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ANALYSIS OF POTENTIAL RENEWABLE ENERGY SOURCES IN THE MUNICIPALITY OF PLJEVLJA IN MONTENEGRO

ANALIZA POTENCIALA OBNOVLJIVIH VIROV ENERGIJE V OBČINI PLJEVLJA V ČRNI GORI

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Keywords: renewable energy sources, hydro energy, biomass, biogas, solar energy, wind energy, Municipality of Pljevlja

Abstract

Renewable energy sources include all sources of energy obtained from natural processes, such as wind, solar energy, hydropower, biomass, and geothermal energy. They are the only inexhaustible sources of energy and simultaneously have the least detrimental effect on the environment.

This paper reports on an analysis of the potential of renewable energy sources in the municipality of Pljevlja, in Montenegro. The strategic plan is the production and use of clean energy that would have a positive impact on the environment throughout the municipality. In addition, the introduction of new technologies for the exploitation of energy resources opens the potential for new jobs. This method of managing renewable resources would enable the more efficient and healthier use of electricity.

This analysis requires the collection of current data, obtained from existing projects, and evaluating and integrating them into a whole. In addition to the analysis of the existing situation of the exploitation of renewable energy sources in Pljevlja, reasons for or against their use are also presented.

The project supports environmentally friendly technologies for the production and consumption of electricity generated from natural resources, which is urgently needed in the municipality of

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Pljevlja, because it is quite polluted due to the negative impact of the existing methods of generating electricity.

Povzetek

Obnovljivi viri energije vključujejo vse vire energije, ki jih zajemamo iz stalnih naravnih procesov, kot so veter, sončno sevanje, hidroenergija, biomasa, geotermalna energija. Oni so ne samo edini večni vir energij, ampak so za okolje tudi najmanj škodljivi.

Projekt se nanaša na analizo potencialov obnovljivih virov energije v občini Pljevlja ki se nahaja v Črni Gori. Strateški načrt je pridobivanje in poraba čiste energije, ki bi imela pozitiven vpliv na okolje v celotni občini. Poleg tega bi uvedba novih tehnologij izkoriščanja energetskih potencialov v Pljevljih odprla možnost morebitnih novih delovnih mest, kar predstavlja tudi pozitiven vidik za prebivalce. Takšen način vodstva z obnovljivimi viri bi omogočil učinkovitejšo in bolj zdravo rabo električne energije v občini Pljevlja.

Naloge sem se lotila tako, da sem predhodno zbrala podatke, ki sem jih pridobila na osnovi že znanih projektov in meritev, in vse skupaj združila v celoto. Poleg že znanih analiz trenutnega stanja izkoriščenosti obnovljivih virov energije v občini Pljevlja, so predstavljene tudi možnosti izkoriščanja le-teh v omenjeni občini, kakor tudi razlogi za ali proti izkoriščanju obnovljivih energijskih virov.

Projekt podpira okolju prijazne tehnologije proizvodnje in porabe električne energije, pridobljene na podlagi naravnih virov, kar je v občini Pljevlja nujno potrebno, iz razloga ker so Pljevlja mesto ki je precej onesnaženo zaradi negativnega vpliva dosedanjega načina proizvodnje električne energije na tem področju.

1 INTRODUCTION

When planning for the future of any country within the global economy, it is vital that each country be capable of independently meeting its energy needs. The production of energy is one of primary sources of greenhouse gas emissions; consequently, alternative (renewable) sources of energy play a key role in the production of electricity and heat with little or no CO_2 emissions. In order to reduce dependence on fossil fuels and imported energy, many countries have started programs for the exploitation and development of renewable energy sources.
The Municipality of Pljevlja is located in the north of Montenegro, near the border with Serbia on one side and the border with Bosnia and Herzegovina on the other. It is located in a valley surrounded by mountains, which impede the air flow rate. Pljevlja occupies an area of 1346 km², which represents 10% of the entire territory of Montenegro; it is the third largest municipality in the state.

Figure 1: *Characteristics of Pljevlja*

The location hinders easy transport links, and the local economy depends primarily on the thermal power plant and coal mine, which are the main sources of income and employment of citizens. Agriculture is poorly developed; other natural resources have not been sufficiently exploited, [1].

2 METHODS OF ANALYSIS

The basis of the project is collecting data obtained from existing projects, and evaluating and then grouping the date into a whole. In addition to the data collected, I have made an analysis of the full potential of renewable energy sources, as well as the extent of their utilization in Pljevlja.

