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Life cycle assessment in choosing alternatives for energy sector development

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ABSTRACT

Development of industrial activities have negative effect on natural resources and environment therefore, production systems must respect the principles of sustainable development by minimize natural resource consumption and pollutant emissions.
Life cycle assessment (LCA) of a industrial activities is a technical tool, a method that allows evaluation of the socio-economic activities in relation with the environment, from birth to death. The aim of this paper is analysis of resource and energy consumption in Romania, using LCA, that can identify environmental and socio-economic aspects of analyzed sector, for taking effective measures, to ensure quality requirements, social, economic, protect environment and improving energy.

Indexing terms/Keywords

Keywords: LCA, energy marketing management, cycle audit, good planning.

Academic Discipline And Sub-Disciplines

Management; Industrial Marketing

SUBJECT CLASSIFICATION

Marketing management: Analysis of the resource and energy consumption in Romania; Case study

TYPE (METHOD/APPROACH)

Life cycle assessment (LCA) as method/technical that allows evaluation of the socio-economic activities in relation with the environment

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1. INTRODUCTION

Many industrial instalations and Romanian technologies are old and inefficient or improperly used or some are destroyed for a long time. The remaining to be upgraded by changing the process, equipment efficiency, operation and maintenance procedures, or even complete change in technology. All these changes to rebuild the system requires a huge human and financial.

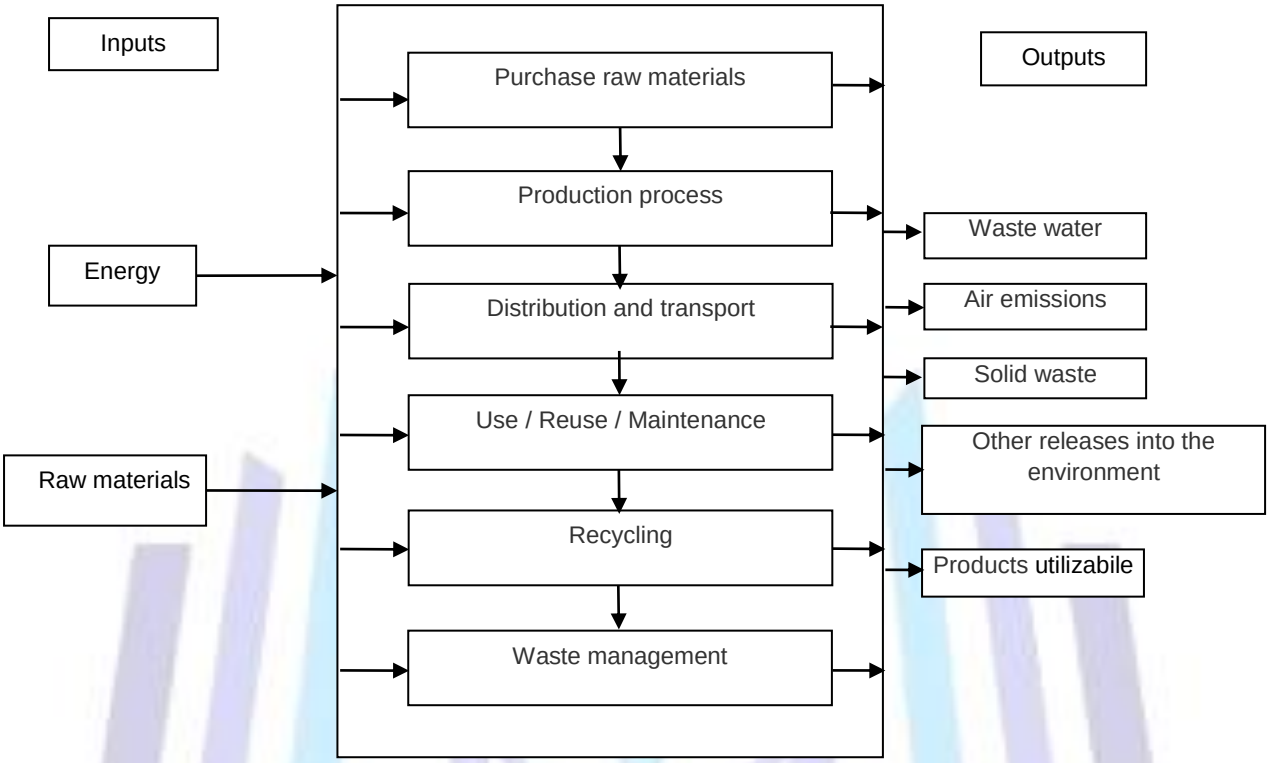

Fig. 1: System limits

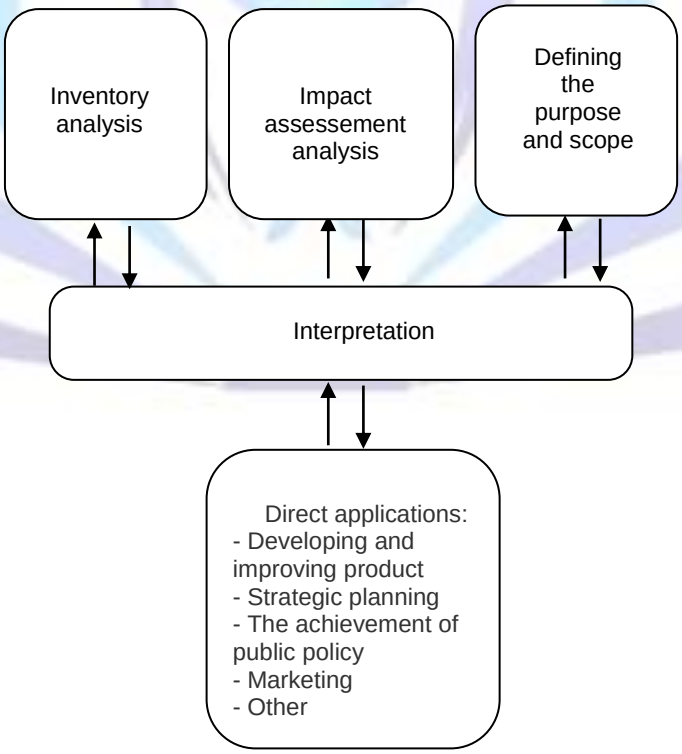

Fig. 2: The life cycle assessment

Life cycle assessment (LCA) is a technical tool for identifying and assessing opportunities to reduce environmental impacts associated with a particular product, production process or activity [1, 2, 3, 4]. LCA is a method that takes on

increasingly greater audience in environmental assessment in relation to socio-economic activities [5, 6, 7, 8]. Using this method are evaluated consumption of energy and materials, on the one hand, and environmental impact human health and ecosystems, on the other, in carrying out the key stages of the process for obtaining a product and its use, starting with extraction raw materials, obtaining product, use and recycling, transport, until the final disposal of wear product or waste useless (see Figure 1). Due to the overall eye on the process and product LCA was considered as an analysis "*from birth to death*."

