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ENVIRONMENTAL EDUCATION AND MANAGEMENT (COMBUSTIBLE WASTE): A SUSTAINABILITY APPROACH

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"Human truth is not nature's truth!"

Abstract: The current situation of the planet and the environment, affected by problems such as the high rate of emission of greenhouse gases (GHG), high amounts of waste and global warming, to mention just a few problems, demands, in the current context, an awakening from human consciousness to environmental problems. This fact imposes cultural, ethical and professional changes in societies. This article is the result of the mini-course on Environmental Education (EA) and Environmental Management (GA), given by the authors to the Department of Logistics of the Armed Forces of Angola (FAA), due to the need for the course and the theme in the corporation, which handles fuel and other waste. The objective was to discuss with the corporation the relevance of the theme, taking into account the sustainability criteria within the current context of environmental crisis and the scope (in the FAA and at the national level), in order to have knowledge about the characteristics and treatment of the waste and associated GHG emission levels, in particular, the characteristics and emissions of fuels, whose utility is diverse and GHG emissions occur at various stages of the life cycle. It was considered important to inquire about the emissions of these residues in order to learn how to deal with and mitigate the associated negative environmental impacts. The method adopted was qualitative and illustrative, based on the bibliographic review, and the materials used were the bibliographic references on the subject, with emphasis on EA and GA books.

Keywords: Environmental education. Environmental management. Fuel-waste. Greenhouse gases. Sustainability.

INTRODUCTION

The phrase "The earth is blue" became the slogan of environmentalists after humans were able to observe the earth for the first time. What was seen on the planet, from the heights, were clouds, seas and portions of land. In the last decades, although it is still possible to see the clouds, the seas and portions of land, the landscape of the planet is seen with numerous buildings and some evidence of damage to the flora, and science confirms the existence of significant amounts of gases that cause damage the ozone layer and put the planet and human health at risk (BIDONE, 1999; VAZ DE ALMEIDA, 2020).

Land has been converted into the largest waste deposit and human action continues to degrade the main source of productive resources, the land (VIEIRA, 2015). This process of land degradation took ungoverned proportions from the industrial revolution, where services became mechanized and the demands for the means of production demanded a greater exploitation of the resources in the land, putting at risk the availability of resources, the quality of life on earth and environmental sustainability (PRADO, 2014; VIEIRA, 2016; GOTTI; OLIVEIRA DE SOUZA, 2017).

As a result, in recent decades the world has been facing several problems: social (demographic growth and the multiplication of solid waste, open sewers); environmental (destruction of fauna and flora, irrational use of resources, increase in GHG emissions into the atmosphere and global warming); economic (high costs for implementing environmental education programs and low carbon technologies, degradation of nature and the environment whose restoration requires economic planning), among other problems. Since, human beings have been identified as the main cause of these problems, in particular, the problem of contamination of the environment and climate change, due to human activities and their dependence on fossil fuels (REGIS; BUNCHAFT; SAMPAIO DE ALENCAR, 2009; MFUMU, 2021).

In the search for solutions, the so-called "green movements" were created and several social groups alienated from the theoretical foundations of different philosophical currents, which seek solutions such as environmental education and management, within the academic perspective, to solve environmental problems such as the rescue fauna, flora and all biodiversity (REGIS; BUNCHAFT; SAMPAIO DE ALENCAR, 2009; MFUMU, 2021). However, the environmental movement, which defends the conservation of the environment, the quality of life and the possibilities of a long life, has not yet managed to respond to all the environmental problems caused by human beings (REGIS; BUNCHAFT; SAMPAIO DE ALENCAR, 2009; DRA, 2012; VAZ DE ALMEIDA, 2020), mainly those caused after the industrial revolution, such as the increase in production and population, the exploitation of resources, pollution and the generation of greater amounts of waste in a way much higher than the natural absorption capacity. of the land (VIEIRA, 2015).

Currently, environmental management is applied, but the environmental discourse is very focused on Cleaner Production (P+L), through the application of modern and low-carbon technologies discussed in 2015 in the Paris Agreement during the climate negotiations (TOLMASQUIN, 2016), although in this process solid waste and the rational use of energy are still neglected, which are an old problem for humanity, particularly in capitalist countries where the imposed development for a consumerist and inconsequential society is encouraged (BIDON, 1999). ; VAZ DE ALMEIDA, 2020). Because of this, many of these countries refuse to sign the Kyoto Protocol.[1], which recommends the reduction of GHG emissions, attention to global warming, sustainable economic and social development and the exploration and use of ecologically friendly energies.

According to Prado (2014), energy is vital for human subsistence, but energy can be used observing social, economic and environmental issues in order to maintain quality of life. The author argues that it is essential to grow in a sustainable way when one does not want to stop economic growth, and many problems can be minimized through awareness, rational use of resources, application of GA and dissemination of EE in educational institutions, in organizations and in the media channels of wide coverage and impact.

However, the permanent problem that has affected humanity with regard to environmental issues such as climate change, waste (solid and fuel), garbage, use and flows of petroleum derivatives or not (energetics), has evidenced the lack of education environment and the precariousness in the implementation of environmental management.

ENVIRONMENTAL EDUCATION AND ENVIRONMENTAL MANAGEMENT

ENVIRONMENTAL EDUCATION (EA)

First, it is important to understand that the environment does not represent only nature, but also culture and vice versa. It is a process in which the human being, as the main driver of changes and development in society, is capable of modifying the environment, but also being modified by it. This situation expresses a joint relationship that involves society, human education and the preservation of the environment. Figure 1; illustrates this relationship from the interconnected parts in the image, and highlights EA's straightforward commitment to sustainability.