Hydropower - Through the analysis of hydropower, I have concluded that Pljevlja has serious potential for drinking water and the potential for the construction of hydropower infrastructure (mainly small hydropower). In terms of the water supply, the Tara and Cehotina Rivers are significant flows. Utilization of hydropower would occur on the Cehotina River downstream from Pljevlja to the border with Bosnia and Herzegovina. The Cehotina is a tributary of the Drina River and is the northernmost river in Montenegro, with a length of 124.5 km. The estimated gross energy potential of the river is 463 GWh. To date, there have been several possibilities for exploiting the energy potential of the Cehotina River, i.e. for the construction of small hydropower plants. Regarding the current status of utilization of water resources, the beginnings of exploiting water power date back to the 1980s, when a dam was built on the Cehotina in Otilovici. The main objective was to provide sufficient water for the cooling generator units of the Pljevlja thermal power plant. Currently, it is the only hydropower plant in Pljevlja, [2].

Biomass - Pljevlja has available a certain potential of biomass that has not exploited. The total area of the municipality is 134,600 ha, of which forests and forest areas occupy 79,458 ha or 59%.

Table 1: *Capacity and agriculture statistics in Pljevlja [3]*

Capacity of agricultural land	Surface (ha)
agricultural	55,161
forests	**79,458**
TOTAL	134,619

The capacity of the forests in the municipality of Pljevlja is 11,394,824 m³, of which 11,181,667 m³ is state-owned. Among conifers, spruce is the most common at 66.6%, then fir at 21% and other conifers at 14.4% (black and white pine). Most of the entire municipal area is occupied by forests, which is a favourable condition for woodworking, the development of small enterprises processing wood, the utilization of wood waste and the processing of waste into briquettes (for heating and biomass). The largest wood processing company is called Vektra Jakic; there are also a several smaller companies. Large areas have been covered with wood waste, which is produced in the company.

Figure 2: *"Black points" of biomass in Montenegro, [4]*

In the previous fifty years, a landfill was made, containing 150,000–200,000 m³ of wood waste, which is an "ecological bomb" that would release large amounts of carbon monoxide in case of arson and would simultaneously endanger the local environment. The enterprise Vektra Jakic is polluting the atmosphere with boiler flue gases. According to the current practice, wood waste is not disposed of properly, but is left in the open, and the incurred methane is released into the atmosphere. The issue of waste wood is a significant problem, which is usually referred to as "black points" of biomass in the municipality of Pljevlja. No system exists for obtaining energy from biomass, although given the current conditions, it would be beneficial to use such energy for home heating, [3].

Biogas - Biogas is one of the least explored potentials of renewable energy sources in Pljevlja. Currently, there is no facility for obtaining biogas. Although there is a certain amount of municipal waste and waste from agriculture, this energy source is completely ignored. In addition, the amount of waste that could be used for such purposes is not known. All this has a bad influence on residents and the municipality. Instead of obtaining environmentally friendly energy, much of this waste is discarded and disposed of in landfills outside the city, which are a serious problem for the environment. All citizens should be aware of the negative impact of landfills, primarily for the protection of the environment in which they live. It is necessary to analyse the potential and possibilities of utilization of biogas in Pljevlja, in order to enable the production of biogas and also reduce environmental pollution.

Solar energy - Pljevlja's potential in terms of solar energy is entirely unexplored. At the municipal level, as well as at the state level, no data have been obtained from measurements; consequently, there are currently no possibilities for using solar energy in Pljevlja. Not only in the municipality, but also in Montenegro, solar energy is a renewable energy source that does receive sufficient attention. Montenegro has no solar power plant. On the south of country, solar energy is used for heating water. To date, in Montenegro exist only nine public buildings equipped with solar cells and about 190 similarly equipped rural houses. However, such use of solar energy does not exist in Pljevlja. To start using solar energy, it is necessary to make accurate measurements of it, and to make plans for its proper utilization. According to the experts, the Pljevlja area probably is not suitable for the construction of solar power plants to generate electricity; however, energy can be obtained in large quantities from solar collectors for household needs and the needs of tourists, [5].