This feature distinguishes it from other methods of analysis such as environmental impact assessment or environmental audit, which treats the impact of process/product on the environment only in a certain phase of its existence [9, 10, 11, 12]. Also, LCA takes into account the environment, unlike other methods of analysis (such as risk assessment) which refers only to environmental safety.

Intensification of industrial activity has a negative effect on natural resources and environment [13, 14]. To counteract this negative effect, all production systems must respect the principles of sustainable development, that minimize natural resource consumption and pollutant emissions. LCA has three separate components, but interrelated (see Figure 2): inventory analysis; impact assessement; improvement analysis.

2. ENERGY INDUSTRY. ENERGY MARKETING MANAGEMENT

2.1 Energy industry

Energy industry underpins the development of national economy, because it provides electricity and heat all economic sectors, including administrative and residential areas. This branch includes fuel extraction (oil, natural gas, coal etc.) using other energy resources, electricity production and thermal and sending them to the consumer. A last-minute statistical analysis of resources and energy consumption in Romania [15] indicate of a situation quite different from the world (see Figure 3)

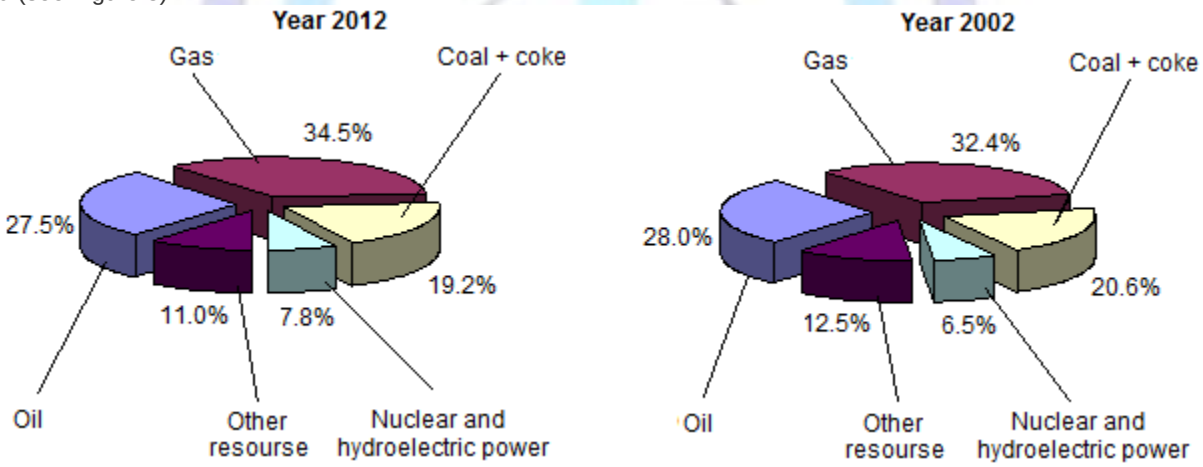

Fig. 3: Primary energy resources

LCA can be recommended to identify all environmental aspects of sector analysis and recommendations for measures and actions to reduce environmental impact.

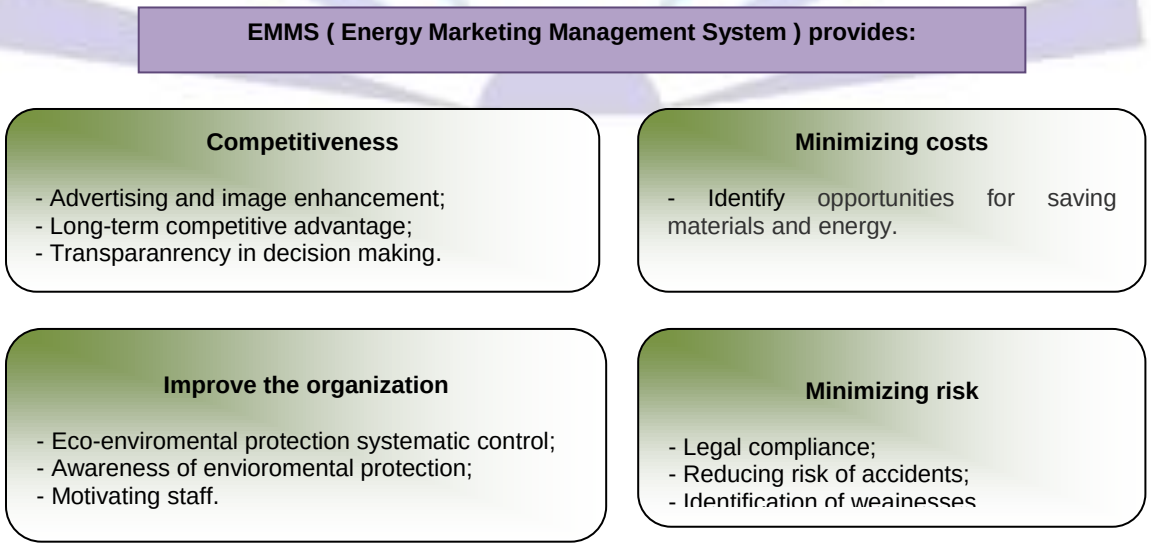

Fig. 4: The benefits of energy marketing management system

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2.2 Energy marketing management

The main purpose of a marketing management system is to improve energy efficiency and energy performance, to ensure compliance with quality requirements, environmental and socio-economic. In Figure 4 we can see more groups of arguments for implementing an energy marketing management system (EMMS).
This should reduce costs and emissions of greenhouse gases through energy marketing management systematization. Complete requirements for an energy marketing management system are defined in standards international (ISO 14001, ISO 16001).
In Figure 5 we can see which are the main stages of an EMMS.

