that the space distribution profile of substance concentrations emitted into the atmosphere approximately follow the normal distribution with a concentration dependence of pollutant, whose form when shown in a histogram is a bell.

The representation of the distribution is also given the name of Gauss curve. The association of that dispersion concept, in other words, the mathematical foundation associated to the normal distribution, gave the name of Gaussian model, whose diffusion equation is presented below. It allows the estimation of the concentration of pollutant in the receptor points, previously defined in the entrance file of the mathematical model. The Gauss equation is given by: (Cornwell, 1991)

$$c(x,y,z,H) = \frac{Q}{pS_y S_z u} * \left[\exp\left[-\frac{1}{2}\left(\frac{y}{S_y} \right)^2 \right] \right] * \left[\exp\left[-\frac{1}{2}\left(\frac{H}{S_z} \right)^2 \right] \right] \quad (1)$$

Where:

χ - The concentration of the pollutant in the receptor point, (g / m3);

Q – Emission rate of the pollutants (g/s);

u – Wind speed (m/s);

Sy, Sz – Standard deviation of the plume, in the horizontal axis and in the vertical axis respectively;

y – Receiver distance, horizontal coordinate (m);

z – Distance of the receptor, coordinated height, (m);

H – Effective plume height (h + H), (m);

h – Real chimney height, (m);

ÄH – Plume elevation (m).

It is important to emphasize that in this work the coordinate z is considered zero, because the concentration was estimated for receptors at the ground level.

This model shows the pollutants concentrations in certain area, in function of:

- The emission source distance;
- The meteorological parameters (direction and wind speed, atmospheric stability classes, and mainly the local temperature and height of the mixture layer);
- The area topography (plain, mountainous, etc);
- The emission sources characteristics, in the case of point sources, it is necessary to know: height, diameter, temperature and exit of the gases, source location and pollutants emission rates.

These are the input data for the mathematical model, selected for the specific case, it shows the pollutants concentrations in the point of interest to analyze the air quality, be it in the urban areas or industrial areas.

Using a three-dimensional system x, y, and z, with the located origin on the ground, to locate all of the emission sources, it is assumed that:

- The coming concentrations of a continuous pollutant source are proportional to its emission rate. And it is assumed that the emission is continuous and constant during a long modeled period, and this calculation is made dividing the total maximum load emitted in the period (usually of one year, 8.760 hours.) for a certain source (considering the non-working periods).
- These concentrations are diluted by the wind at the emission point. The higher the wind speed, the smaller the pollutants concentration.
- The pollutants concentration close to the emission source follows the Gaussian distribution, reaching the maxim concentration in the center of the plume.
- Mass conservation exists; in other words, there are no chemical reactions, washes, precipitations or other removal processes (in these cases specific options exist in the models).
- Standard deviation of the pollutants concentration in the plume, in the axes if y is empirically related to the turbulence levels in the atmosphere, and increases with the distance of the source. The turbulence is represented in the simulation, through the classes and atmospheric stability.

3.3.3. Modeling Simulation

The simulator ISC-AERMOD *View* was used for the simulation of pollutant dispersion.

It is a friendly interface for the atmospheric pollutant dispersion ICST3, ISC-PRIME, AERMOD and AERMOD-PRIME algorithms developed by US.EPA, the American Environmental Protection Agency . The Lake's Environmental company created this interface and it was especially developed for Microsoft Windows 95/98/ME, Windows NT/2000/XP.

ISC-AERMOD *View* uses six pathways that compose the run stream file as the basis for its function organization. These pathways are:

1. Control Pathway: Where the modeling scenario is specified, in other words, the overall control of the modeling run.

2. Source Pathway: Where the sources of pollutants emissions are defined .

3. Receptor Pathway: Where the receptors to determine the air quality impact at specific locations are defined.

4. Meteorology Pathway: Where the atmospheric conditions of the area being modeled are defined, so they can be taken into account when determining the distribution of air pollution impacts for the area.

5. Terrain Grid Pathway: The option of specifying the grid terrain data to be used in calculating dry depletion in elevated or complex terrain.

