ENVIRONMENTAL IMPACT OF ELECTRICITY

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Abstract*: Electricity is justly considered today as an indispensable factor of existence and development of society. Besides its incontestable benefits, there can be revealed some forms of environmental impact that, to a greater or lesser extent, create concern amongst specialists, as well as among the general public. The paper proposes an analysis of the impact on the environment of the electricity, starting from the different forms of production of electric energy, presenting also the negative environmental effects of transport, distribution, and use of electricity.*

1. INTRODUCTION

Since the beginning of electricity production and its use, the benefits of electricity have been worldwide recognized. Gradually, however, a number of shortcomings, negative effects accompanying electricity from the extraction and exploitation of energy resources to its use have been revealed.

Over time, highlighting negative effects has generated measures and solutions to reduce the negative impact on the environment. This paper reveals, in a structured form, the types of impacts associated with the generation, transport, distribution and use of electricity.

The methodology of this study combines different methods, mainly literature review, classification, data analysis and problem identification.

2. FORMS OF ENVIRONMENTAL IMPACT OF ELECTRICITY

There are many forms of impact that the energy sector produces on the environment. Of these, an important part is due to electricity, their presence being identified in the energy production phases, but also in the stages of transport, distribution and use.

The most well-known negative effects are on air, water and soil, both because their detection is easy, and because these contaminated environmental factors can substantially amplify the effects of pollution.

In addition to the thermal power plants that affect these environmental factors to a large extent, other forms of energy production have been identified that have negative environmental influences, even if they are not at the size of those caused by the thermal power plants.

Other forms of impact are also associated with activities in the electricity sector, such as noise pollution, vibration, visual pollution, waste generation and electromagnetic pollution (Table 1).

Table 1. Forms of environmental impact

Environmental impact forms / Types of activities	Air pollution	Water use and pollution	Land use and soil pollution	Noise	Vibration	Visual pollution	Impact on flora and fauna	Use of hazardous materials	Waste generation	Electromagnetic pollution
Thermal power plants	√	√	√				√		√	
Nuclear power plants	√	√						√	√	
Hydropower plants	√		√	√	√		√			
Wind power plants			√	√		√	√			
Solar power plants	√	√	√					√		
Geothermal plants	√		√							
Electricity transport	√	√	√	√		√	√			√

2.1. Air pollution

When talking about the air pollution generated by the energy field, the production in the thermoelectric power plants proves to be the worst for the environment. The amount and the wide range of emissions make this form of production the most commonly nominated in environmental impact assessments of energy. Both in the case of coal-fired power plants, and

hydrocarbon power plants, the air environment factor is the most affected.

The combustion gases of the thermal power stations generate a series of harmful emissions to the atmosphere, of which the greatest harmful effects are sulfur oxides, nitrogen oxides and ash dust.

Istrate and Guşă [1] present a wide range of techniques for the treatment of the gases emitted by the thermoelectric power plants, grouping them into three main categories:

- Pre-combustion treatment technologies;
- During combustion treatment technologies;
- Post-combustion treatment technologies.

In relation to pollutants being treated, the authors distinguish as procedures for the reduction of pollution the desulphurization, denitrification and reduction of solid emissions from combustion gases [1] (Table 2).

Table 2. Treatment techniques of emissions of thermal power plants

Treatment techniques of gaseous emissions	Type of purification techniques	Example of specific procedures
Sulphur oxides emissions treatment	Physicochemical desulfurization processes	Sulfur dioxide neutralization reactions with basic substances
	Treatment of fuels in pre-combustion phase	• Washing of coal • Hydrodesulfurization
	Combustion of powdered coal	• Limestone Additive Process
	Combustion in fluidized bed	• Combustion in stationary fluidized bed • Combustion in circulating fluidized bed
	Dry procedures	• With active coke or copper oxide • With calcium compounds • With nahcolite and trona
	Semi-dry procedures	• Semi-dry NIRO procedure • Mixt procedure
	Wet procedures	• With alkaline adsorbent • Ammonia absorption procedures • With alkaline-earth adsorbent • Hybrid procedure
Nitrogen oxides emissions treatment	Primary methods of reducing nitrogen oxide emissions	- burning in stairs, non-stoichiometric burning, optimal sizing of the furnace
	Secondary reduction methods	• Dry procedures • Wet procedures
Reduction of solid emissions	Use of filters	- mechanical filters, - acoustic filters; - wet filters, - electrostatic filters, - filters with bags made of woven or non-woven material.