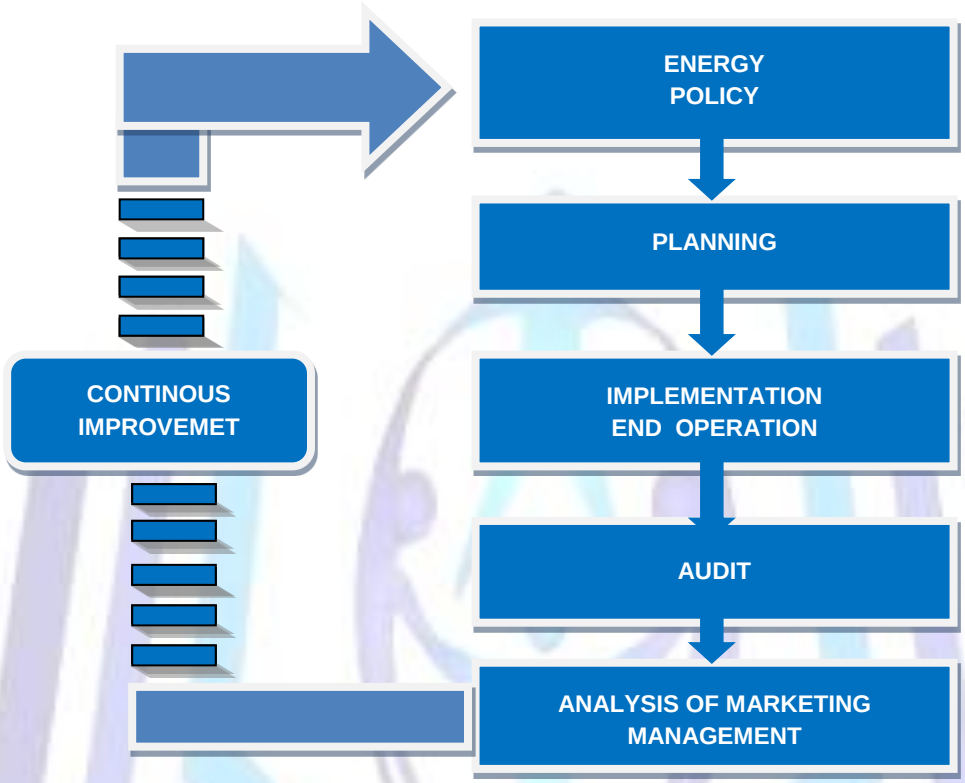
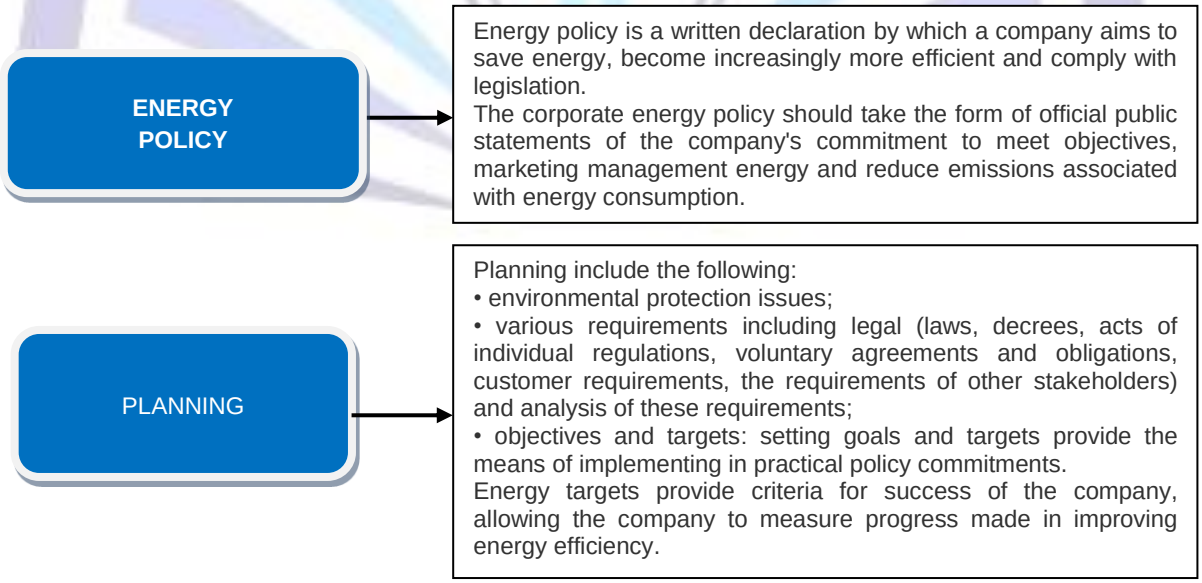


Fig. 5: Energy marketing management cycle

Below I will detail each step of EMMS, which include the following:



EMMS is based on good planning [16, 17, 18, 19], whose steps are shown in Figure 6:

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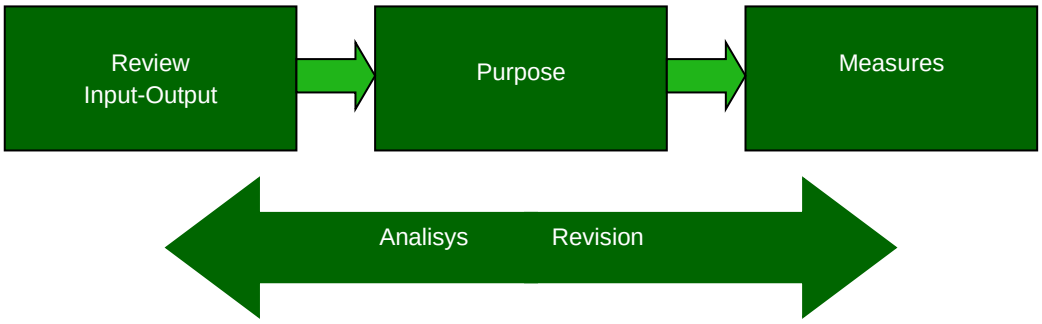