6. Output Pathway: Where the output results that are necessary to meet the needs of the air quality modeling analysis are defined .

3.3.4. Input data

The input data of the model is divided in three main groups for each pollutant:

- Meteorological data;
- Pollutant sources;
- Receptors data.

1. Meteorological data:

ISC-AERMOD VIEW requests meteorological data for every hour regarding a complete year.

Speed and wind direction: the air movement in the atmosphere has decisive importance in the transport of pollutants thrown in the atmosphere. Those movements in smaller time and space scales mix pollutants with the less concentrated adjacent air, lowering concentration of gaseous pollutant after the release of a particular source.

Wind is a vector field and as such it presents three components (x,y,z) and its result determines the direction of the wind in each instant. The vertical wind component (z) is responsible for the turbulence while the other components determine the transport and the dilution of the pollutant plume.

The horizontal wind component (north-south and east-west) is commonly considered, therefore it is stronger. The horizontal wind movement is responsible for the gradient of horizontal pressure and also for the gradient of horizontal temperature.

2. Pollutant sources data

The emission sources of pollutant were classified as punctual sources, the chimneys. This data refers to: height, diameter and coordinates (x, y) of the chimneys, temperature, speed and concentration of the gases exit.

3. Receptors data:

The UTE's own facilities

The UTE's periphery

4. Modelling Analysis and Association of the Environmental Costs

4.1. Modelling Analysis

The modelling was performed for the Camaçari UTE, using the input data regarding the year 2000.

A grid was elaborated with spacing of 1575 by 1148 meters, totaling 1152 receptors and consequently 1152 evaluation areas, containing the coordinates x, y. In this case, the coordinate z is zero, because all of the estimates of the pollutant concentrations were calculated at the ground level.

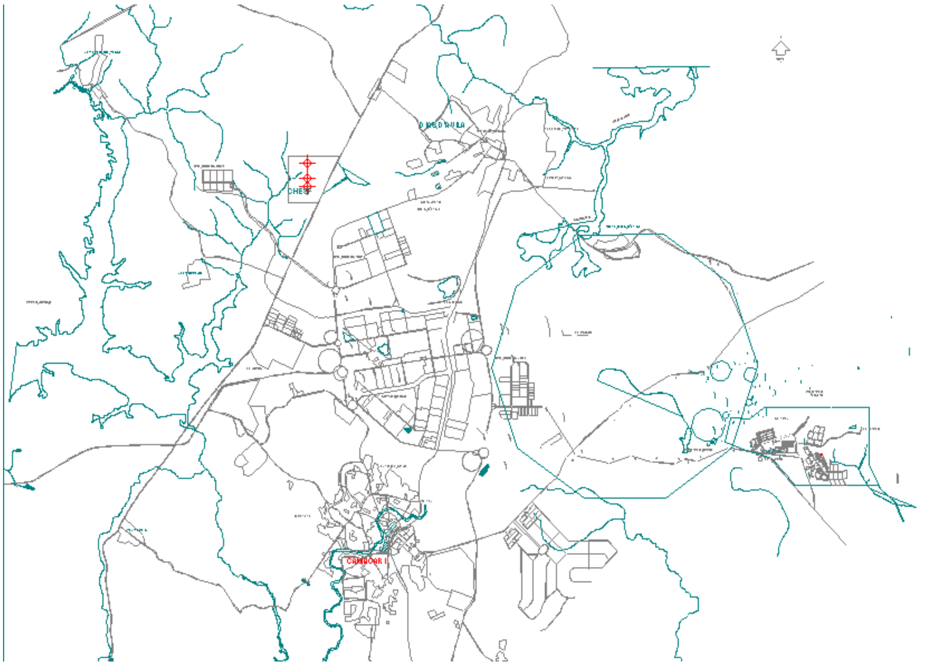

Figure 1. Map of CHESF Official Influence Area.

The Fig. (1) presents the map of the Camaçari UTE official influence area, containing its own facilities, the Camaçari petrochemical complex as the urban perimeter of the municipal districts of Lamarão do Passe, Leandrinho, Camaçari, Dias D'Ávila and Nova Dias D'Ávila. For a better visualization of the pollutants dispersion, the resulting grid is approximately four times larger than the map of the CHESF official influence area , containing all the 1,152 evaluation areas.

