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GUIDELINES FOR EVALUATION OF THE ENVIRONMENTAL EXPENSE

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ABSTRACT

The main objective of this research is to establish guidelines to fit the Environment Account in the Nuclear Fuel Cycle, using as study of case the Uranium Hexafluoride Production Unit of Centro Tecnológico da Marinha in São Paulo. The Environment Accounting, branch of the accounting science, supply a source of tools capable to measure the protection efforts, the nature preservation, the environment monitoring and the recovering during all the Conversion phase (since the Uranium concentrated, the yellow cake, up to the Uranium hexafluoride production). It was performed several researches, visits to the Centre, databank creation, interviews and extensive consulting to the Preliminary Safety Report, in order to obtain the percentage of the total expenses related to environment protection in regarding to the total amount invested in the unit. It was also evaluated the total preserved green area making possible a preliminary environment accounting balance.

1. INTRODUCTION

Since the beginning the humanity utilizes the nature resources as infinite resources. From the middle XVIII century, with the Industrial Revolution in Europe, the pollution increasing has been noted. The perception that the nature degradation was causing injures to human health becomes evident in England, London region, due to an event in December, 1952. In this period, most of industries, mainly the ones related to electric generation to homes, used coal as fuel. The gases from the process, rich in sulfur, were released to the atmosphere causing a phenomenon called “smog” (smoke+fog) [1].

Due to the Environment degradation, companies feel obliged to incorporate the social responsibility to their objectives. The inclusion of environment protection to their objectives amplifies substantially the scope of the Accounting science, that can be applied in any activit field, including the nuclear one.

The accounting of all nuclear plants expenses, in order to not demonstrate negative impacts to the environment is demonstrated by the Social Balance, an instrument that permits to give transparency to the companies activities, supplying indicatives of economic, social and environmental performances.

The Accounting science, in its branch Environmental Accounting, supplies a group of tools that permit to measure all efforts of protection, conservation, recovering and monitoring of

the environment during the nuclear fuel cycle, which include several phases of the industrial process (Prospective, Benefit, Purifying, conversion, Isotopic separation, fuel element fabrication, irradiated fuel reprocessing and radioactive rejects treatments).

2. OBJECTIVES

To establish directives to the environmental accounting performance in the different steps of uranium processing, comprehensed since the uraniun concentrated dissolution (yellow cake) and the production of uranium hexafluoride (UF_6). An study of case of Unidade de Produção de Hexafluoreto de Urânio (USEXA), implemented by Centro Experimental de Aamar (CEA) do Centro Tecnológico da Marinha em São Paulo (CTMSP), has the objective to identify and quantify the environmental expenses.

3. THEORY SUMMARY

3.1. Environment

The environment is the group of elements biotype (alive organism) and anti-biotype (solar energy, ground, water and air) which integrate the Earth layer called biosphere, that supports ans is the alive organism home [2]. The perception of future regarding to the environment is not so clear. People must recognize that all resources are not unlimited. The impact of human activity on nature is comparable, according to some specialists, to the biggest catastrophes in the geological past of the Earth. The humanity must recognize that destroying the environment put in risk its own existence.

3.2. Environmental Accounting

Several scienses such as Economy, Law, Engineering and Adminsitration are already concerned to the environment reservation, and the Accounting, as a social science, presents conditions to give its contribution through the Environmental Accounting.

The people sense of Ecology has been affecting the companies' environment and raised in importance due to its importance in the people quality of life. For instance, some organizations have been creating a new administrative position in their structure with the responsibility to deal with all activities related to the environment. This new function and the conscience of this ecologic variable at the companies affect directly the private and public environmental properties [3].

The Environmental accounting has been a new branch of the Accounting science since February, 1998, with the final "financial report of the environmental liabilities and costs", released by the United Nations intergovernmental working group of experts on International standards of Accounting and Reporting – ISAR [4].