1. The Kyoto Protocol or Kyoto (1997-2005, signature and force), is an international treaty that takes care of serious commitments on the reduction of GHG emissions and the problem of global warming

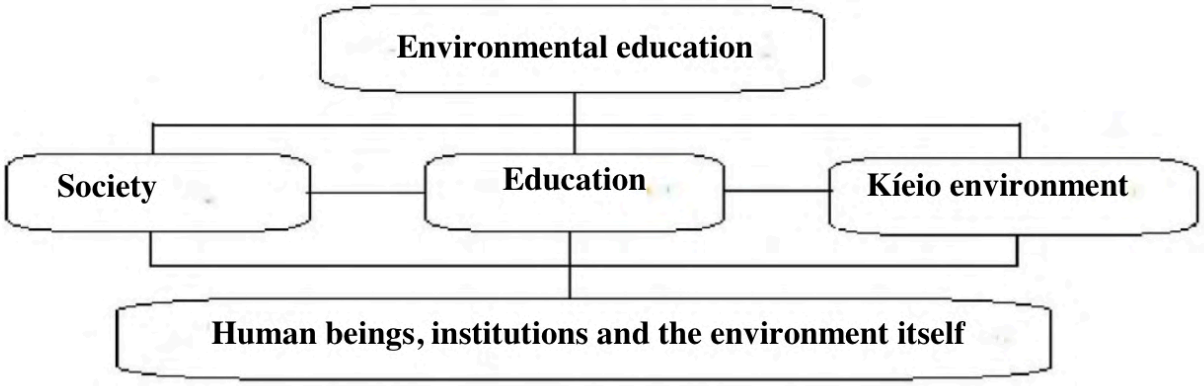

Figure 1 - Environmental education and its relationship with society and the environment.

Source: author's elaboration.

Environmental education is a multidimensional social field related to ecological aspects, the conservation of resources, economy, sustainability and the relationship between society and the environment, in which it seeks to find and promote solutions to environmental challenges. It involves reduction, reuse and recycling programs, known as the 3Rs campaign (BIDONE, 1999; REGIS; BUNCHAFT; SAMPAIO DE ALENCAR, 2009; VAZ DE ALMEIDA, 2020). Being that:

- Reduction; consists of reducing the quantities of waste produced. More explicitly, it can be said that it is a preventive attitude that allows conscious consumption and avoids the production of unnecessary inputs and, consequently, a lower production of waste.
- Reuse; consists of reusing materials for other uses. This process avoids unnecessary discards in nature and early recycling.
- Recycling; consists of transforming discarded materials or waste into raw material to produce new materials. It is the last step that you must take after you can no longer reduce and reuse. It's transforming the old into the new, it's redoing the production cycle.

Some authors such as Bidone (1999) and Prado (2014) consider that EE helps to create awareness about the economy of energy resources and its applicability (EE) is essential in society. In Table 1; Some objectives and benefits of environmental education are briefly presented according to the perspective of the authors mentioned above.

ENVIRONMENTAL MANAGEMENT (GA)

Environmental management is a set of measures, guidelines and administrative and operational activities such as planning, direction, control and allocation of resources, adopted by business management to avoid or reduce, as far as possible, environmental problems (GOTTI; OLIVEIRA DE SOUZA, 2017). It is associated with the elaboration of environmental policies, measures and social transformations, in particular, in the industrial sector, with the objective of maintaining environmental security and reducing economic and environmental impacts resulting from technological projections and humanity's energy demand.

This implies the correct and non-

Environmental education	
Goals	• Alert and raise awareness about the systematic processes of environmental education • Make understanding and responding to problems involving the relationship • To understand the mechanisms that govern the natural system • Make the human being responsible as the protagonist of the guarantees and maintenance of the planet Give competence and citizenship through active participation in the rescue and promotion of ethics, reconciling nature with culture
Benefits	• Reduction of waste • Maximizing the efficiency of generating units and savings for consumers • Improved use of natural resources (reduction and recycling) • Efficiency and effectiveness in distribution logistics with less environmental impact • Disclosure of penalties and application of restrictions on non-compliance with rules or inappropriate use of resources
Challenge	• The big challenge is the lack of a clear notion about sustainability and the lack of knowledge and disrespect for environmental issues throughout the process and not just in occasional situations (the challenge is a cultural trail, without social competitions; thought, action and citizenship)

Table 1 - Objectives and benefits of applying environmental education in society.

Source: author's elaboration.

conflicting maintenance of legal texts for the protection of nature, the improvement of the industrial technological system, review and optimization of production processes in accordance with environmental standards, licensing, changes in consumption patterns, application of P +L, evaluation of energy transport methods and the preservation of the environment from the monitoring of emissions of polluting gases into the atmosphere.

The areas of resource management, risk management, handling environmental accidents and recovery of environmental liabilities, represent a matter of vital importance to direct technological and sustainable development. This approach includes behavioral changes in energy users, the implementation of better energy management systems, the promotion of political actions, environmental self-management and the dissemination of more efficient technologies and the application of research and development programs.

Any change in the environment has repercussions on society and needs to be addressed in the legislation so that there are management strategies for the exploration and production processes, as well as the appropriate inspection or environmental control measures (GOTTI; OLIVEIRA DE SOUZA, 2017; PRADO, 2014).). In this context, GA takes care of the elaboration and applicability of the norms that guide the adequate planning of administrative and operational guidelines, aiming at the improvement of environmental conditions in organizations (GOTTI; OLIVEIRA DE SOUZA, 2017).

