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DOCTORAL THESIS

COMPARATIVE ANALYSIS OF THE ECO-ENERGY EFFICIENCY FOR MICRO-HYDRO AND COAL-FIRED POWER STATIONS

SUMMARY

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CONTENT

INTRODUCTION

The existing antagonism between the continuous increase of the demand for energy against the background of the demographic explosion and the need to reduce the emissions generated by the burning of fossil fuels, given that worldwide 40% of the energy is provided by them, is also specific to Romania, especially nowadays. coal plays a major role in the national energy mix.

Hydropower is the type of renewable energy used most frequently, Romania benefiting from a high potential of hydropower resources. As micro-hydroelectric plants have a lower carbon footprint, they are often promoted in response to the significant reduction of greenhouse gases and thus to mitigate the effects of climate change. However, the negative environmental effects of micro-hydro power plants should not be underestimated, even if they are promoted as energy sources with low environmental impact.

Although the micro-hydroelectric plants have a small capacity, they affect the natural flows of the rivers, which normally provide large waters imposed by the melting of the snow in the spring and summer and small waters caused by the low rainfall during winter and autumn, thus giving the mountain rivers a character unique dynamic. Changing this natural dynamics negatively affects the fauna and flora of the entire aquatic system, as well as the riparian ecosystems. At the same time, the accumulation dams limit the natural dynamics of the river, because downstream of the accumulation lake the river remains with a small flow of water, upstream the sediment transport is affected, and the volume of water in the accumulation lakes varies according to the requirements of the energy system.

In the current context, characterized by an alarming increase in the complex pollution caused by obtaining energy from coal burning, major attention must also be paid to the power plants and the analysis of the opportunity to reduce the dependence on fossil fuels used as a raw material base. The energy installations that use coal as fuel influence the environment, affecting the ecological balance not only in the location areas, but also imposing a complex impact on all the environmental factors in the area around them.

Starting with 2017 the European Union has set new regulations on industrial emissions, the deadline being 2021, aimed at protecting the health of the population and the environment by reducing the pollution emitted by the energy industry. The regulations are more restrictive than those at present and are aimed at reducing pollutants, such as suspended particles, carbon dioxide, nitrogen oxides, sulfur dioxide and mercury, which are harmful to human health.

Taking into account the important role that the power plants play in the energy mix due to the security they offer compared to the renewable sources, at national, European and global level, it is necessary that the two categories of resources be achieved in a fair way for the population. , but also for the environment.

I. PURPOSE OF THE WORK AND THE RESEARCH METHODOLOGY

The choice of the topic of the doctoral thesis took into account the continuous concerns regarding the protection of the environment, which are of importance, both theoretical and practical, considering relevant the deep analysis of the connection between two of the most important fields of energy recovery, hydropower and thermal energy, on the one hand, and improving environmental issues on the other.

The purpose of this work is precisely the complex analysis of the two types of energy production, which will allow the concrete identification of that energy source that works favorably in a certain geographical area, in accordance with the environment and efficient for the population.

In this respect, case studies were defined, namely the micro-hydroelectric plants on the Buda and Capra streams in the upper basin of Argeş, respectively the Govora thermal power plant and its coal supplier, the Berbeşti mining basin.

The need of the thesis lies in the fact that its resolution will show whether the location of micro-hydroelectric plants is timely and efficient from an eco-energy point of view and if it has an essential role in the economic development of the area. Also, the analysis of the Govora power plant and the Berbești mining basin is necessary, as it is possible to determine the extent to which a traditional power plant is currently energy efficient, and to keep it in the energy mix it is important to look at whether it is necessary to re-technologize it.

In this context, it was considered that a complex analysis of two main energy sources, thermo-energy and hydropower, as well as finding indicators by applying which can be compared the impact generated on the natural environment by the two different forms of energy production, reported on environmental, economic and social issues.

The final aim of the study is to determine the eco-energy efficiency and validate either a larger number of micro-hydroelectric plants, with cumulative effects due to the arrangement on the same river, compared to the refurbishment of older thermoelectric power stations, or to establish the recommended alternative for optimizing the production capacities of the power plant and reducing the impact. on the environment.

In this respect, the complex objectives of the power plant and the mining basin that supply it, as well as of the micro-hydroelectric plants, have been established as main objectives. Analyzing comparatively the obtained information aims to determine indicators that allow the establishment of the eco-efficiency of the two distinct energy sources, in the context of a certain geographical space in which they are implemented, taking into account, at the same time, the economic and social impact.