The Environment Accounting is one of the General Accounting branch such as: public accounting, financial accounting, costs accounting, banking accounting and others, as shown

on Figure 1, and must be applied according to its dependency and relationship to the activity or operation.

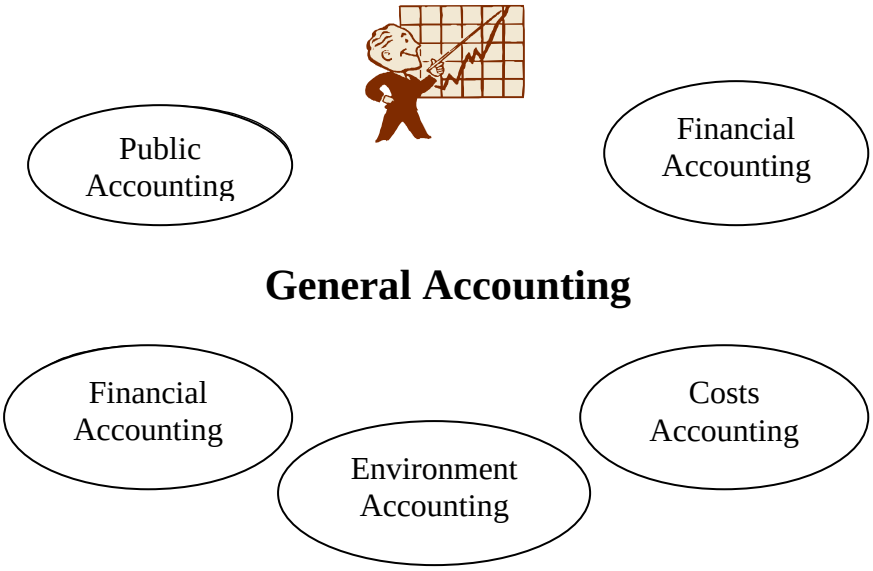

Figure 1 Accounting branches

3.1.1. Social Balance

The social Balance is a group of information from companies that justify to the society the reasons to their existence. A positive Cost X Benefit shows the a company adds some value to the economy and to the society due to the respect to the human rights and because their operational process is developed with no environment injuries [5].

The Social Balance idea started to be spreading out at the beginning of 70's. In 1977, it was approved in France, a law that makes mandatory to release this social information. Initially it was only used to supply information regarding to human resources, but with evolution of social responsibility, the added value concept, the Social Balance started to deal with how much the company was adding to the social environment economy where it was inserted. Following the dissemination of this concept of the sustained development, the rules of environment quality certification, the Social Balance starts to deal with some social aspects related to the Environmental preservation and conservation [6].

In Brazil, the proposal only gained national importance when the sociologist Herbert de Souza, known as Betinho, in June, 1997, launched a campaign to the voluntary publishing of the Social Balance. Supported and with the participation of Companies leadership, the campaign has been increasing and generating a lot of discussions at press.

One of most controversial points of Social Balance is to be compulsory. Some people consider it is necessary to impose the publishing of this kind of Balance and others defend that it should be a company choice. Ribeiro says that independently it is compulsory, by the social responsibility , the company which always look for profits must include in her objectives the society satisfaction. By society, it is understood investors, clients, government, employees suppliers and people in general. By satisfaction it is understood not only the product quality but the environment before, during and after the production process, safety and labor environment conditions and quantities and correct prices, it means all the product or service life cycle [7].

This is the main causative of several discussions, such as in academics space or in regulatory organization and support of accounting professionals. It includes an observation to the compulsory or not of the Environmental Accounting, because in most of countries there is no laws obliging the publishing of data regarding to the environment. The attention dispensed by the companies is a competitive factor and the Environmental Accounting application can and must occur independently of the existence of law that becomes it mandatory. None competitive advantage has been imposed as compulsory to the companies [8].

The Social Balance envolves information of social matter, pointing out some values: Added value, Human Resources, Environmental an Benefits to the Community.