Wind energy–The Municipality of Pljevlja is not suitable for the use of wind energy, because the average wind speed is too low (0.5–0.2 m/s). Wind energy could be exploited on the mountain tops and ridges. If windmills were set up in these areas, they would be turbines for weak flow, and small for rated power. Due to the lack of data, it is difficult to assess the real potential of wind and possibilities of its utilization. Existing data are primarily from meteorological stations, where the wind measurements were not carried out at different heights and at the heights at which windmills operate. Because of this, it would be advantageous to make more detailed and accurate measurements at locations that could be appropriate for windmills. However, setting up large fields of windmills in this area would not make sense, because the wind potential is not sufficiently large to justify such a step, [6].

It can be concluded that Pljevlja exploits renewable energy sources to a very small extent (the existing Otilovici hydropower plant). The reason for this is simply the fact that the potentials remain under-explored. The main problem is the lack of funding for the development of projects, coupled with a low awareness of the citizens about the positive effects of electricity production from renewable energy sources.

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3 RESULTS AND DISCUSSION

Analysis of the potential of renewable energy sources says that they can have a highly significant role in the energy balance of the municipality, also at the state level. However, there are many obstacles that prevent wider use of renewable energy sources in Pljevlja, for example, very low prices of traditional energy sources and fuel, not enough investors interested in particular technologies, the lack of a legal basis for using renewable energy, and finally an uninformed public that is not aware of the possibilities of using the renewable energy sources.

Pljevlja is an industrial centre, which produces large amounts of energy via a thermal power plant and coal mine. However, my idea is to find an alternative that will represent a safer, more efficient more adaptive method of electricity generation.

In addition to the analysis and research potentials of renewable energy, a plan for their development in Pljevlja can also be created. Currently, hydropower and biomass energy are available. Other energy sources have not been sufficiently explored, so it is not possible to plan for their further exploitation. For the development and use of the energy potential of biomass and water, it is necessary to do a feasibility study and to make an assessment of the implementation of certain activities, both from a technical as well as an economical perspective.

Planned methods of development of renewable energy sources in Pljevlja:

- hydropower - the construction of a small and medium HPP,
- biomass – district heating project;

Hydropower

In Pljevlja, small streams are a highly important part of the hydro potential. Of all the existing small streams in Pljevlja, two have serious potentials that have been partially explored. Based on that, I set some assumptions about the possibilities of using these two streams for energy purposes. The Gotovusa River is the right tributary of the Cehotina, and at that place it is possible to build a dam. The left tributary of Cehotina is called the Rijeka. The canyon of the Rijeka River can be used for a small hydropower plant.

There is also a possibility of building medium-sized hydro power plant on the Cehotina. In all of the documents on the use of water power, the Cehotina is seen as potentially having a hydropower facility. In addition to the existing Otilovici hydropower plant, there are two more possibilities of building medium hydropower plants on the Cehotina. There are some alternative solutions that would be adapted for construction.

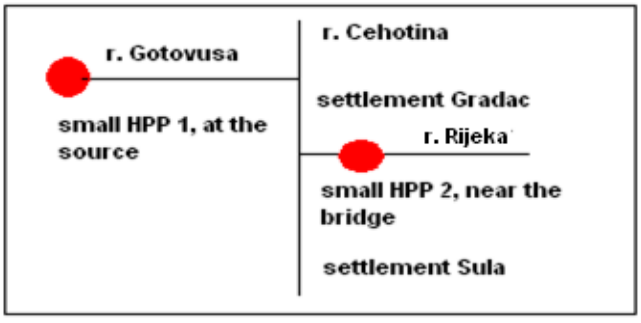

Figure 3: *Situation along the Cehotina, Pljevlja*

Variant 1: According to this variant, construction of downstream reservoirs, called Gradac and Mekote is predicted. However, if we pay attention to the amount of water in the direction of flow rate to the Drina and the possibility of building a larger tank, it would be ideal to take into account the second variant.

Table 2: *Variant 1- presentation of basic data for the HPP Gradac and HPP Mekote*

Name of HPP	Category	Length performance (km)	Q_{med} m^3/s	Q_{inst} m^3/s	H_{b} (m)	H_{n} (m)	P_{i} (MW)	E_{ann} (GWh/year)	V_{k} (hm^3)	Elevation (masl)
HPP Gradac	derivation	4.0	12.56	38	78	70	23	65.5	85	742
HPP Mekote	derivation	6.2	15.39	38	74	62	26	70.6	74	657
TOTAL							49	136	159	

Variant 2: Bearing in mind the level of the Cehotina and its high altitude position, we can conclude that below of Gradac morphological and other conditions are such that there will be greater accumulation and a rather effective solution for the use of water in a natural way; that would require the construction of the Buk Bijela reservoirs.