The proposed research methodology comprises a set of specific activities, among which are mentioned:

- the knowledge of the fundamental data by consulting the works that are indicative in the field;
- up-to-date documentation of the specific bibliography and the scientific literature itself, making reports on the continuous observation of reality;
- displacement in the field, both in the mountain area of the Argeş river, as well as in the area of the Govora power plant and the mining basin that supplies it with raw materials;
- direct measurements of the basin elements and of the mining area;
- observation, following climatic and hydrological parameters, modification of the biotic, pedological cover;
- specifying the aspects related to the flow of the flowing water, the relief in the area, the flow and the water quality of the streams;
- qualitative and quantitative approach to data and information collected from the field;
- analysis and processing of data collected from the field, systematization and structuring of the obtained results;
- comparative analysis and obtaining support for the final conclusions.

II. STRUCTURE OF THE DOCTORAL THESIS

The paper "Comparative analysis of the eco-energy efficiency for micro-hydro and coal-fired power stations" presents in detail two distinct energy sources, having as a case study the Govora power plant with the mining basin that supplies it and the micro-hydro power plants in the upper basin of the Argeș river. By solving the doctoral thesis, the aim was to establish the efficiency of each of them in the context of the complex impact that they manifest on all the components of the environment.

In accordance with the objectives of the thesis, I have structured the text into seven chapters, with a balanced weight and spread over 230 pages. Each of the chapters has its own importance in dealing with the research topic and has been divided into several sub-chapters, which, in their turn, we have divided according to certain well-defined criteria.

The first chapter, "The analysis of the energy strategy at national and European level", is based on a careful follow-up of the directions of evolution of the Romanian energy sector contained in the document that defines the vision of this field and sets out the main energy goals and policies of our country, namely " The Energy Strategy of Romania 2019-2030, with the perspective of the year 2050".

This programmatic document indicates the major landmarks of Romania, as well as the European and global ones, which influence and determine energy policies and decisions.

The second chapter, "Location and operation of micro-hydroelectric plants", includes essential information on the location of micro-hydro-power plants on two of the tributaries of the Argeș river in the area of the springs, namely the Capra and Buda streams, as well as details on the

geomorphology, geology and hydrogeology elements of the region, the hydrographic network, the climatic regime, the terrestrial and aquatic ecosystems, the anthropic activities and the description of the operation of a micro-hydroelectric plant.

The third chapter, "The impact of micro-hydroelectric plants on the environment" is dedicated to identifying and evaluating the most important consequences generated by the placement of hydroelectric power stations on mountain rivers on the main components of the environment, illustrating the real and potential disturbances generated by the implementation of these projects.

The fourth chapter, "Location and operation of the coal-fired power stations and the coal supplier", contains essential information on the geographical location, elements of geomorphology, geology, hydrography, hydrology, the climatic regime and the biopedogeographic envelope of the Govora CET area and the Ber basin. where does the fuel that supplies the power plant come from.

At the end of this chapter I described in detail the functioning of the Govora power plant, presenting at large the constructive elements.

As the energy sector is considered the main source of pollution of the environment, the protection and conservation of the environment representing a concern of national, economic and socio-human interest, we have presented in this chapter the types of emissions from the power plant and from the mining basin, the exploitation in coal quarry generating a complex impact on all environmental components in the area.

In chapter five, "The impact of the power plant and the lignite quarries on the environment", based on the information obtained in the previous chapter, we allocated a significant part to the application of the tools for identifying and evaluating the impact, respectively checklists, networks and impact matrices.

In chapter six, "The global impact index and the hierarchy of environmental components", we set out the methodology used to calculate the global impact index, which makes it possible to identify the environmental state based on a relationship between the natural or ideal state and the existing state at a at one point, the main quality indicators specific to the environment under study.

In chapter seven, "Comparison of the two forms of energy production from an eco-energy point of view", we also included the basic characteristics of the micro-hydroelectric plants and the power plant, which play an important role in the approach taken, as they allow me to alternatively follow the two energy sources.

In this respect, we calculated the amount of energy produced, the production costs, the selling price of one kWh the population served and the degree of certainty regarding the energy supply in the National Energy System for each of the two energy sources.