4.1. Nuclear Fuel Cycle

Nuclear Fuel is all the material that contains a fissionable fraction and which is possible to be used in a nuclear reactor to generate electrical energy or in a reactor used in researches to obtain the neutron flux adequate to produce radioisotope or to the materials analysis. For everything is necessary to keep a chained reaction, using the Natural Uranium or riched one, or even the fissile material obtained in others reactors, such as ^{233}U e ^{239} Pu.

The production of nuclear energy requires more than a steam system per nuclear reactor, it must be associated to a generator turbine in order produce electric energy from the heating created by the nuclear fission. All the process steps must be specified because each one involves different technologies, since economics aspects through safety and environmental [9].

The nuclear fuel is an essential part of an efficient and safe operation of nuclear reactors, then safety, confidence, economy and quality are closely characteristics of the nuclear fuel.

To use Uranium as the nuclear fuel in electricity generator plant is necessary several processes of transformations chemical and physical since the production of the gross mineral, reactions in the reactor till its final disposition in the nuclear fuel cycle [10]. The Figure 2 presents the simplified diagram of the Uranium process, since the gross mineral up to the uranium hexafluoride production.

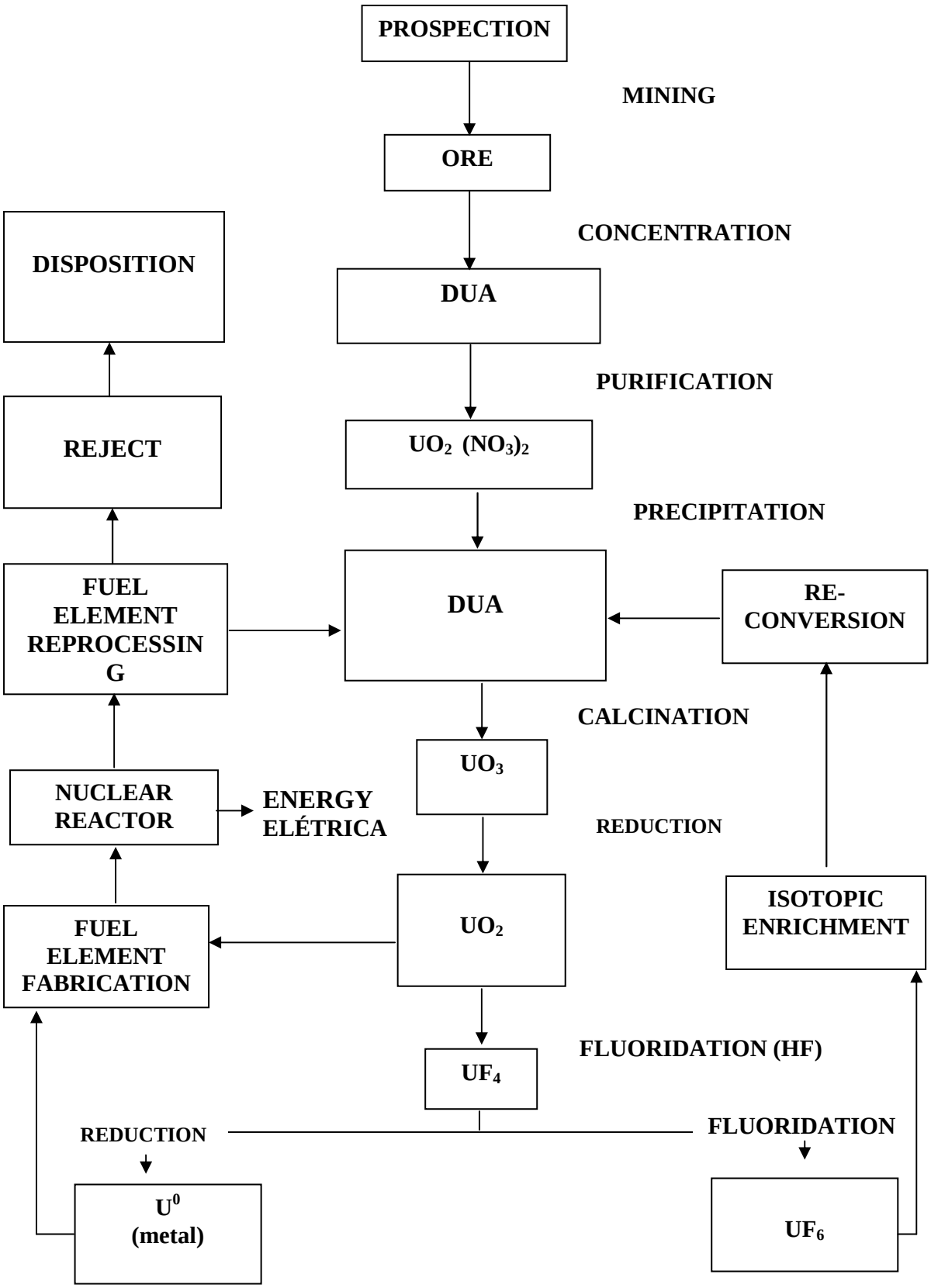

Figure 2. Nuclear Fuel Cycle

4. METHODOLOGY

Several sources of information and different database regarding to the environmental, chemical and accounting areas were consulted to compound the methodology of this research. A history database of the company was compiled; several interviews with the project design staff were made; the Preliminary Safety Analysis reports was consulted; the use of environmental accounting in nuclear fuel cycle at conversion step; visiting to Centro Experimental de Aramar and finally, the USEXA case study.