The pollutant emission sources, chimneys, were classified as point sources, and all the necessary data are listed in Tab. (1). These data refer the: height, diameter of the chimneys, temperature, exit speed and concentration of the gases.

Table 1. Necessary data used in the modelling of the pollutant dispersion

Parameter	
Chimney Height (m)	15.6
Chimney Diameter(m)	6
Chimney Exit speed of the gases (m/s)	12.2
Temperature of exit of the gases (K)	400
Emission rate of PM (ton/year)	20.3
Emission rate of CO (ton/year)	25.6
Emission rate of SO_2 (ton/year)	108.2
Emission rate of NO_X (ton/year)	374.9

The necessary meteorological data was inserted in the program through a table containing the following data in this sequence: Year, Month, Day, and Hour, and Wind Speed, Room temperature in Kelvin, Stability Class, Rural and Urban Mixing Layer Height in meters.

4.2. Modelling Results

The modelling consisted of determining the resulting concentrations in the evaluation areas established in the beginning of the program, for each one of the pollutants studied, with the pollutants sources.

For each one of the presented results, a graph that illustrates the behavior of the plume of all the pollutants studied was elaborated .

An example of the plume behavior is demonstrated in Fig. (2).

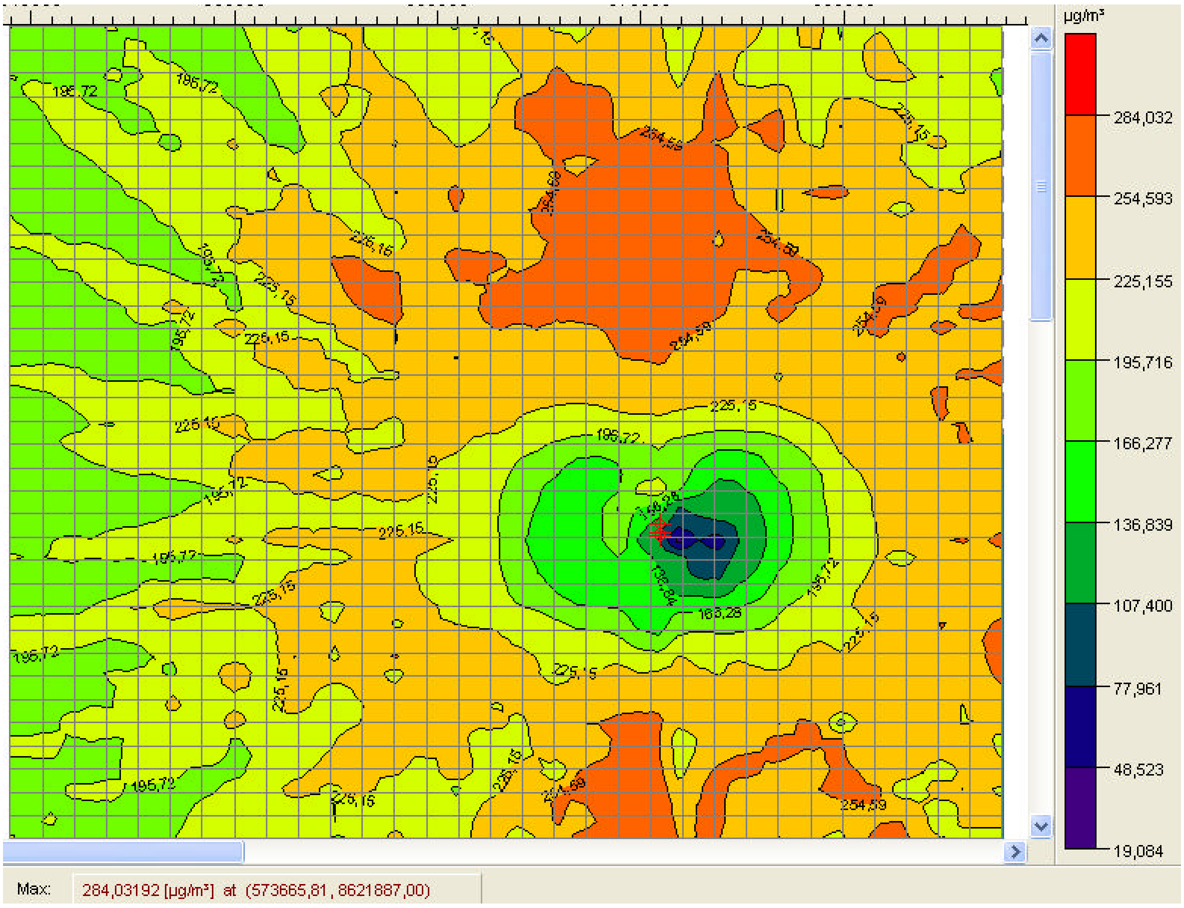

Figure 2. An example of the plume behavior

Tab. (2) presents the maximum pollutant concentrations in agreement with the CONAMA 03/90 pattern obtained from the modelling for each one of the pollutants.

Table 2. Maximum pollutants concentrations, the environmental pattern associated and location.

Pollutant	Maximum Concentration (µg/m3)	Legal Pattern (µg/m3)	Location
SO_2 (24Hr)	21.69	365	6649m northeast of CHESF
SO_2 (Annual)	1.94	80	4109.92m northwest of CHESF
NOx (1Hr)	284.03	320	17106.79m northeast of CHESF
NOx (Annual)	6.72	100	4109.92m northwest of CHESF
CO (1Hr)	19.39	40000	17106.79m northeast of CHESF
CO (8Hr)	10.19	10000	2012.65m northeast of CHESF
Part. Mat. (24Hr)	2.09	240	2012.65m northwest of CHESF
Part. Mat. (Annual)	0.36	80	4109.92m northeast of CHESF

It is emphasized that the NOx concentrations were compared with the environmental standard for NO_2; therefore, the results were conservative.

It is also emphasized the coincidences in the locations due to the meteorological conditions, of maximum concentration of CO and NOx, both at a 1 hour average . It is the same location of the annual averages of SO_2, PM and NOx. These are the most critical locations, in other words, of worse air quality in the studied total area.