The end of the chapter supports the initial hypotheses and establishes the extent to which the environmental quality changes generated by the two energy sources analyzed can be compared, by

identifying and applying three indicators, respectively: the energy efficiency indicator (K1), the social efficiency indicator. ecological (K2) and energy efficiency indicator (K3). The three indicators were designed in such a way as to allow the comparison of the energy performances related to the environmental impact.

III. CONCLUSIONS

The conclusions that can be drawn from this paper can be divided into two categories, namely: conclusions regarding the quality of the environment in the two areas under analysis and conclusions regarding the results indicated by the three indicators proposed to be used for comparing different energy sources.

From the qualitative analyzes of the samples taken from the water of the Capra and Buda rivers, based on the measurements and observations from the field, as well as using the results of studies carried out in the investigated areas, a worrying conclusion is drawn, that although impact studies have been carried out and followed constantly reducing the impact of hydropower activities, the tributaries of Argeș continue to be adversely affected, and the final result materializes in the degradation until the disappearance of the ichthyofauna on certain sectors of the two streams.

As a result of the environmental quality assessment in the area of the Berbești mining basin and the Govora power plant, a real improvement has resulted, due to the efforts of the two economic agents to modernize the technologies used and to align to the current European standards the industrial society on the one hand, but and by the quantitative reduction of the activities carried out, on the other hand. However, the direct and indirect effects on the environment manifested by the activities carried out are significant and it is necessary to use the best technologies available to ensure the continuity and maintenance of activities with age and tradition in the area.

A common problem in both cases is the one related to the degradation of the landscapes as a whole and the real decrease of the tourist potential of the area, especially in the case of micro-hydroelectric plants. It is necessary to implement measures to manage the resulting artificial landscapes and programs to monitor all the activities carried out, aimed at optimizing the quality of the environment in general, and that of the areas in particular.

As the micro-hydro and thermo-power plants represent two different energy sources as a way of functioning, raw material used and manifestation of the impact on the environment, it was a challenge to identify ways to compare the magnitude of their influence on society and the quality of the environment, with all its components.

Equally, attention must be paid to thermal power plants and mining operations, which irreversibly transform and influence the natural environment, exerting a strong pressure on nature and its resources, but which can be refurbished and modernized to integrate into the broader concept of sustainable development. elected that by acquiring the status of full member country of the

European Union, starting in 2007, Romania is facing the obligation to adopt European norms in the field of environmental protection and implicitly to monitor its quality.

Analyzing comparatively the two distinct energy sources, I was able to obtain a complete picture of the situation regarding the quality of the environment and the current socio-economic aspects involved in the location of the micro-hydro power plants present in the mountain area and the functioning of the power plants with old traditions.

From the analysis of the results obtained by determining the three indicators proposed for the comparison of the two different energy sources, it turns out that the micro-hydroelectric plants that have a small capacity, have a major influence on the components of the environment, a fact also supported by the value of the global impact index, which is between 1 - 2 (Iig = 1.87), which indicates an environment affected within permissible limits, but very close to the value 2, which indicates the discomfort of the life forms.

As a result, we must not overlook the many negative environmental issues, such as changing the flow of brooks, the configuration of the brook, the long-term damage to the aquatic and riparian ecosystems, which cannot be improved under the functioning of the micro-hydroelectric plants. A complex analysis is required regarding the opportunity of placing the micro-hydroelectric plants on the small mountain rivers, as they have a yield of 71% and produce a relatively small amount of energy that is injected directly into the National Energy System.

From the point of view of energy efficiency, the functioning of the micro-hydroelectric plants analyzed leads to the destruction of the natural ecosystems, ensuring small amounts of energy in relation to the impact generated, raises problems from the point of view of the energy supply of SEN due to the efficiency and unpredictability of the production. At the same time, the natural dynamics of the river is limited by the numerous accumulation dams and the volume of water stored in lakes, which varies depending on the requirements of the energy system. It results in a small flow of water downstream of the lake of accumulation and modification of sediment transport upstream.

By comparison, the Govora power plant that uses coal as a fuel influences the environment, profoundly affecting the ecological balance in the area where it is located and generates a complex impact on environmental factors; impact materialized by a global impact index of 2.36. This value indicates that the operation of the Govora power plant generates an impact that causes discomfort to the life forms in the area and its surroundings.

If we take into account the high energy production and the efforts supported by the major investments in modernization and the rigorous maintenance of the Govora cogeneration power plant, the existing and future measures to limit the impact on the environment, we can appreciate that the power plant has a high energy efficiency and it may continue to be a significant segment of the Romanian energy mix, due to the safety it offers compared to renewable sources.