5. EXPERIMENTAL DEVELOPMENT

The first step pf the nuclear fuel cycle is the production of nuclear pure Uranium hexafluoride known as “yellow cake”. In the past, this production was obtained from mines in Poços de Caldas city in the Minas Gerais state, supplying all he necessities of Angra I power plant and all technology researches phases. Nowadays, most part of Uranium production comes from *Caetité* city in Bahia state, where the Brazilian Nuclear Industries (INB) explores Uranium from the *Lagoa Real* mine [11].

The nuclear material to be used as raw material in Uranium concentrate composed basically by ammonium diuranate (DUA) and impurities. Since a group of chemical processes, this material is transformed to Uranium hexafluoride (UF_6). After that, the product in enriched by the isotopic separation process by the ultracentrifuging method in plain operation in Brazil.

Then the product is reconverted in Uranium dioxide to permit the pastille fabrication, it means fuel elements that will integrate the nucleus of a nuclear reactor. The UF_6 technology production implementation in industrial scale is an important part of the national effort to obtain full knowledge of the complex fuel cycle production. The technique to obtain UF_6 in laboratory was already developed in Brazil and the industrial scale production is the next step pursued.

The Brazilian Navy Technology Center in Sao Paulo is implementing in the *Centro Experimental de Aramar*, the uranium hexafluoride production unit called USEXA, and this will be study of case in the present research.

The USEXA is composed by a complex of buildings where are installed the processes units. Figure 3 illustrates the processes units:

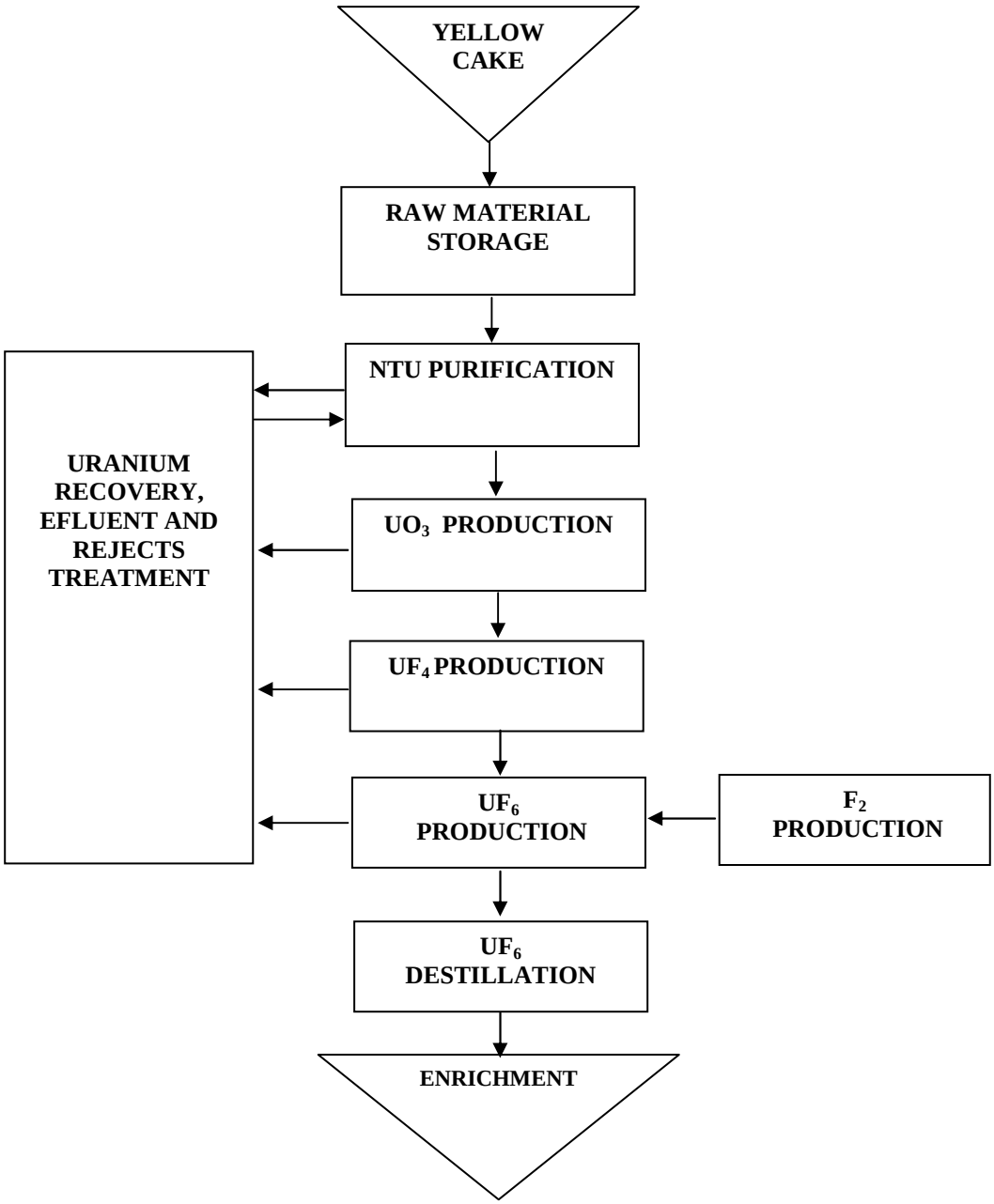

Figure 3. Process Simplified Diagram

The research started during a visit to the USEXA installation and it was collected several information from the company's database, several interviews with technician and management staffs and several consulting to Preliminary Safety Report Analysis (RPAS).

The first visit to the USEXA was very important to observe the installations, equipments and all the area occupied by the plant, and gave us the possibility to understand the processes of a Uranium hexafluoride production plant. Later on, several others visits were done to validate the obtained data and to better understand the rejects and effluents treatment units.

The USEXA keeps an historical databank since the beginning f the Company's work, which permitted to obtain all the information included in this research. From this databank the expenses with the Environmental safety were identified. The expenses related to the Individual Safety Protection were excluded because they are imposed by labor laws and the objective of this work is to obtain, purely, the Environmental expenses of this project.