4.3. Association of the Environmental Costs

The association of the environmental costs was based on the European project ExternE. One of the main objectives of this project is to quantify the various environmental and social costs associated with electric power production and consumption

In the early 90's, the European Commission of the 5th Program of Environmental Action "Towards Sustainability" demanded the integration of environmental dimension in other political areas.(Krewitt, 2002) Political decisions should take into account the costs and benefits based on the technological and scientific information available.

The European Commission in collaboration with the North American Department of Energy began a project to access the environmental externalities of energy. Those externalities include the natural environment and urban damages, such as air pollution effects in health, buildings, grains, forests and global warming. The traditional monetary valuations of fuel cycles tends to ignore these effects. However, there is a growing interest in adopting a more sophisticated way to approach the involvement of the quantification of these environmental impacts and of health in the use of the energy and its environmental costs.

In the mid 90's the North American contribution ceased, due to regulatory differences with Europe. Meanwhile, more than fifty teams from fifteen European countries participated in the project improvement activities.

The growth of the acceptance of the ExternE Project methodology is due to the scope of the applications, which were originally developed for the energy section. The ExternE method has proved that it can supply useful advances for cost-benefit analyses in European environmental policy measures. It is methodology that encompasses the construction of the energy generating plant to the transmission lines, as well as the diseases, deaths, damage to the nature and agriculture, reduction of the vision field and other ecological damages.

From this methodology the monetary valuation of the external environmental factors described in the Tab. (3) was developed .

Table 3. External Environmental Factors - Project Expresses

Pollutant	US$ / ton of pollutant
SO_2	3770
NOx	2010
PM	1450
CO_2	120

The table above indicates that each ton of a certain pollutant in the atmosphere associates a monetary value. The responsible company should pay this value for the release of these pollutants that cause damages to the environment which the company is part of. Besides, this value differs for each pollutant, because the environmental impact caused by each one of them is different.