Fig. 6: The main stages of planning

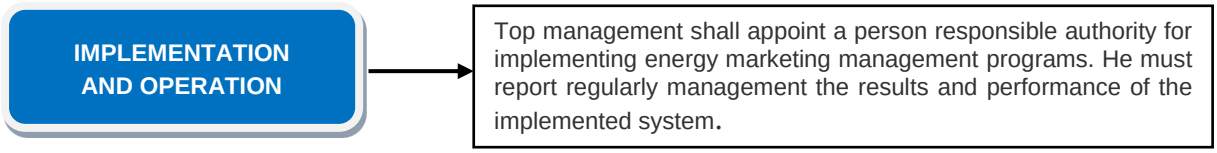
Analysis inputs - outputs (material flow analysis and energy analysis) leads to the identification of objectives, and they lead to concrete measures/actions. It is important that these procedures be reviewed and revised as needed (see Figure 6).
Transparency in the flow of materials provides a basis for sensitizing and raising awareness. Tools such as analysis input/output analysis of material flow and energy flow analysis, is an information system that allows determining the effectiveness of material and energy flows, and effective measures taken. Thus they become important tools in measuring the actual environmental performance improvement.

2.3 Analysis inputs – outputs

The first step in the initial analysis is to identify areas of significant energy consumption. Figure 7 presents an overview of industry inputs and outputs

Fig. :7 Principle analysis of input – output

At first the company needs to assess the quantity and nature of energy consumption. Energy analysis should include both current energy consumption and past.
Level of detail depends on the size of the organization and energy consumption, but should include a minimum of energy input (electricity, oil, natural gas, etc..) and estimates on the final (drying, pumping, air conditioning, lighting, etc.)..
Trend in recent years, energy consumption must be analyzed and used as a departure in defining the target date. The report will include information already available, such as energy bills, readings measuring instruments, energy reports of buiding administrators or any other existing information [19]. Often great opportunities to improve energy performance will result in administrative measures inexpensive, ie staff training to stop the equipment when not are in use, promotion and awareness of energy efficiency in the working practices of staff. Company should update this analysis annually. Reports should be based, if possible, the actual measurements. Be kept in mind the changes in the organization, such as increased production, changing facilities, staff qualifications and job descriptions.
Internal audits involve a systematic inspection and comparison of current methods of working 17, 20] with the procedures specified in EMMS/ environment. The aim is to verify that the EMMS is functioning properly. On the one hand, the audit should identify and highlight areas where EMMS requirements have been met, and on the other hand it should identify non-conformities and to propose possible improvements.
An audit can focus either on a procedure (eg.: emergency response) or on a particular area of activity or production line [20]. The key to success for EMMS is involvement of all employees in this action. If employees are not aligned to these new requirements, the system will be difficult to implement and maintain. The audit is an important tool in measuring employee engagement in different areas/departments of the company.



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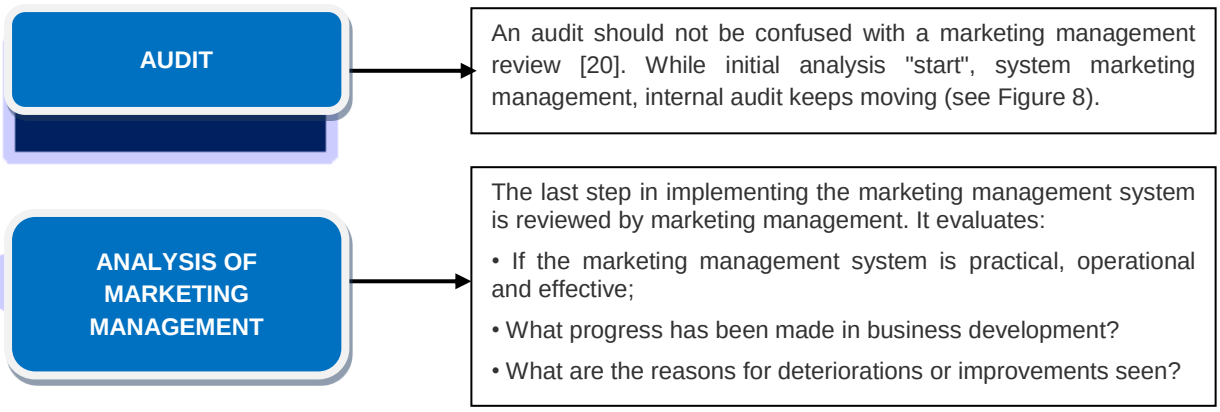