The used criterion was to find a relationship among the databank registration and several items: RPAS, suppliers, rejects, effluents, permissions and uranium treatment. The obtained data were based on the dollar conversion due to several monetary unit changes and the inflation that occurred in the Country the USEXA project has started; so this method permitted to obtain the percentage of expenses related to the rejects and radioactive effluents treatment and recovering. Each data collecting permitted to create tables and submit them to specialists for validation. Some information were compromised due to the lack of details during historic registration related to the environmental aspects. The databank has more tan 10,000 registries, stored up to year of 2007. All of them were analyzed, separated and checked by specialists in order to obtain an estimate of the environmental protection expenses compared to the total project ones.

After the collecting of the direct expenses related to the environment at the USEXA project, other indirect expenses were also raised. They are all the ones USEXA contributes at *Centro Experimental de Aramar* in their projects and environmental programs.

All the data were obtained by the interviews at the *Coordenadoria de Infraestrutura e Gestão Ambental* (Environmental Quality Engineering) and in the Radioprotection and Environmental control Department. It was estimate the expenses of the main environmental projects and programs e by some established criteria it was possible to estimate and attribute to the USEXA, its contribution parcel referred to indirect environmental expenses.

6. RESULTS AND DISCUSSIONS

It is important to point out that the biggest difficulties to compile all environmental expenses data from USEXA were the information analysis stored. The analysis and interpretation of the data were very difficult because they have been compiled from 1986 to 2007, and during this period several changes in the Brazilian monetary system occurred besides several changes in the project.

6.1 Environmental Expenses not Shared with Centro Experimental de Aramar (CEA)

The USEXA project has mainly in its Uranium treatment unit, the environmental expenses not shared with CEA. They are associated only to the project of the Uranium hexafluoride pilot plant.

Table 1. Environmental Expenses not Shared

Project Amount	Criterion	Environmental Expenses not shared
U$$ 44.000.000,00 R$ 76.000.000,00	Identificationon the environmental expenses databank	U$$ 2.300.000,00 R$ 4.066.000,00

The criterion adopted to calculate the environmental expenses amount not shared in the USEXA was the consulting and analysis of the historic databank of the company. The amounts was obtained in dollars and converted to Real based on the quotation obtained from the Brazilian Central Bank dated from March, 27th, 2008 [12]. The environmental expenses defined by this method, reached 5.35% of the total project amount.

6.2 Environmental Expenses Shared

To attribute to USEXA its parcel of contribution related to the shared expenses of the projects and programs existing in the *Centro Experimental de Aramar* a criterion of proportional distribution was adopted.

6.2.1. Environmental Impact Study and Environmental Impact Report (EIA and RIMA)

The Study of Environmental Impact and its respective Environmental Impact report were performed to be used in CEA and all the expenses are shared by all the nuclear installations implemented there.

The total amount obtained for EIA and RIMA was Cr$1.770.000.000,00 (related to December, 18th, 1992), which updated and corrected by the IGP-DI from FGV [13] represents an amount of R$ 930.000,00.

The criterion to establish the distribution to obtain the contribution from USEXA in the total environmental expenses shared, was to divide the total amount obtained by the main five nuclear installations in the CEA. It is important to point out that the adopted criterion is justified because, independent of the size or complexity, for any of the five installations to be licensed it would be necessary the EIA/RIMA elaboration as requested by the CONAMA Nº 001 from January, 23rd, 1986.

6.2.2 Integrated System of Aramar Efluent Treatment (SITEA)

Considering the area where CEA is implemented and al activities developed, there is a great worry to the generated effluents releasing to the environment. The treatment of such effluents is necessary in such way that permits the reutilization or releasing observing the required standards. The SITEA has the objective to treat the liquid effluents generated in all the several industrial installations of the CEA.