Although the power plant has higher emissions, through higher energy production, higher efficiency, sustained by cogeneration, and the large number of beneficiaries, it has higher energy efficiency and offers security in the supply of the National Energy System, imposing the proper emission management. of carbon dioxide for limiting the impact manifested on the environment, consistent material investments, refurbishment and modernization of existing installations, highly selective exploitation of raw materials.

Micro-hydro power plants also have a significant role on the energy market, which is especially useful if they can contribute to the energy supply of isolated households, especially in the high mountain areas, who do not have access to the national electricity distribution network.

In this way, it is possible to ensure the supply of the network in an insularized system, on the basis of conservationist principles and the legislation in force accepted for the areas protected by law. In the current European context, priority must be given to renewable energy sources and technologies that have the least negative impact on the environment and biodiversity, taking advantage of the advantage related to certain geographical or climatic situations in order to ensure a beneficial result for the population.

It is important that the location of a micro-hydroelectric plant and the arrangement of the storage basin are also studied some of the possibilities of multiple use of the respective hydropower management, namely, in addition to the main energy purpose to intervene in the subsidiary and recreational-sports activities such as fishing, rafting, activities tourist, boat trips, drinking water supply of isolated households and water catchments for irrigation.

The power plants have superior energy efficiency through cogeneration energy production, under the conditions of modernization, refurbishment and ensuring a rigorous maintenance, having as priority ecological criteria that can ensure a high degree of protection of the population, as well as the environmental factors involved, through the real reduction of emissions.

IV. OWN CONTRIBUTIONS

We have prepared numerous maps made with GIS technology, for the presentation and capitalization of the information and numerical data obtained from the field trips: the map with the framing of the studied area at the country level, the map with the positioning of the analyzed area within Arges county, the map with the positioning of the area at the region level. , map with the location of MHC on Capra and Buda streams, map of relief units in the Argeș basin, geological structure map, soil map, vegetation map, map with the location of Capra and Buda basins in Natura 2000 site - ROSCI0122, map of the Argeș river hydrographic area, map with the location of the MHC on the Capra stream, map with the location of the MHC on the Buda stream, map with the location of CET Govora in the county, map with the location of CET Govora in relation to the protected areas, map with the location of the mining basins in Oltenia, map of the quarries and

dumps in the basins Berbești mining, mapping of the Capra and Buda, the location on the cartographic support of the MHC on the Capra and Buda rivers.

The unique mapping supports include measurements and mapping made in the Capra and Buda river basins and they have tracked the individualization of the micro-hydroelectric plants on the map, the distances between them, the location of the confluence with other tributaries, the type and quality of the vegetation, the fauna, the soil, the measurement of the riverbed, the location and the size of the accumulations. , fish ladders, dams or bottom thresholds. The maps from the Berbești mining basin were based on information obtained in the field, as well as statistical data taken from CET Govora.

We have inserted in the work numerous images, from the personal archive, in which are presented the 12 micro-hydroelectric plants, images with the accumulation dams on the Capra and Buda streams, field images with the component elements of a micro-hydroelectric plant, images from the Berbeşti mining basin and from the thermal power plant. Govora.

For the identification of the impact generated by the micro-hydroelectric plants, the power plant and the mining operation on the environment we used checklists and the impact networks, and for the evaluation of the impact generated on the environment we used impact matrices.

We determined the global impact index and elaborated the charts for the power plant, the mining operation and the micro-hydroelectric plants.

We have designed and defined three indicators that allow the comparison of the two forms of energy production: the indicator of eco-energy efficiency (K1), the indicator of socio-ecological efficiency (K2), the indicator of energy efficiency (K3). These indicators allow the establishment of sustainability criteria based on concrete values determined for each energy source, including in this case the micro-hydroelectric power stations, the renewable energy source and the thermal power plants, an exhaustible source. The proposed energy efficiency indicators will serve to validate that project that is required in a certain area, locally, but also nationally, to optimize the purpose for which it was achieved and the environmental performances in the area. Thus, feasibility studies and impact studies should be carried out that contain these indicators and that will allow the avoidance of sensitive areas from the point of view of local biodiversity and implicitly the appearance of major conflicts with the existing species and habitats of conservative interest. In this way, the nature conservation needs are taken into account and the aquatic and forest ecosystems can be maintained in optimal conditions.

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