Even though solar power production does not pollute air, the production of equipment and devices generates some greenhouse gas emissions. They have to be mentioned, even if

their values are much lower than other technologies. Emission estimates for photovoltaic systems in these stages are between 30 and 85 grams of carbon dioxide per kilowatt-hour.

Open loop geothermal systems generate emissions of carbon dioxide, ammonia, methane, boron, and hydrogen sulfide, which in the atmosphere are converted to sulfur dioxide, but their volume is substantially lower than that of thermal power plants.

Even hydropower plants face in operation with certain greenhouse gas emissions, the size of which varies according to the nature of the land, the size of the storage lake, and the climatic area in which they are built. So, flooding the land leads to vegetation decomposition, which leads to methane and carbon dioxide, reaching emissions of over 200 grams of carbon dioxide per kilowatt-hour [2].

Regarding the power transmission companies, they can pollute air both during construction work (suspended particulates) and during operation. Thus, sulfur hexafluoride pollution can occur due to the leakage of equipment or combustion gases emissions resulting from the generating sets or possible fires or explosions. High voltage overhead lines can cause pollution with ozone and nitrogen oxides due to Corona discharge occurring around active conductors, especially during rainy weather, but the contribution of these pollutants to the diminution of air quality is reduced [3].

2.2. Impact of electricity on water

In what it concerns the impact of electricity on water, two forms of impact can be identified: water pollution, as a result of activities in the chain of extraction, production, transport, distribution, use, and water consumption in these activities, which, in some cases, is significant.

In the case of coal-fired thermal power plants, as well those based-on fuel oil, the water flows consumed are significant, and restituted ones pollute the surface waters.

The energy production based on solar energy is associated with water consumption depending on the technology used. If, in the case of photovoltaic cells, water consumption is specific only to the production process, in that of the solar thermal collectors, it is significant in their operation. The type of equipment and cooling system influences the water consumption. For example, when using wet cooling technology with cooling towers, between 2200 and 2500 liters of water per megawatt hour of electricity are used.

Geothermal production facilities also use water for cooling and re-injection, depending on the technology used and the size of the operation. Water consumption per megawatt-hour is between 6000 - 15000 liters of water.

Also, in the transport of electric energy, can occurred accidentally effects on the water. For example, in the case of an electricity transmission company, the poor maintenance of the water-oil separators or the lack of precipitation caused the concentration of the pollutants in the internal sewerage network of the transformer stations.

2.3. Impact on land use and soil pollution

The transmission of electricity, due to the nature of high-voltage electrical installations, is associated with a significant impact on the environment through field surfaces occupied by power stations and overhead power lines.

Although there are no sources of soil pollution in normal electricity transmission activities, accidental pollution may occur during construction, installation, maintenance, such as leakage of oil, fuel, or some due to leaks, damage, failures of equipment with electro-insulating oil.

The use of solar energy for the production of electricity is also associated with land use, depending on the technology used. In the case of solar energy, the dislocation of the land depends on the technology, the topography of the site and the intensity of the solar resource.

Estimates for photovoltaic systems range from 3.5 to 10 hectares per megawatt, while estimates for concentrator collectors are between 4 and 16.5 hectares per megawatt. In order to reduce the impact, some solutions have been proposed, such as location on brownfields, lanes of the electric lines or buildings [4].

Use of wind energy to produce electricity is also associated with the impact on land use due to the location of wind turbines and the corresponding infrastructure. This is even more significant in the case of offshore facilities, thanks to bigger turbines than onshore facilities.

The lands affected by a geothermal system depend on the energy conversion system, power capacity, resource reservoir properties, wells and piping systems. the type of cooling system, the facilities required for operation [5]. However, land use for geothermal wells, pipelines and power plants is low compared to land use for other extractive energy sources such as oil, gas, coal and nuclear.

Another problem faced by geothermal systems is the land subsidence risk due to the removal of water from geothermal reservoirs. The use of open systems without the return of energy effluents in the source aquifer can lead to land drainage / compaction or surface water pollution. Restitution of water is often problematic when the water is exposed to atmospheric air or the water temperature exceeds> 50 ° C (in case of seasonal storage) [6]. Also, hydrothermal plants, the enhanced geothermal systems, are exposed to earthquake risk [5].

Hydropower plant construction and land flooding can lead to loss of forest lands, dislocation of cropland areas, erosion and sedimentation in reservoirs, soil degradation through construction. Land topography and size of generators influence the land area required to build a hydropower plant.