The SITEA is sized to treat up to 20 m^3 of effluents per hour. Considering Operational cycle, water demand and effluents generation in each installation, the daily volume of effluents generated during the processes is 8.2 m^3.

The criterion of distribution used to obtain the USEXA contribution in the shared environmental expenses of SITEA was the rate of flow in m^3/h, transformed in m^3/day. The total amount of the SITEA project was divides by total rate of flow installed and multiplied by 8,2 m^3/day from USEXA.

6.2.3 Monitoring Lagoon

The effluent treated in the Integrated Effluent Treatments System of Aramar is sent to a Monitoring Lagoon or it is recycled in the CEA installations. The lake has the objective in monitoring the effluent before its releasing to the receptor, and released from that after a environmental control.

The criterion of distribution used to obtain the USEXA contribution of the environmental expenses shared in the monitoring lagoon was the same adopted at the SITEA, it means, dividing the total amount of the project by the total capacity (430 m^3/dia) and multiplying the result by 8,3 m^3/dia from USEXA.

6.2.4 Drain Treatment Station (ETE)

The Drain Treatment Station is a treatment unit that adopts the aerobic process to treat the sanitary drais of CEA installations.

The USEXA contribution related to the environmental expenses shared to the Drain Treatment Station was estimate from the total amount of the project divided by the number of installations to be installed at CEA (24 installations), since the station was constructed to serve all the units, conventional or nuclear.

6.2.5 Drain Collecting Net

The drain collecting net belongs to ETE, is part of the project and has the objective to treat the drain from all the units of the CEA.

The adopted distribution criterion to establish the USEXA contribution related to the shared environmental expenses of the drain collecting net was the same used to the drain treatment station, dividing the total amount of the drain collecting net by the total number of installations foreseen to the CEA.

6.2.6 Degraded Areas Recovering Services

The degraded areas recovering is based on replant native vegetation including fruit and ornamental trees, preparation of the ground and specialized man power.

The estimate amount represents the present expense of the project considering besides the environmental degradation due the human occupancy, the degradation due to burnings, storms, winds and floods. In most cases, the degradation is resulting from the construction of buildings installations and so, the recovering is associated to the proper unit.

The criterion of distribution to the recovering of degraded areas was divide the project amount by the number of foreseen installations in the CEA.

6.2.7 Radioecologic Laboratory (LARE)

As per RIMA(1997), the activities of the Division of Radiology and Environmental Protection, which includes LARE, objective to monitor the operation and implementation effects of the CEA activities over the environment and to provide radiology protection by means of radioactive material releasing controls; evaluation of individual exposition to radiation; compliance of radioprotection rules; detection of environmental changes and monitor the reject and effluents treatment efficiency. Its activities also contemplate the periodic collecting, processing and analysis of samples from the main sources of contamination (air, surface waters, water wells, water from rains, samples from bottom of rivers, ground vegetation, products from agriculture, fishes and milk), to determine the radioactive element concentration.

Monitoring the activities on environmental point of view is demanded by CNEN, independently of the number of existing installations. Therefore, the criterion of distribution adopted was divide the total project amount by the number of nuclear installations and conventional installations (consider as one installation) foreseen to operate in the CEA (six installations).

6.2.8 Meteorology Observation Station

The air quality control is performed by a meteorological tower with sensors of temperature, wind direction and speed, pressure, humidity and rains. This control permits follow up of the local weather to support the usual, emergency and accidental releasing to the atmosphere of the installations of CEA. No operational and maintenance costs were considered to calculate the costs.

The station is an environmental exigency from CNEN, since that any nuclear installation needs of permanent monitoring. So, existing one or more installations at CEA this exigency will always exist. In this way, the criterion to calculate the contribution of USEXA relative to the shared expenses related to the meteorological observation was dividing the total amunt of the project by the number of main nuclear installations (total of 5).