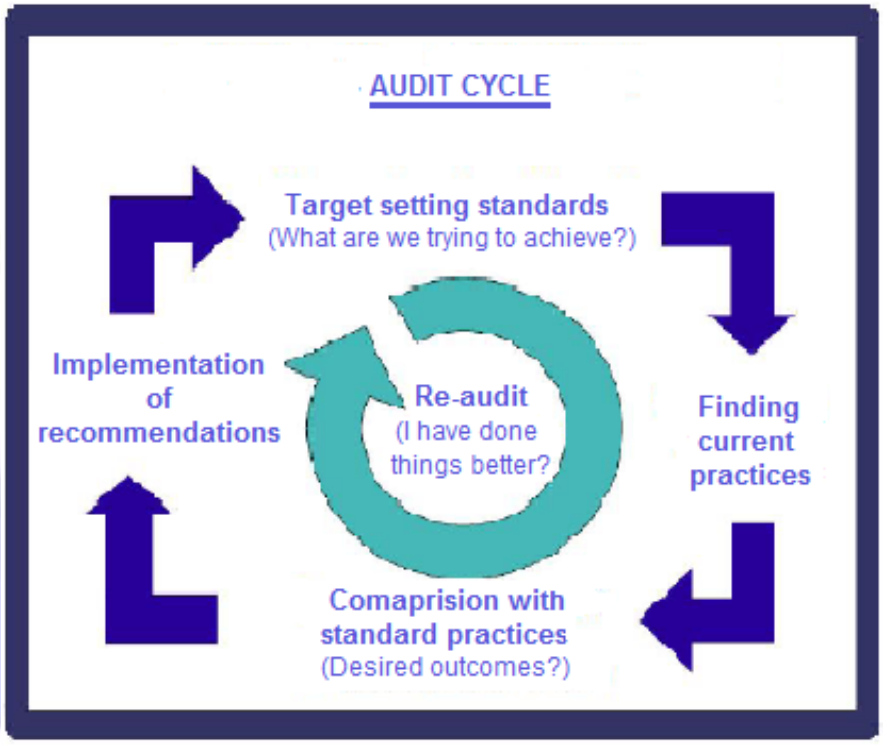

Fig. 8: Cycle audit

3. CASE STUDY: EFFICIENT USE OF ENERGY IN THE PAPER INDUSTRY

3.1 General

The idea of papermaking originated in China 2,000 years ago and became popular in Europe in the mid 13th century. In those days, the fibers of mulberry bark, papyrus, straw or cotton, were used as raw materials for paper production.
Industrialization paper production began only in mid-19th century, and also when people started to draw and use the wood fibers as raw material. Energy has always played a major role in the production of paper. initial production of paper have always held near rivers large to ensure water supply and hydroelectric energy required for manufacturing process. Solar and wind energy helps drying and bleaching of paper.
Widespread use of fossil fuels began with the industrialization of papermaking. Today around 48% of primary energy used in European industry of pulp and paper is generated from fossil fuels.

3.2 The life cycle of paper

The forest is a renewable resource providing both raw materials and wood fibers biofuels for energy production Figure 9 shows the main stages of the life cycle of paper.

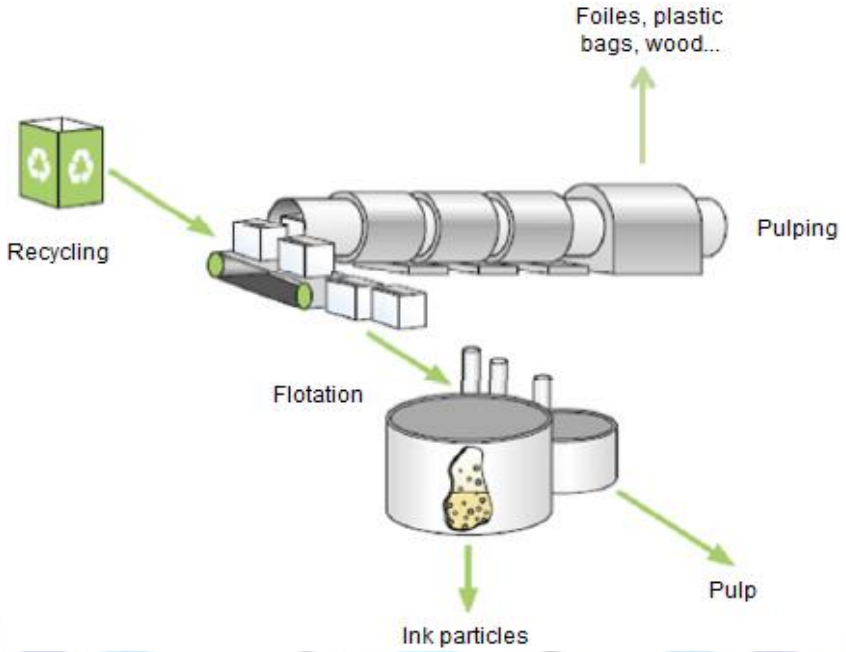

Fig. 9: Manufacture of paper from recycled fibers

Both wood and wood-products industry, are transported to the pulp mill, where it is separating cellulose fibers from other wood components. Extracted fibers (cellulose) are mixed with water and certain chemicals before being used in paper-making machine. Wastes from wood industry and pulp and paper mills are burned to obtain energy, to save fossil fuels and to reduce the amount of waste disposed at landfills. Waste paper are collected and sorted by use, is then recycled and reused in the paper production process.

3.3 Raw materials for papermaking

The raw materials of paper-making process are: fiber (cellulose), chemicals, water and energy. Mix first three form the "paste" used by paper-making machine.
Different fibrous materials such as wood, non-wood or sawdust industrial plants (primary or virgin fiber) and recovered paper (secondary fiber) can be considered raw materials in papermaking. Initially the fibers are extracted from raw materials and is produced so-called "pulp" (cellulose). This pulp is mixed with water and other chemicals before being introduced into paper machine, in which the formation of the paper. Wood is an organic material which contains about 49% carbon, 44% oxygen, 6% hydrogen and less than 1% nitrogen and inorganic elements such as sodium (Na), potassium (K), calcium (Ca), magnesium (Mg) and silicon (Si). These elements form the macromolecules and thus are created the basics of wood: cellulose, lignin and semicellulose. Flexible cellulose fibers are bound together and reinforced by lignin. Figure 10 presented the principle of simplified cellular composition of wood.

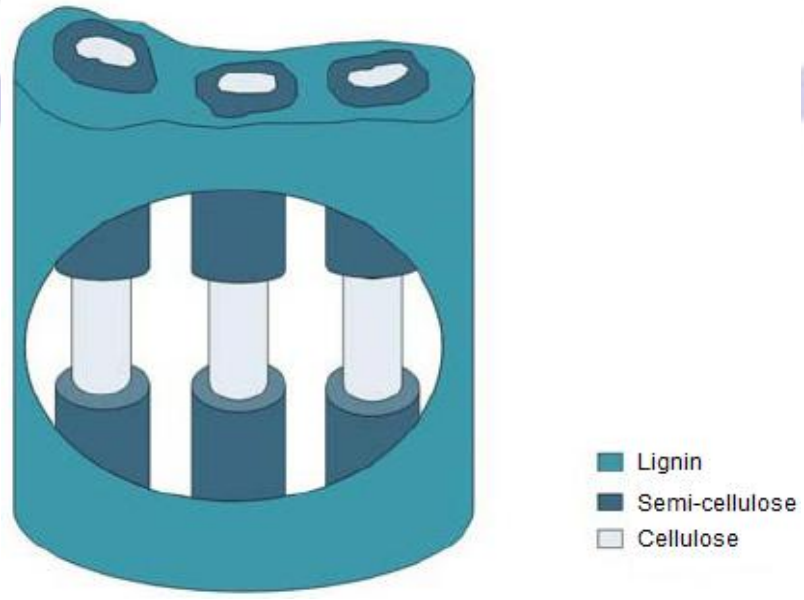

Fig. 10: Simplified principle of cellular composition of wood

Paper-making may be used only cellulose fibers. They must be mechanically or chemically separated from other components of wood. Fibers of softwood (such as spruce, fir and pine) are longer and more rugged than hardwood fibers. Of fibers from softwood to obtain tensile strength and tear the paper, while hardwood fibers lead to smoother surface of a sheet of paper. Because soft wood contains more lignin than hardwoods, it requires more energy and more chemicals to separate the desired fibers, other wood components.