2.4. Noise pollution

Sounds, depending on their intensity, duration and frequency, can be considered one of the forms of pollution. Infrasound and ultrasound, at certain intensity levels, may be dangerous for humans, but also for other forms of existence.

The various activities in the energy sector are generating noise that can affect the employees of the companies involved, but also the population in the vicinity of the noise sources.

Installations and constructions specific to the transport of electricity generate noise due to the Corona discharge phenomenon around the overhead power lines, as well as the noise caused by the operation and vibration of the electrical installations. Also, during the construction of these installations, noise levels can be exceeded due to the operation of the equipment.

Intermittent, short-lived noise caused by flashover of insulating chains or switching action nearby the switching action may also be noted.

During operation, the noise generated by the operation of a wind farm creates pollution sound. The operation of wind turbines is associated with the noise produced by them: aerodynamic, generated by the turbine blade movement, and mechanical, due to the turbines themselves by their components.

2.5. Impact on vegetation and wildlife

There are a series of pollutants generated by the thermoelectric power plants with direct effects on the human body, like oxides of nitrogen, sulphur oxides, some heavy metals, carbon monoxide (respiratory diseases). Sulphur dioxide, sedimentary dusts, as well as different combinations of chlorine and hydrogen have direct effects on the vegetation. Carbon dioxide and nitrogen dioxide contribute to the greenhouse effect.

Sulfur dioxide contributes to the formation of acid rain with harmful effects on vegetation, forests, crops, watercourses and lakes. Acid particles formed can cause lung and heart disease [7].

Near the very high voltage lines, genetic and reproduction changes have been observed in some plant species.

A problem faced by hydropower developments is that of retention in accumulation lakes of sediments and increase of nutrient volumes. This leads to the multiplication of aquatic weeds that endanger the existence of other species of aquatic flora and fauna.

There is a risk that, at certain periods of the year, if the amount of water stored in the reservoir is high, some portions of the downstream river to be dried, with negative effects on animal and plant species. The risk is also amplified by the evaporation process that is more

pronounced in the reservoir area.

Due to the excess atmospheric humidity in the area, climatic disturbances can be caused by lowering the average zonal temperature and frequent foggy weather.

There are number of studies that have analyzed the effects of wind turbines on fauna, especially on birds whose habitats are affected. Changes in air pressure due to turbine blades have also been identified, with effects on their existence. But the most severely affected are by the collisions with the moving wind turbines. Negative effects have also been identified on fish and marine fauna [8].

Although the negative effects of the hydrokinetic systems have not yet been identified, there are some hypotheses about the potential impact on the environment. The need for extended marine space for wave energy equipment or the possible damage caused by these to aquatic habitats, as well as possible changes in salinity and hydrology can pose dangers to marine life.

Wave energy devices and associated cables can have negative impact, interfering with movements of whales and other large animals. More, they can alter sediment transport affecting benthic habitats, beach geomorphology, and intertidal ecology [9].

2.6. Visual pollution

Visual pollution is primarily determined by electricity transmission activities. In the same category, wind turbines are also registered.

As well, under certain lighting conditions, wind turbines can create the so-called shadow flicker effect [8].

2.7. Electromagnetic pollution

High and very high voltage installations cause the appearance of an electromagnetic field around them, the intensity of which varies with distance and voltage.

In the case of installations, constructions and equipment used in energy transport, the phenomenon of electrical induction can be revealed in metallic structures not connected to the earth and, also, radio interference phenomena.

In a study, Popescu [10] points out that because of parasitic radiation of high voltage lines, transformation points, radio-TV transmitters, radars, communications systems may pose dangers to the human body, especially organs slightly irrigated with blood (eye, bile, spine, etc.). The effect of electromagnetic fields on biological organs is dependent on the intensity and frequency of the field. He highlights the occurrence of the thermal and electrochemical effects.

According to the European legislation, transposed in Romanian legislation, two categories of effects of the electromagnetic field on the human body can be identified: direct

and indirect effects, *figure 1*.