6.2.9. Summary of Shared Environmental Expenses

Table 2. Summary Table of Shared Environmental Expenses

Project/Environmental Program	Estimate Amount	Distribution Criterion	Distribution Criterion Definitions	Shared Environmental Expenses
EIA e RIMA	R$ 930.000,00	5 installations	05 nuclear installations	R$ 186.000,00
SITEA	R$ 2.630.000,00	m^3/day	value x 8,2 m^2 / 480m^3/day	R$ 45.000,00
Monitoring Lagoon	R$ 200.000,00	m^3/day		R$ 3.500,00
ETE	R$ 800.000,00	24 installations	05 nuclear installations 19 conventional installations	R$ 33.334,00
Drain Collector Net	R$ 200.000,00	24 installations		R$ 8.334,00
Recovering Services	R$ 23.000,00	24 installations		R$ 959,00
LARE	R$ 4.460.000,00	6 installations	05 nuclear installations 01 conventional installations	R$ 744.000,00
Meteorological Observation Station	R$ 250.000,00	5 installation	05 nuclear installations	R$ 50.000,00

6.2.10. Green Area

The CEA is located in a property donated to the Brazilian Navy and was part of the Ipanema National Farm, in Iperó city – São Paulo state.

The calculation of the CEA green area as done subtracting the total possible occupied area from the total area.

(+) Total Area = 8.603.000,00m^2
(-) Possible Occupied Area = (1.277.000,00m^2)
(=) Green Area = 7.326.000 m^2

The quotation to an area in this region, with occupied area equal tp 4.5% of the total area is about R$ 22.32/ m^2 [14]. This value is adopted as the quotation to this region. It is important to point out that the improvements (constructions) implemented increases the price for square meter. For CEA case the occupied area is 14,8% , that would increase the property according to other quotations obtained from other electronic addresses [15].

To put value on CEA green area, it was multiplied the value for square meter by the preserved green area: 7.326.000 m^2 X R$ 22,32 = R$ 163.516.320,00

In this case, the active is considered as a whole, avoiding the fragmentation among the different units of CEA. The sustainability gains importance when the preserved area contains a high number of species due to its dimension.

6.3. Environmental Balance

The Environmental Balance tries to demonstrate how mch the company is investing in the Environment. It is presented in table 3.

Table 3. Environental Balance of USEXA

Description	Value	% in relation to the total Project (R$ 76.000.000,00)
1. Environmental Expenses not shared	R$ 4.066.000,00	5,35%
2. Environmental Expenses shared	R$ 1.041.127,00	1,37%
3. Total (1+2)	R$ 5.107.127,00	6,72%
4. Environmental Active (Green area preserved)	R$ 163.516.320,00	215,15%

3. CONCLUSIONS

The present work studied the environment expenses of USEXA. The project has been developed at CEA (Iperó-SP) by the *Centro Tecnológico da Marinha em São Paulo.*

The percentage obtained from expenses integration, along more than 20 years, shows a value of 6,72% from the total amount foreseen to the project. This result is a pure number, since it was not considered the expenses regarding to individual Protection Equipments as they are mandatory by labor laws, and the objective of this work is to obtain environment expenses of the project.

Another factor to be pointed out is the environment active represented by preserved areas at CEA, that means the value increasing of the properties of the region [16], it means that the company adds benefits, independently of the marketing transactions [17] and must be presented in the Social Balance as a factor of competitively [18]. In Brazil, Environmental Accounting is in evolution, opening several opportunities to discussions since this practice is not regulated yet [19].

So, curiously, the biggest Usexa patrimony, or even from the CEA, is the preserved area which in the marketing terms represents more than 200% of the industrial investment. It is a reason of proud for any institution that wants to adequate to modern time, when the the environment preservation is a crucial question. Nowadays, Brazilian consumers, in more than 52%, make option for products ecologically rights despite of others. Som studies foresees that quickly more than 78% of consumers wil have the same actitude[20].

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