The improvement of these environmental conditions can be done through the implementation of P+L in organizations, eco-efficiency, risk management, accident prevention, waste treatment and the implementation of an environmental management system (EMS) in organizations that, requires prior audits and enables organizations to obtain environmental

Environmental management system	
Topics	**Dimension**
Environmental management models	Spatial (Area): local, sectoral
Risk assessment and management	Thematic (Delimitation): for air, for water
Environmental audits and certification process	Institutional (Agents): for company, for society

Table 2 - Topics about the environmental management system and its dimensions.

Source: author's elaboration.

certifications. In Table 2; some topics about the environmental management system addressed in the companies that make up the environmental management are presented.

It is important to understand that waste is a combination of combustible and non-combustible materials. They have chemical and biological properties (BIDONE, 1999; DRA, 2012; VAZ DE ALMEIDA, 2020).

WASTE (FUEL AND NON-FUEL)

PROPERTY OF WASTE (CHEMICAL AND BIOLOGICAL)

Chemical properties can be:

- Hydrogen Percentage (pH); explains on a logarithmic scale the acidity, alkalinity or neutrality content of the residue, which is generally in the range from 0 to 14, in which 7 is the neutral point, below 7 the acidity and above 7 the alkalinity (REGIS; BUNCHAFT; SAMPAIO DE ALENCAR, 2009; VAZ DE ALMEIDA, 2020). The pH is important in the composting processes, measurement of the granulometry of the residues, measurement of humidity and temperature.
- chemical composition; consists of the determination of carbon, ash, phosphorus, potassium, calcium, fats, mineral and soluble residues.
- Carbon/nitrogen ratio; indicates the degree of composition of the organic matter.
- Calorific value; is related to the waste combustion process, that is, the ability to release heat when submitted to burning. It can be lower or higher calorific value, the difference being the final state of the mixture of combustion gases and water vapor that is formed in the burning of the hydrogenated substance. In practice, it is the amount of heat given off during the combustion process of 1 kg of waste (SAVI, 2005).

The biological properties are related to microorganisms such as fungi and bacteria present in the waste and which are responsible for the decomposition of organic matter and also pathogenic organisms such as bacteria, viruses, worms and protozoa that are potential causes of disease in humans.

WASTE CLASSIFICATION

According to Presidential Decree 190/12, in its article 4, due to its chemical and biological characteristics, waste is classified into:

- Dangerous; those whose characteristics may be flammable, corrosive, reactive, toxic and, due to other characteristics, they present a risk to human health and the environment.
- Non-hazardous; those whose characteristics are not similar to those described above. They can be commercial or sector solid waste (originating in

commercial establishments or derived from industrial activities, but which do not exceed the daily volume of 1100 liters and cannot be deposited or treated as urban solid waste); hospital, domestic, special waste (packaging, paper, equipment), among others, which can be collected and treated.

TRANSPORT OF WASTE

The transport sector represents more than 20% of total energy consumption in industrialized countries and more than 14% of total energy consumption in developing countries (PRADO, 2014).

Transport is a mechanical process carried out by compact or non-compact means, from the point of generation to the point of final disposal. Transport allows the confirmation of the quantities produced, the recognition of flows from origin to destination, the identification of agents with whom dialogue must be established and participation in the logistical process. These agents must have specific training and be certified in accordance with the regulations of the Ministry of the Environment, they must be instructed on the correct packaging of the waste and the correct use of the equipment necessary for emergency situations, accidents or breakdowns and the working conditions must comply the precepts of hygiene and safety at work (DRA, 2012).

Deposition sites must not be more than 25 km apart, for economic and safety reasons. In case of significant volumes, it is recommended to build transfer points. The transport, loading, unloading, transshipment, cleaning and decontamination operations of hazardous waste must consider the risks associated with the nature of the service, with safety materials such as safety panels and risk labels marked according to the corresponding classification and type. risk, emergency equipment, periodic inspections, among others, must be used and applied in the means of transport and/or waste storage equipment.

For example, vehicles transporting fuel or hazardous waste must avoid using roads in densely populated areas, environmental protection areas or water reservoirs or close to them, and the itinerary must be programmed in ways that to avoid risks of accidents on roads and at times of greater traffic (DRA, 2012).

CHARACTERISTICS OF HAZARDS ATTRIBUTED TO WASTE

- H1: relating to explosives; substances that may explode under the effect of a flame, or substances sensitive to friction and shock.
- H2: relating to fuels; substances that, in contact with other flammable substances, present a strongly exothermic reaction.
- H3: referring to easily flammable waste; substances or preparations, in a liquid state, the flash point of which is below 21°C, and which can ignite or heat up at normal temperatures and pressures.
- H3B: referring to flammables; liquid substances and preparations whose flash point is equal to or greater than 21°C and less than or equal to 55°C.

Other classifications and characteristics, referring to corrosive, irritating, ecotoxic, mutagenic, infectious, harmful, carcinogenic substances or preparations, among others, can be consulted in Presidential Decree 190/12 of 24 August.

The authors Gotti and Oliveira de Souza (2017) propose some technical solutions to reduce emissions in the transport sector: improvement of thermal efficiency, improvement of mechanical efficiency, use of alternative fuels to diesel and gasoline and improvement of technologies with gas turbines. for vehicles (although this proposal still falls short of reality because of technology prices and other inconveniences).