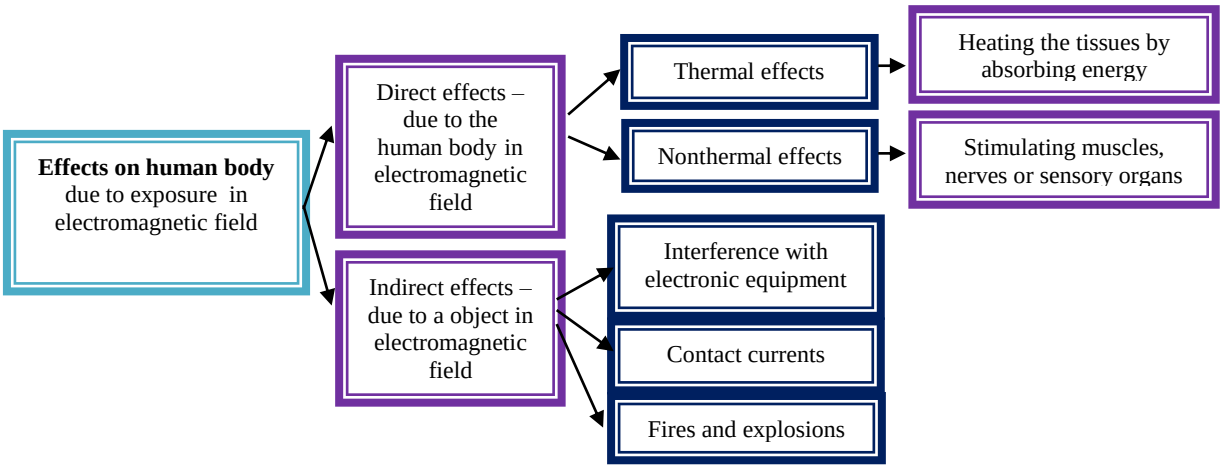

Fig.1 Effects of exposure of human body in electromagnetic field

In what it concerns electromagnetic influences on the environment, Nicolaescu [11] also groups them into two categories. In the category of direct influences of the electromagnetic field, there are ecological perturbations on plants and animals, pollution by the electromagnetic induction effect, as well as by the accidents it can produce. As indirect influences, the author highlights noise pollution, indirect environmental pollution, air ionization, and radio-TV broadcast disruptions.

2.8. Use of hazardous materials

In the production of photovoltaic panels, several hazardous materials are used, depending on the cell type, such as acetone and acids: sulfuric, nitric and hydrochloric. They also contain a few toxic materials.

The potentially hazardous elements (Hg, B, As and Cl) produced in the geothermal solution are largely injected back into the production tank.

2.9. Waste generation

Among the activities in the energy sector, the largest generators of waste are the thermoelectric power plants. They generate solid and liquid waste, with negative effects on soil and water.

Of the solid waste, the most important are slag, ash and various compounds used in the purification processes. Liquid waste results from the treatment of the water used in the thermal circuit, the cooling water, the leakage from the main circuit, and the liquid lubricant residue.

Although electricity transport activities do not generate waste, the occasional existence of waste as a result of certain maintenance or construction works can be highlighted. If some

of these can be considered non-hazardous, there is also a range of hazardous waste for the environment: hazardous electric and electronic equipment, waste oil, accumulators, batteries, sludge from water-oil separators, various materials contaminated with hazardous substances, etc. [3].

Another major source of waste is represented by the nuclear power plants. In Romania radioactive waste is classified into six groups: exempt waste, transition, very low activity. low and medium activity of short life, respectively long life and high activity waste. The last 4 types have storage restrictions, requiring special high depth deposits to provide radiological barriers between radioactive substances and the environment [12].

Nuclear reactors used in the production of electricity produce radioactive waste not only during operation, but also after their shutdown or decommissioning. The author presents several radioactive waste management solutions: reducing the amount of radioactive waste by compaction or using a wet air pollutant filtering installation in combination with a liquid radioactive waste treatment facility that can treat the resulting mud instantly; or by accumulation in special tanks.

3. CONCLUSIONS

In the energy sector specific activities, a wide range of impact forms can be highlighted both during the construction of installations and facilities, as well as during the operating period.

If the negative influences identified during the construction phase are present for a limited period, relatively short, in the case of influences during the operating period, they are maintained over the lifetime of the equipment.

In some situations, the impact can be increased with the depreciation of the installations. For this reason, it is necessary a permanent monitoring of the values of pollution indicators.

In what it concerns the construction of energy facilities and equipment, the legislation of many countries requires that, since the design period to be identified the forms of impact they will generate in construction and operation, as well as measures to diminish these negative influences.

In order to identify, to analyse the negative effects produced and to find suitable solutions, there are necessary collaborations between specialists from different fields: electrical engineering, medicine, biology, geology, chemistry, physics and statistics.

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