Recovered paper

In 2006, 56% of paper and cardboard was recycled in Europe. Newsprint and cardboard are the main produce that are made from recycled paper.

Chemicals

Chemicals account for up to 30% of 'paste'. The addition of fillers (for exemple calcium carbonate - chalk or kaolin) is more opaque paper and wear resistant, smooth surface contributes to the paper and increase its flexibility. Several stages of pulp, such as dissolution of lignin from wood fibers and bleaching new and clean, requiring the addition of chemicals.

Water

The most important raw material is water. This is necessary for cleaning, cooling, steam production, and functions as a binder in the creation of hydrogen bonds between the fibers of the paper. Papermaking processes may require from 10 to 100 liters of water per kilogram of paper produced. Modern paper mills use water loop circulation systems of water to minimize demand "fresh".

Energy

Most paper mills have their own facilities for producing electricity and steam. Today autogenerarea energy is almost 60% of total energy used in European pulp and paper industry. Hidorelectrică energy, natural gas, fossil fuels, waste and biomass fuels, and energy that is recovered in the production process, is converted into steam and electricity to power the process.

Natural gas, shells and the remains of manufacturing are burned to produce heat.This is in turn used to produce steam turbines operating steam producing electricity. Excess steam from the turbine is used for heating of manufacturing. Heat recovery systems also contribute to the power plant of paper. It also has electricity provided by hydropower and the remaining energy is taken from the national distribution network.

Paper mills using energy in the form of steam for heating and drying (for example paper-making machine) and electricity to operate different machines and engines. Energy cost is about 15-25% of total production costs. Energy demand for producing one tonne of paper is between 3 and 5 MWh, which is the average amount of energy that is consumed by a household (family) European for 3 - 4 months. Due to these economic reasons, reduction of primary energy demand and the imposition of efficient use of steam and electricity generation, have always been key element in paper industry. In particular combustion by-products of the manufacturing process and biofuels (bark, wood residues and other residues from forestry operations) contribute to reducing the amount of fossil fuel use and sustainable use of resources.

In addition, heat recovery installations manufacturing process reduces the overall demand for energy and thus is reduced and the amount of CO2 and other emissions.

Paper production process

Manufacture of paper can be divided into two main stages that transform raw materials into finished product (see Figure 11).

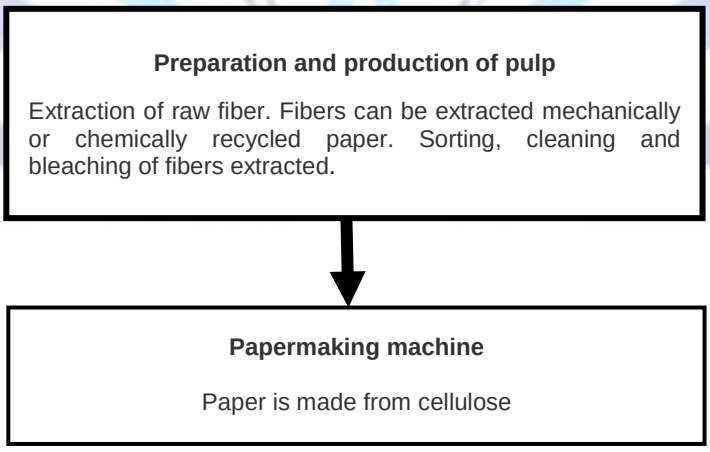

Fig. 11: The preparation and papermaking system

In producing chemical pulp using a combination of heat, chemicals and pressure to separate the lignin from wood cellulose fiber is then removed by washing (delignification). To this end, peeled logs are washed and chopped. Sorting (pulp) removes chips too large to be reprocessed. Sawdust can be burned along with shells and other waste.

Wood chips are "cooked" with a so-called "boiling liquid" (white liquor) containing sodium hydroxide (NaOH) and sodium sulphide. Under the influence of these chemicals and process temperature between 155 and 175° C, lignin and some broken wood semiceluloze so remain only cellulose fibers. Extracted fibers contain "black liquor", a mixture of chemicals

(in the boiling liquid) and lignin. The cleaning processes, cellulose is separated from black liquor, which is then transported to a chemical recovery system, which recovers about 70% of energy input to the process of boiling and more than 90% of chemicals used.
Initially, the pulp is brown. Depending on the degree of purity of white and desired paper, cellulose must be bleached to remove lignin and more of the remaining impurities. Chlorine and its compounds, ozone/oxygen in different forms and hydrogen peroxide can be used as bleaching chemicals (see Figure 12). Because of the negative environmental impact of chlorine compounds, there are objections against their use, and most modern paper mills use chlorine-free processes.

Fig. 12: Cellulose fibers

Chemical recovery system (which is recovered and energy)
The recovery system, water is discharged from black liquor evaporation, the remaining liquor is then led to a recovery boiler. Black liquor organic components (lignin and other organic compounds) with high energy content and are burned to produce steam.
Chemicals used in pulp production are collected at the bottom of the tankrecovery and returning to the process (see Figure 13).