REGULATION AND RESPONSIBILITIES IN THE NATIONAL CONTEXT

Angola is a developing country, because of this, activities of industrialization, resource exploitation, national reconstruction, among other activities, take place in it, which do not distance it from the current pressures exerted on other countries in the world, regarding the form of exploitation of natural resources and the emission of gases that cause the greenhouse effect and cause global warming. As a result, the Angolan government considers it necessary to adapt to the global dynamics and adopt internationally established measures for good practices in the exploitation of natural resources, reduction of harmful gas emissions and conservation of the environment in the process of national development, as well as the promotion of the quality of the environment in the national territory in order to guarantee the country's sustainable economic and social development.

The regulation of waste management in the national territory is based on Presidential Decree 190/12 of 24 August, pursuant to subparagraphs b) and i) of article 120 and paragraph 3 of article 125 of the Constitution of the Republic of Angola (CRA), and the decree establishes the general rules of production, deposit in the soil or underground, release into the water or the atmosphere, treatment, collection,storage and transport of any waste, import and management of gaseous, liquid and solid pollutants (Law 5/98, of June 19, Environmental Bases), except for those of a radioactive nature or subject to specific regulations.

The regulation is applied to natural, legal, private or public persons who carry out activities likely to produce waste or involved in waste management and is applied to all types of waste existing in the national territory.

The Minister of Culture, Tourism and Environment (MCTA) is responsible for approving the rules that ensure the applicability of this regulation and, in case of doubts and omissions, the problems are resolved by the President of the Republic, under the terms of the CRA.

In Angola there is the Basic Environmental Law 5/98, of June 19, approved by the Ministry of Urbanism and Environment (MINUA), currently MCTA, which contains general guidelines on environmental management. It is considered as the Law of the legal framework of the most specific laws, among which is included the Law of Environmental Defense Associations, approved in 2006. Therefore, Angolan citizens can communicate to local government authorities and/or on environmental problems in the country, according to Decree nº 51/04, of June 23, on Environmental Impact Assessment (DRA, 2012; VAZ DE ALMEIDA, 2020). There is also the National Program for Quality and Environmental Standardization (DRA, 2020), created in 2016 and approved in 2020 by Presidential Decree No. 125 of the CRA, with the aim of raising awareness and mobilizing economic agents that exploit natural resources and the public power, participatory management, the promotion of sustainability, protection and ensuring the preservation of the environment. Among several guidelines, the program regulates the waste transport and treatment processes (fuel spillage, creation of fuel transport lines) in the exploration and storage areas.

This program also includes diplomas and all standards on company certification processes and the application of good practices in education, management and environmental conservation. The technical standards of this program are described in the Strategic Program for New Environmental

Technologies (PENTA), which serves as an orientation guide on the legal and institutional provisions that condition any implementation, operation, expansion or regularization of undertakings in the MCTA SGA.

The MCTA, the Municipal Administrations and the Communal Administrations, are the legal authorities and managers of waste in Angola. It is incumbent upon the MCTA to disclose the mandatory compliance rules on the procedures to be observed in the management of waste, carry out licensing, accredit operators and carriers. The Municipal and Communal Administrations are, according to Decree 02/07 of 28 August, responsible for promoting sanitation and environmental management, in particular the management of local waste (DRA, 2012; DRA, 2020).

It is pertinent to reinforce the understanding that waste is a combination of combustible and non-combustible materials. The focus of this mini course is fuels; usefulness, composition, hazard, effects on the environment, levels of greenhouse gas (GHG) emissions such as carbon dioxide (CO2), methane (CH4), nitrogen oxide (N2O), among others.

COMBUSTIBLES

Fuels are energy sources that serve multiple uses such as generating electricity, driving internal and external combustion engines, domestic use, among other utilities. Generally, these energy sources derive from petroleum, in the specific case of fuel oils, diesel, gasoline and, in other cases, they are associated or not with petroleum, as is the case of natural gas. Other fuels, such as coal, biomass and uranium, are found and exploited in nature in processes other than petroleum refining, but they have some similar utilities to those derived from petroleum.

However, despite their usefulness, (fossil) fuels have been identified as the main cause of environmental pollution, global warming and climate change, as they are associated with GHG emissions, such as CO2, CH4, N2O, organic compounds not metals and emissions of other particulate materials composed of ash and dust in suspension, which affect the quality of air in the atmosphere (VIEIRA, 2016; MFUMU, 2021). In Table 1; some GHGs and their characteristics are presented.

The GHG emissions from these fuels can be estimated using methods (emission factors from the Intergovernmental Panel of Climate Change - IPCC or Life Cycle Assessment - ACV), governed by the standards of the International Organization of Standardization - ISO: 14000/14040/14044, and emission factors and associated environmental impacts directly depend on the type of fuel. Because of this, emissions are accounted for in the processes of exploration of raw materials, transformation, transport, production, consumption and/or end of life, that is, upstream, midstream and downstream, depending on the method applied and the scope (borders) of the search.