Since CO_2 has global affects, unlike the other pollutants mentioned in the table where the environmental impacts are local, it won't be included in the valuation.

The environmental costs association of the pollutants sulfur dioxide, particulate material and nitrogen oxides were attributed according to the following provisional equation:

$$V = A * H * E * C \qquad (2)$$

V - Environmental costs associated, (US$).
A – Evaluation Area, (m2).
H - Vertical height starting from the ground, pre-defined of 10 m.
E - Monetary value of the ExternE Project, (US$/g).
C - Average concentration for pre-selected intervals of time of each pollutant in the chosen evaluation area, (µg/m3).

The above equation was developed during the course of this study as a preliminary valuation method to be refined upon continued studies.

Each one of the 1152 areas generated by the simulation program was valued starting from its annual average concentration. For that, graphs were generated that illustrate the environmental costs in its respective valuation area using the MATLAB version 5.3 program .

To exemplify the valuation of the environmental costs the annual critical area cited in Tab. (3) was chosen , located 4109.92 meters northwest of the UTE facilities in Tab. (4).

Table 4 – Annual costs associated to each pollutant in the critical area:

Pollutant	US$
SO_2	0.13
PM	0.01
NO_X	0.25
TOTAL	0.39

The same procedure can be accomplished for other intervals of time such as: monthly averages, daily rates and hourly.

The association of the environmental costs, taking into account the monthly average, would have its critical area located 4109.97 meters northwest of the UTE, being the same critical area of the annual average.

Table 5. Monthly costs associates for each pollutant in the critical area

Pollutant	US$
SO_2	0.27
NO_X	0.50
TOTAL	0.77

The environmental cost associated to particulate material is not valued in this period; because the program obeys the resolution of the “National Ambient Air Quality Standard” promulgated by US EPA and it could only be analyzed in daily and annual averages.

For the daily average the critical area would be 6649 meters northeast of UTE with the following associated costs:

Table 6. Daily costs associates for each pollutant in the critical area

POLLUTANTS	US$
SO_2	1.48
PM	0.05
NO_X	2.73
TOTAL	4.26

In the same way as hourly average its critical area would be 17106.79 meters northeast of UTE and the following associated costs

Table 7. Hourly costs associates to each pollutant in the critical area

Pollutant	US$
SO_2	5.59
NO_X	10.39
TOTAL	15.93

The cost mapping was generated for each one of the 1152 evaluation areas of the dispersion modelling program by graphs using the program MATLAB version 5.3 following the same sampling time described above.