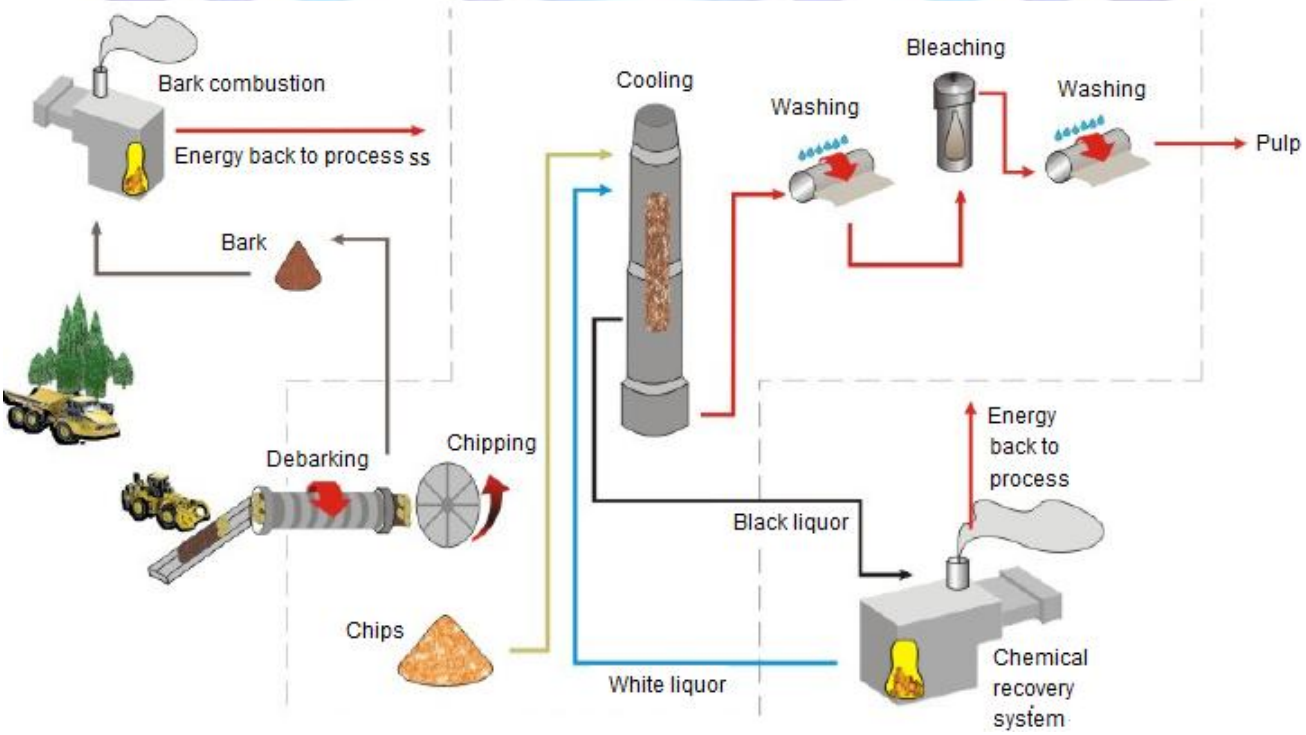

Fig. 13: Technological flow of chemical pulp production

3.4 Pulp made from paper recycling

To save energy and raw materials, paper can be recycled by reusing paper fibers instead of new wood fibers. For this purpose, prepare different recovered paper grades which are then used for paper-making machine. Impurities that are removed during the recycling process can be burned to produce energy.

Energy vs. recycling incineration

Paper recycling contributes to sustainable paper production process, but is always necessary to bring new fiber paper forest cycle. Fiber waste paper contains many broken or destroyed can not be reprocessed. At each cycle of reprocessing, 10-20% of the fibers become too small to be reused and must be replaced.

Paper that can not be reprocessed can be burned along with other household waste in municipal incinerators. Positively influence the paper burn incineration process as easy and reduce demand for additional fossil fuels. Because municipal incinerators typically generate energy, such as steam for district heating and electricity dsitribuţie network..

Recycling paper vs. incineration of new wood fiber

Paper production has many environmental impacts, this chapter will discuss the influences the best known environmental impacts of pulp and paper production.Although there are many different types of paper and pulp processes and paper, different

European and American experts say that the paper made from recycled fiber is less harmful to nature than paper made from virgin fibers.

The Table 1 illustrates the various environmental impacts of the process of producing one tonne of primary fiber paper (new) (Scenario A) in comparison to produce one ton of paper fiber secondary (recycled) (Scenario B).

Table 1. Various environmental impacts of the process of producing one tonne of fiber paper

Raw materials	**A: Fibre, 100% new**	**B: Fibre, 100% recycled**
Wood	2,200 kg	-
Reused paper (recycled)	-	1,100-1,300 kg
Minerals (eg.: limestone)	100 kg	25 kg
Chemical substances (pigments, fillers, etc.).	230 kg	130 kg
Water	30,000-10,0000 l	10,000-20,000 l
Energy consumption	**A**: Fibre, 100% new	**B**: Fibre, 100% recycled
The combustion of wood residues	3-4 MWh	-
The combustion of waste from process	-	0.5-1 MWh
Addition (eg.: fossil fuels)	0.5-1 MWh	1-2 MWh
Total	3.5-5 MWh	1.5-3 MWh
Emissions to water	**A**: Fibre, 100% new	**B**: Fibre, 100% recycled
COD	5-50 kg	2-10 kg
BOD	1.8-2.1 kg	1.6-2kg
AOX	< 0.5 kg	< 0.5 kg
Emissions to air	**A**: Fibre, 100% new	**B**: Fibre, 100% recycled
Greenhouse gases (CO_2 equivalent)	1,200-2,500 kg	900-1,400 kg
Particles	4-5 kg	2.5-3 kg
Sulphur dioxide	10-12 kg	9-11 kg

The most severe effects on the environment have:

• greenhouse gases such as carbon dioxide (CO2) and methane (CH4), contribute to climate change by trapping solar energy in the atmosphere;

• small particles (<10 m) which are scattered in the atmosphere during combustion, can cause asthma and other respiratory diseases or cancer, when inhaled;

• sulfur dioxide: SO2 resulting from boilers burning fuel containing sulfur (coal, oil), and lead to air pollution problems such as acid rain or smog (mixture of fog and smoke).

In terms of energy efficiency of the cycle paper fiber recovery consumes less energy than producing paper from virgin fibers. However, it is possible that recycling processes to assume a higher consumption of energy from fossil fuels because of the new fiber manufacturing process uses more fuel wood. A tonne of paper produced from recycled fibers consumes approximately 2 MWh, or 40% less energy than paper made from virgin fibers.