TYPES OF FUELS AND THE ASSOCIATED ENVIRONMENTAL IMPACT

All fuels, despite their importance and utility, have some negative contribution of greater or lesser impact to the environment. Emissions (direct or indirect) obviously depend on the type of fuel and the technologies applied in the exploration, processing, transport, distribution, storage and consumption or final disposal process (AKASHI et al., 2011). The alternatives for reducing emissions and associated impacts depend on the creation of public policies, application of techniques (top-down and bottom-up approaches), increased

Gas	Symbol	Sources	Global Warming Potential	Life in the atmosphere (years)
Carbon dioxide	CO_2	Fossil fuels, deforestation, transport	1	20 – 100
Methane	CH_4	Vegetation, landfills, livestock, agriculture, transport	21 – 25	10
Nitrogen oxide	N_2O	Fertilizers, deforestation, transport	298 – 310	170
CFCs	CFCs	Sprays, aerosols and coolants	1.300 – 12.000	70 – 100

Table 1 - Greenhouse gases that contribute to global warming.

Source: author's elaboration.

Combustible	Quantity	Electricity production	Energy density (kWh/kg)	Emissions fromGEE [a] (CO_{2-eq}/kWh)
Uranium	1 kg	60 kWh	123.000 – 25.513.889	2 ~ 13 [b]
Natural gas	1 m^3	6 kWh	~ 14	1 – 806 [b]
Combustible oil	1 kg	4 kWh	~ 13	1 – 1503 [b]
Diesel	1 kg	4 kWh	~ 13	1 – 1330 [b]
Coal	1 kg	3 kWh	9	1 – 1300 [b]

Table 2 - Characteristics of fuels and their life cycle GHG FE factors.

a It refers to the estimate of total GHG emissions, that is, the emission of all stages of the life cycle. b These results were obtained from the meta-analytic study carried out by Mfumu (2021), and in the range, the emission factor depends on the type of cycle (single cycle or combined cycle) and reference parameters such as efficiencies, useful life and capacity factors (CHO; STREZOV, 2020). Source: author's elaboration.

investments and technological changes. In Table 2; some characteristics of the fuels, quantities, energy density and their life cycle greenhouse gas (GHG) emission factors are presented.

Nuclear fuel (uranium)

The intensification of the use of nuclear technologies dates back to the 70s and 80s in developed countries after the oil crisis, then there was a slight stagnation in the 90s with market deregulation and economic reforms in Russia and Western Europe. However, it is known that the use of nuclear fuel was marked much earlier in the war and historical events of Hiroshima and Nagasaki (TOLMASQUIN, 2016).

Nuclear fuel (uranium) is a radioactive metal available in rocks. It serves as the main raw material for nuclear systems, has low cost of production, transport and has the ability to produce large amounts of energy with small amounts of raw material (MFUMU, 2021). Compared to other fossil fuels such as oils (fuel and diesel), coal and natural gas, uranium does not show large fluctuations in prices (GUIMARÃES; MATTOS, 2010), does not present conflicts between countries and high contributions in terms of carbon emissions. GHG in its use as a fuel, in particular, in the generation of electricity (MFUMU, 2021) and, unsurprisingly, it constitutes an essential energy source for sustainable development, if we consider water consumption, emissions in the operational phase and energy density (GUIMARÃES; MATTOS, 2010; ADVIR, 2013). At Figure 2; the schematic of a thermal generation plant using nuclear fuel is illustrated.

All thermal generation sources such as nuclear and other coal, natural gas and oil (fuel and diesel) thermoelectric plants have basically the same operating principle (as illustrated in the diagram on Figure 2); and produce emissions of CO, CO2, N2O, CH4, particulate matter and waste. The plants produce energy from the burning of these fuels in the combustion chamber, generating high temperature and pressure steam that moves the turbine blades to which a generator

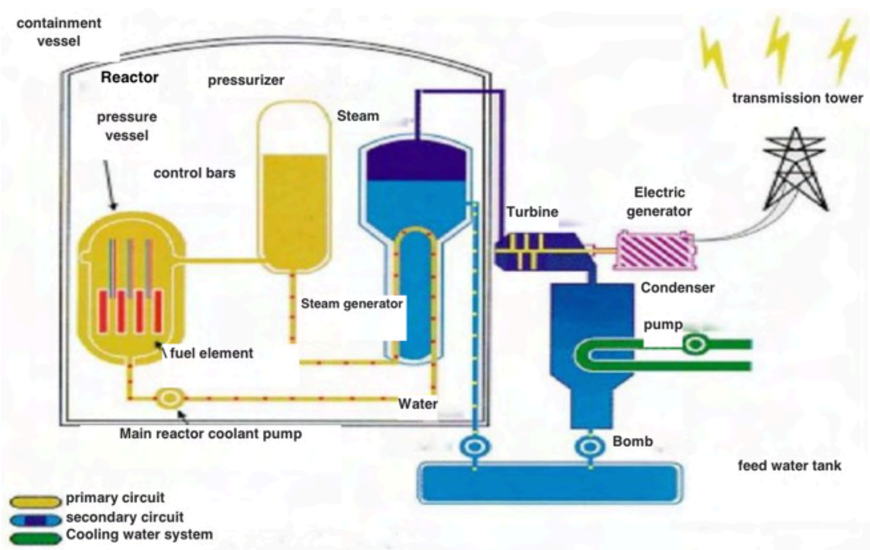

Figure 2 - Schematic of the operation of a thermonuclear plant.

Source: electronuclear.

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is coupled, then the steam is cooled by a condenser and again pumped to the boiler in order to repeat the cycle.