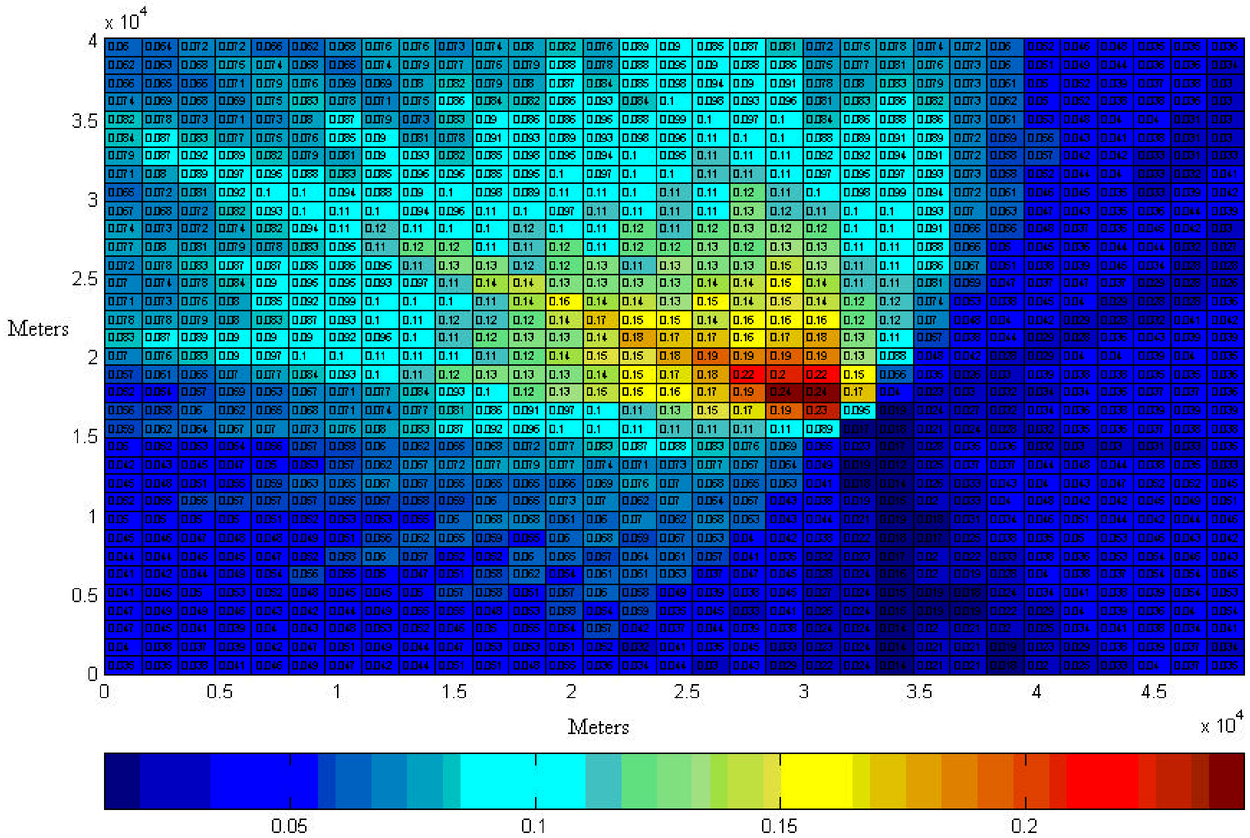

Figure 3. An example of the environmental cost mapping

The monetary values mentioned in Tab. (4) to Tab. (7) would be the compensation for the people exposed directly to the pollutant concentrations by the UTE. At the same time it is necessary to establish norms to define a period of fair time both for the affected people and the pollutant companies.

It is fundamental to perform the elaboration in an appropriate way so that the compensation really happens. Be it through social policies or discounts in the electric power bill, for instance.

These values can be implemented; therefore in this work only the pollutants concentration was taken into account, as done in a specific study of the city of Madrid (Lechón, 2002).

Other factors will be associated in further work, such as the pollutant deposits, the time of exposure, reduced life expectancy, among others, altering the final environmental cost for each evaluation area.

5. Conclusion

The environmental impacts of air quality are analyzed from the deployment to the electric generation of the power plants. These must respect all legislation in effect, selecting the applicable legal requirements regarding the protection and conservation of environmental resources, as well as the process of Environmental Licensing and of Operation License.

With the objective of minimizing these current environmental impacts of the UTE installation and operation, the fuel choice that causes less damage to the environment is providing a solution to assist meeting the standards demanded by the national environmental organs.

To monitor the pollutant emissions originating from combustion there are sensors installed in the exits of the gases, in other words, in the chimneys, that will measure the amount of CO, NOx, SOx and particulate materials, considered the most important pollutants, because they cause enormous damage to the environment. That data, added to the local meteorological data, is the basis for the dispersion modelling used by programs such as ISC AERMOD *View* that comes closest to reality.

Once the dispersion simulation was accomplished, the environmental costs of the main pollutants (CO, SOx, NOx and MP) were associated based on the European ExternE Project. The cost mapping was generated for each one of the 1152 evaluation areas of the dispersion modelling program by graphs using the program MATLAB version 5.3.

The monetary valuation of each evaluation area would be compensation for those people directly exposed to the pollutant concentration of the UTE. It is fundamental to perform the elaboration in an appropriate way so that the compensation really happens. Be it through social policies or discounts in the electric power bill, for example.

These values can be implemented; therefore in this work, just the concentration of the pollutants was taken into account. Other factors will be associated in further work, such as the pollutant deposits, the time of exposure, reduced life expectancy, among others, altering the final environmental cost for each evaluation area.

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