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Steam and electricity generation

The production of pulp and paper, several stages of technological process such as drying secţiuneade, use steam for heating. Steam is generated by exchange of heat between the hot waste gases of combustion processes (fossil fuels or alternative) and chemical recovery, and fresh water (see Figure 14).

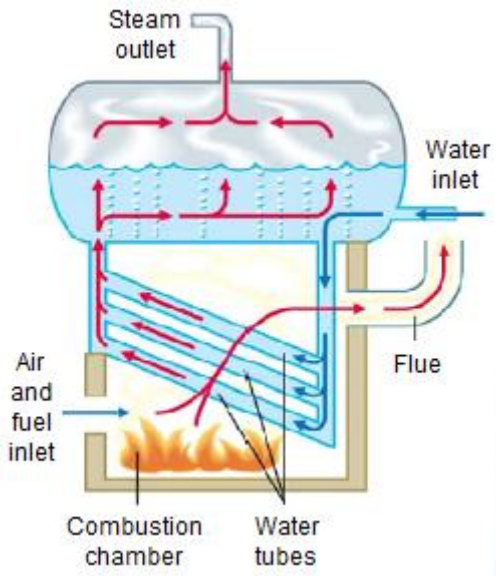

Fig.14: Simplified principle of steam generation

Formation sheets papermaking machine

This is the final stage of the papermaking process. Figure 15 shows the basic components of a papermaking machine. There are five main sections: input section (where you enter pulp, water and other chemicals), section sieve (wet band providing training), press section, drying section and the final group.

At entry, the suspension fiber (viscous pills) made of paper pulp, water and chemicals (fillers, pigments) is distributed throughout the car. The water content of the suspension is 99%. In section sieve, water is removed from the suspension by different vacuum cylinder boxes, thereby increasing solid content to 20%.

Remove water from the fibrous suspension is continued compression molding section paper tape between the metal cylinder. Solid content increases to 50%. Cylinder heated drying section steam evaporates the remaining water in the mixture.

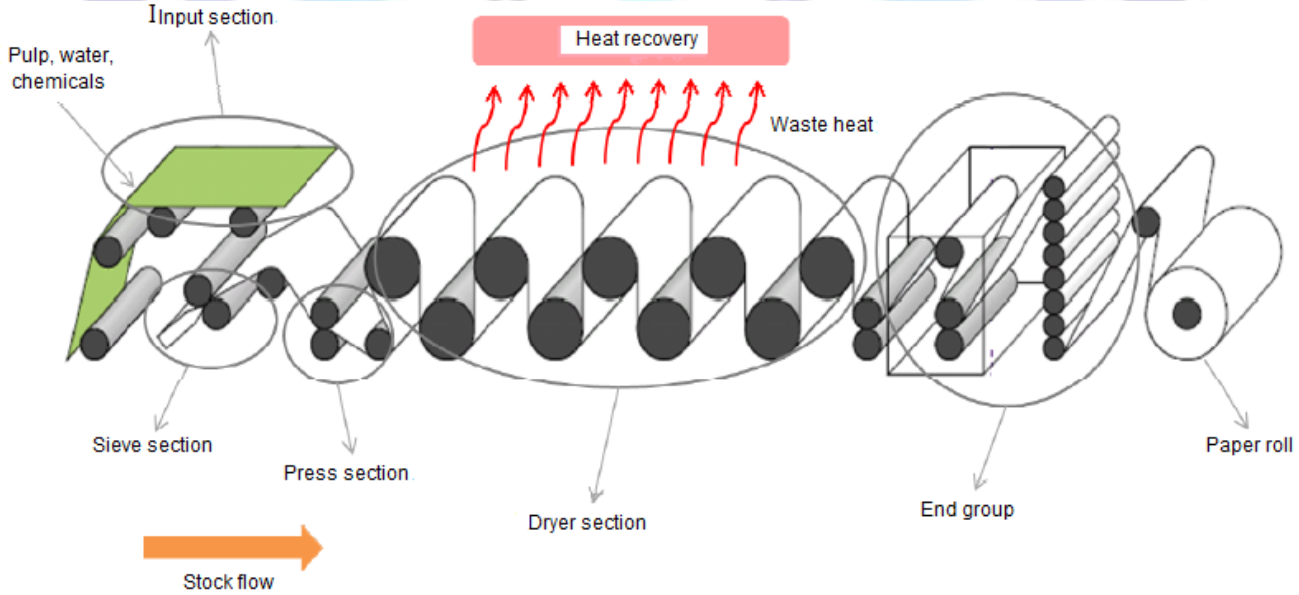

Fig.15: Principle of operation of the machine to produce paper

For efficient operation of energy of papermaking machines, installing heat recovery systems over the drying section. Exhaust air in this section, which contains hot steam is collected and reused to heat different parts of the machine to produce paper.

CONCLUSIONS

*Intensification of industrial activity has a negative impact on natural resources and the environment. To counteract this negative effect, all production systems must comply with the principle of sustainable development, ie minimize natural resource consumption and pollutant emissions, methods to allow assessment in relation to environmental and socio-economic activities leading to the more favorable product cost, expenses and contribute not only to improving the environment, and the sustainable development of society.
*LCA method, which evaluating the direct and indirect effects that occur at each stage to obtain and use a product, from extraction of raw materials to final disposal and the practical case study is demonstrated that by applying a marketing management system properly, can improve energy performance, ensure quality requirements, environmental and socio-economic costs of reducing emissions of greenhouse gases.
*Management-marketing success relies on good planning, where you can identify the objectives that lead to action/concrete actions using those tools to obtain information necessary to determine the efficiency of material and energy flows and effective measures to improve the actual performance environment.
*The EMMS can improve energy efficiency and energy performance requirements of quality, environmental and socio-economic through costs and emissions of greenhouse gases reducing.
*Energy marketing management success is based on good planning, where you can identify the objectives that lead to concrete measures/actions, use those tools to obtain information necessary to determine the efficiency of material and energy flows, and effective measures to improve environmental performance real.
*The case study analyzed, proves efficiency of energy marketing management system, because the paper industry is a viable sector with significant competitive advantages. She holds an important share in industrial production in the country and has an important contribution to the achievement of national income.
*Development is crucial for providing energy and raw materials vital to the national economy sectors: energy, transport, agriculture, chemical industry, etc.

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