The use of nuclear energy avoids the emission of more than 2 billion tons of CO2 compared to the use of coal, and for every 22 tons of uranium, one million tons of CO2 can be avoided in terms of emissions (ADVIR, 2013). However, emissions from the upstream stage, resulting from the process of extracting and converting raw material into fuel, and restrictions related to the final disposal of radioactive waste after its useful life (MFUMU, 2021), still remain reasons for discussion about the sustainability and levels of impact on the environment (GUIMARÃES; MATTOS, 2010; MFUMU, 2021). On the one hand, the levels of radiation during the mining process and the safety of the reactors, cause socio-economic and environmental problems in the areas of exploration and installation. This issue has given rise to growing concerns and negatively influenced public acceptance regarding the use of uranium as a fuel, mainly for electricity generation (GUIMARÃES; MATTOS, 2010; TOLMASQUIN, 2016; MFUMU, 2021). On the other hand, although nuclear systems are equipped with reinforced safety devices (ADVIR, 2013), the issue of accidents is still a problem in the use of nuclear fuel (MFUMU, 2021).

Historically, nuclear accidents are known as Tree Milles Island in 1979 in the USA, Chernobyl in 1986 in USSR-Ukraine and Fukushima in 2011 in Japan. The impact of these accidents has increased the questioning of nuclear safety and forced decision makers to apply severe environmental restrictions, and authorities are called upon to reinforce reactor safety protocols (KADIYALA; KOMMALAPATI; HUQUE, 2016; TOLMASQUIN, 2016: MFUMU, 2021).

Some countries such as Australia, USA, Kazaghistan, Canada, Brazil, South Africa, Namibia, share the largest uranium reserves in the world (LENZEN, 2008), with some countries such as Canada, Japan and Brazil, for example, have technological maturity in the use of nuclear reactors. There are more than 30 nuclear reactors (MFUMU, 2021), the Light Water Reactor (LWR) being subdivided into Pressurized Water Reactor (PWR) and Boiled Water Reactor (BWR), the most commercial. However, as it is a fuel that goes through several industrial stages (see example of the nuclear fuel cycle in Brazil in Figure 3), despite the technological maturity, some countries choose France and Canada, for reasons of scale, for the enrichment of uranium by centrifugation or gaseous diffusion. In these processes, upstream emissions can be higher or lower due to energy consumption in the enrichment process, and the same also occurs in life cycle emissions depending on the types of reactors.

Competitiveness (new reactors, emergence of solar and wind energy) and environmental requirements have forced the technological transition (safety, extension of the useful life of reactors, waste treatment), contributing to the creation and implementation of new technologies with Generation reactors III+, SMR modular reactors and Canadian CANDU reactors, whose safety and environmental impact are lower than other reactors, seeking to make nuclear energy an effective alternative with public acceptance and almost indisputable such as solar and wind technologies.

Until the moment of carrying out this research, no information was obtained on the use of uranium for the generation of electricity in Angola, and thermonuclear generation systems were not found in the country. However, it is known that on the border between Angola and Namibia there are uranium reserves. As mentioned earlier, nuclear energy has been the target of public

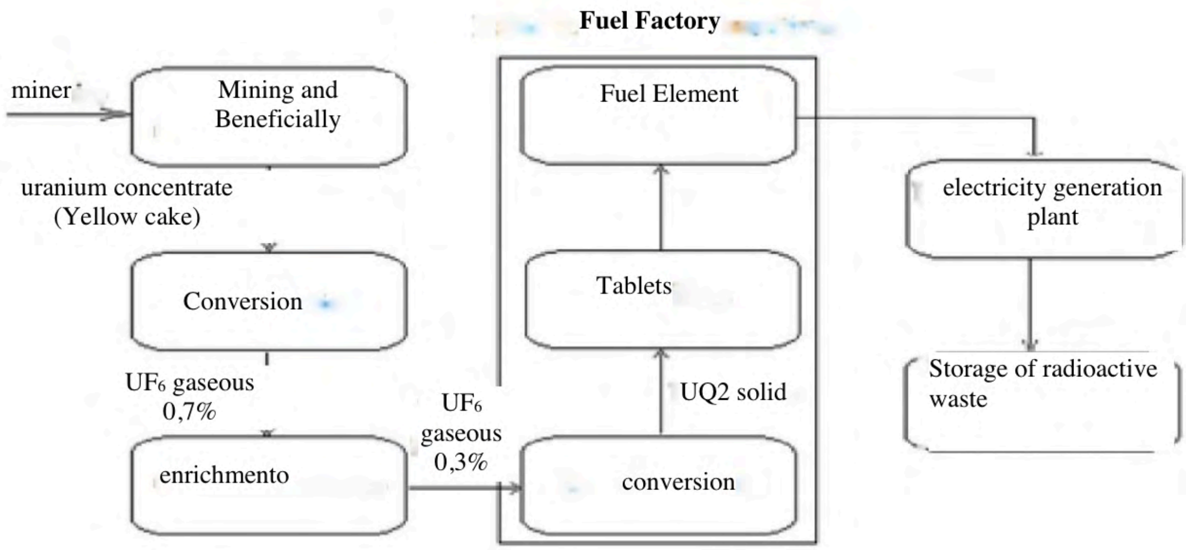

Figure 3 - Nuclear fuel cycle in Brazil.

Source: Adapted from Mfumu (2021).

opinion in terms of sustainability, especially safety. Logically, a properly designed energy policy must ensure that the interests are reconciled; political, economic, socio-environmental. It is therefore considered, although in a "superficial" way, that these are the reasons for the lack of interest in the use of nuclear fuel at the national level, although there are unexplored reserves in the country. Another reason that can be pointed out, besides obviously the lack of research in the country, is the abundance of oil, and from this, derivatives capable of generating thermal electricity are obtained (although with higher GHG EF in relation to nuclear fuel) making Angola self-sufficient in energy from these derivatives and other sources of electricity generation such as renewable hydro and solar sources. It is important to highlight that the use of nuclear fuel goes beyond the generation of electricity, and it has also been used in medicine (X-ray and tumor treatment), agriculture, sterilization of materials, food conservation, scientific research, among other utilities. However, as mentioned above, no information was obtained on the national level.

Oil and derivatives

Petroleum is a flammable mixture of oily substances and is used as a base for the production of fuels. In it derive the oils (fuels and diesel) and other derivatives. Angola has large oil reserves off the coasts of Cabinda and Luanda, and the country is considered one of the important oil producers in Africa and the world.

According to the National Agency of Petroleum, Gas and Biofuels of Angola (ANPG), until February 18, 2022, the country recorded an average daily production of 1,189,195 barrels of oil, while the production of natural gas and liquids the daily average was 131,956 barrels of oil equivalent, not counting the production of some blocks such as 2/05, 3/05 and FS/FST. ANPG was created in 2019, under Presidential Decree No. 49/19 of February 6, in response to the need to organize the Angolan Government's oil sector.

Combustible	Gross production (barrels)	Daily average (barrels)
Petroleum	36.865.039	1.189.195
Natural gas and Liquids	4.080.843	131.956

Table 3 - Daily gross production of oil and natural gas in Angola, until February 2022.

Source: author's elaboration with data - ANGP (2022).

In Table 3; it boils down to the production of oil and natural gas in Angola, until February 18, 2022, according to the ANPG.

Natural gas (GN)

Natural gas is a fossil fuel and versatile energy source, composed of hydrocarbons in a gaseous state under ambient conditions. The composition is essentially methane (CH_4) above 70%, ethane (C_2H_6) in smaller proportions and propane (C_3H_8) below 2% (TEIXERA et al., 2021; TOLMASQUIN, 2016; MFUMU, 2021). This fuel can be combined; when it is dissolved in the oil in the geological reservoir, in the form of a gas cap, or not associated; when it is free of oil and water in the reservoir (ANP, 2020). Its utility goes beyond energy purposes, and has also been used for domestic, industrial, fertilizer use and transportation.

Worldwide, NG has been considered an essential fuel for the development of energy systems and electricity generation from high-efficiency combined cycle systems. By the end of 2019, NG represented 23% of the world's primary energy demand (TEIXERA et al., 2021). This occurred to the detriment of other fossil fuels such as coal and petroleum derivatives, since NG has offered security in the generation of electricity, easy and quick start-up of electric plants, stability and low greenhouse gas emission factor (MFUMU), 2021).

According to Teixera et al (2021), natural gas has a higher calorific value than coal and almost equal to oil, and NG emits up to 44% less CO_2 compared to coal, 17% less compared to coal. to the liquefied gas itself. In Figure 4; This comparative reduction in CO_2 emissions from NG is illustrated graphically in relation to emissions from coal, fuel oil, diesel, gasoline and liquefied gas.

However, the use of natural gas does not negate the considerations of technical, economic aspects, above all, socio-environmental aspects. From the perspective of the life cycle, during the extraction and transport processes, natural gas leaks occur and, consequently, emissions of CH_4, which is considered a more aggressive gas to the environment compared to CO_2.

According to Mfumu (2021), during these processes, also known as the upstream stage, emissions can range from 1 to 83 gCO_2-eq/kWh, in particular for electricity generation systems, where additional energy consumption and leakages occur. of CH_4 from NG. Other authors such as Bouman, Ramirez and Hertwich (2015) and Atilgan and Azapagic (2015) consider that emissions reach up to 152 gCO_2-eq/kWh, and in many cases they reach up to 26% of life cycle emissions, resulting from flows of NG CH_4 in exploration, processing and transport activations. However, with the pressures of climate change is the accelerated technological growth that aims to create and implement carbon capture technologies. There are large billion-dollar infrastructure projects to capture CO_2 in industrial centers and transport it in pipelines to storage locations. Most of these

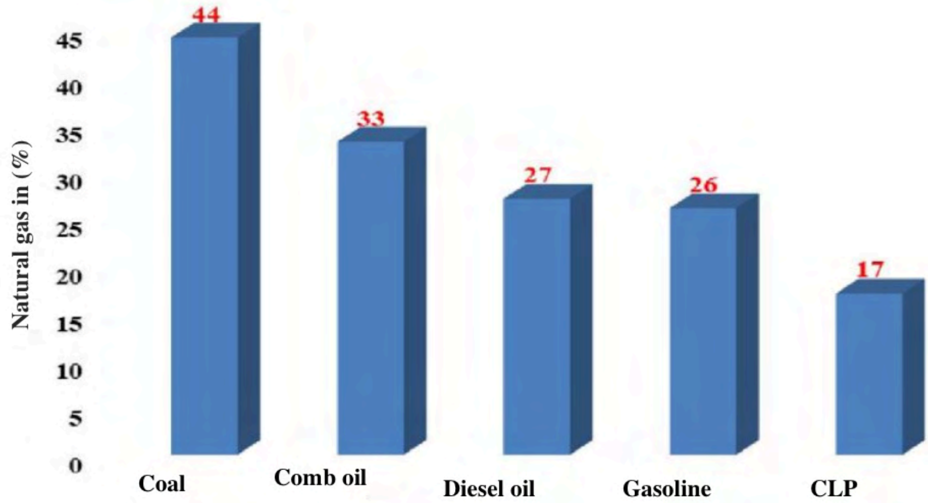

Figure 4 - Comparison in % of CO_2 emission from natural gas with other energy sources.
Source: author's elaboration with data from Teixera et al (2021).

billion dollar projects are being executed in the USA, Australia, Europe, China, Correia, New zaland, Middle East, where there is political will and mature technology for the installation of these projects and large proven reserves of natural gas.

In the national context, according to Macauhub (2018), until the end of 2018, the proven reserves of associated NG were estimated at 113,267 million m3. However, in Angola there is only one project to explore the NG deposits since 2013, in block 14, led by Chevron with 36.4%, Sonangol with 22.8% and other groups such as Total, ENI, BP with each 13.6% share, with a daily supply capacity of 5.2 tons and a 30-year exploration forecast.

The lack of several exploration projects for NG deposits at the national level can be explained by the fact that the country does not have a market as mature as those existing in industrialized countries, and the implementation of ambitious projects to capture CO_2 is still far from the national reality. Even so, it is believed, for the coming years and, following the dynamics of developed and developing countries, that within Angola's strategic plan, NG will also be considered as a fuel contributing to national revenues, a fuel strategy of energy transition for the sustainable development of the country and, within the permanent global need to reduce GHG emissions, conservation of the environment, competitiveness and the indispensability of energy security and stability, the Angolan executive considers the future implementation of large projects, including those for capturing CO_2.

Fuel oil and diesel

Fuel oil and diesel are energy sources that derive from the oil refining process. Normally, they are used as fuels in internal combustion engines with cooling, lubrication, recirculation, ventilation and centrifugation systems to remove the heat generated in the engine operation and avoid contamination in combustion (MFUMU, 2021). For the generation of electricity, these energy sources are important in thermoelectric plants that work intermittently and guarantee the complementarity of electricity demand, especially in isolated systems.

Both energy sources have a low cost compared to natural gas, but GHG emissions exceed natural gas emissions by up to twice (TARANNUM; MOHAMMEDY, 2019). Fuel oil has in its composition heavy hydrocarbons such as carbon, hydrogen, sulfate, nitrogen, and has a high sulfur content and points of varying viscosities and densities (TARANNUM; MOHAMMEDY, 2019; MFUMU, 2021). Diesel, although also cheaper than natural gas, is viscous and corrosive and has sulfur dioxide, nitrogen oxide and particulate materials in its composition that cause changes in biodiversity (KARMAKER et al., 2020; MFUMU, 2021).

Angola, being a country abundant in oil, these derivatives are often used for multiple tasks. There is in the national territory the company SGS, Angola. Lda, which develops quality inspection tests and certification of fuels and oils. In the case of diesel, the sulfur content, metal content, viscosity, determination of distillation, pour point and density are tested. In this context, diesel is tested as bunker fuel, power station fuel, raw material and blending component (SGS-ANGOLA, 2022).

At the national level, the largest market for these products is still the transport of people and goods, in which emissions and environmental impact are not estimated, thus demonstrating the lack of scientific studies on the subject. However, the emission factors of these fuels vary according to the activity. In electricity generation, to mention an example, Mfumu (2021) estimated the life cycle GHG EF for Brazil at 1001 gCO2-eq/kWh and 1178 gCO2-eq/kWh, in fuel oil and diesel electricity generation, respectively, and considers the values presented in Table 2, obtained from meta-analytic studies. According to Karmaker et al (2020), the average emission can be in the order of 640 gCO2-eq/kWh in the generation of electricity from diesel oil, and Tarannum and Mohammedy (2019) state that the emission of CO2 in the transport of these fuels is higher in relation to natural gas emissions in pipelines.

CONCLUSION

Education and environmental management must continue to be associated with reflective and decision-making processes on environmental issues (environmental policies, production policies, economic measures, development and security), awareness, rescue of ethical and citizenship values based on sustainable development strategies to improve the quality of life on the planet.

In the particular case of the use of waste and energy, among several proposals and for environmental reasons, the idea of growing production of renewable liquid fuels such as alcohol and biodiesel, the generation of electricity through renewable sources such as solar, wind and biomass, and the proposal to use natural gas instead of coal, diesel and fuel oil is maintained, due to its greenhouse gas emission factor.

Currently, at least so far, there is still no fuel that can definitively replace oil. Uranium and natural gas, despite being less environmentally aggressive than petroleum derivatives, are currently not able to meet the world's energy demand. The industrial structure has a dense and rigid mesh, impossible to be replaced in the short term, despite the current technological advances.

Angola, in particular, needs to adjust to world growth and dynamics, especially in scientific research, in order to present its contribution in figures with consistent and tangible results on related topics. At the national level, the problem of solid waste is still permanent, EA and GA issues have not been properly understood in society so far and GHG emissions from electricity generation systems or fuels are not estimated. It is known, however, that the country produces electricity through hydroelectric and thermoelectric sources. The production of electricity using fossil fuels can be balanced with the use of natural gas, solar and wind energy and the expansion of hydroelectric plants, due to the resources and potential that the country has. The effort of the executive and the ministries of guardianship is recognized, but there are still insufficiencies in the fulfillment of environmental norms, leaving the country on the fringes of the practice.

It is important to understand that energy, the environment and economic development are intimately connected. Because of this, the form of production, transport, distribution and consumption of energy will always be associated with GHG emissions, and the application of strong environmental measures and policies is crucial to mitigate the damage caused to the planet and achieve sustainable development with lower volumes of GHG emissions into the atmosphere.

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