Table 3: *Variant 2 - presentation of basic data for the HPP Gradac and HPP Milovci*

Name of HPP	Category	Length performance (km)	Q_{med} m^3/s	Q_{inst} m^3/s	H_{b} (m)	H_{n} (m)	P_{i} (MW)	E_{ann} (GWh/year)	V_{k} (hm^3)	Elevation (masl)
HPP Gradac	derivation	3.8	12.56	38	85	77	25	72	85	742
HPP Milovci	dam		17.18	50	119	117	50	149.7	386	650
TOTAL							75	222	471	

It can be achieved with construction of the Milovci reservoir, whereby the construction of the Mekote reservoir should be omitted.

With the construction of reservoir downstream from Mekote, on the Milovci profile a greater accumulation and a greater amount of energy are obtained; moreover, there is a possibility that the water from Cehotina can be used in the direction of the Buk Bijela reservoir. The main value of the second variant is reflected in the fact that it is possible to obtain a major accumulation at Milovci (386 hm^3), which can be successfully integrated into the environment. We can see that Version 2 (Milovci hydropower plant) is better than Variant 1 (Mekote hydropower plant) for several reasons.

Biomass – district heating project

The project concerns remote heating infrastructure, which has many advantages, including economic benefits. With this example, we use biomass as fuel.

Advantages of heating with biomass:

- It is a renewable source of energy;
- it reduces pollution;
- it enables the development of new forest regions;
- it creates jobs.

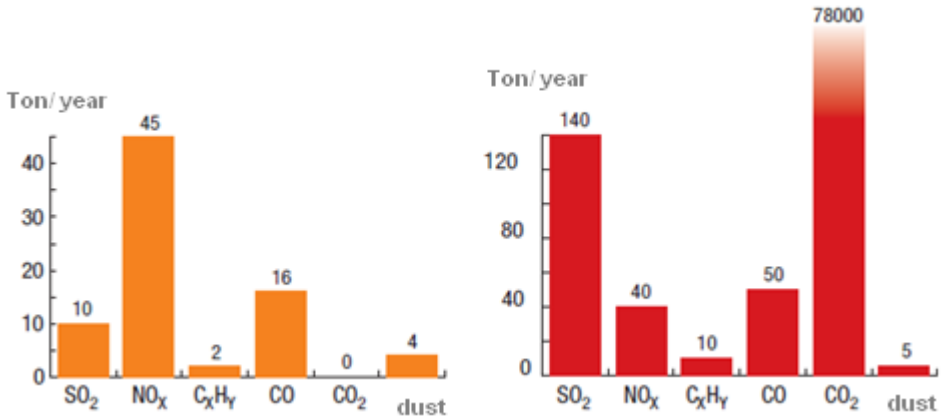

Figure 4: *Comparison of emission values in the use of biomass (left) and fossil fuels (right)*

Feasibility of the project - Currently, the heat for industry and households in Pljevlja is produced from burning coal or wood, or by electricity. Coal is the least advantageous fuel, which causes excessive pollution in winter and disrupts the ecological balance of the environment. The municipality currently provides a very low level of heating services (for ten buildings in the city centre). They are heating with outdated, inefficient boilers that are placed in garages. The furnaces are manually managed, and have unsupervised releases of gases that cause extensive air pollution. A biomass heating system in Pljevlja would increase the energy efficiency in place, visibly reduce greenhouse gas emissions and also reduce the use of electricity for heating.

Phases of the project:

- implementation of the technical works,
- implementation of the project requires significant corporate development support.

Results to be achieved:

- replacing the old heating system,
- reduction of the environmental pollution,
- improving the economic aspect,
- introduction of new products, including sales of heat.

Project organization - In places where the district heating system is not formed yet, organization of the project must start from the beginning. The aim of the first phase requires a means for

assessing the feasibility of the project. The main investor should be the European Bank for Reconstruction and Development.

Table 4: *SWOT analysis*

STRENGTHS	OPPORTUNITIES
• additional sources of revenue for the municipality, e.g. sale of scrap; • environmentally beneficial way of heating; • compared with other fuels, heating with wood is more cost effective than with fossil fuels; • the municipality has the capacity (factories, machinery) for the production of wood products.	• the possibility of obtaining resources for co-investment; • additional revenues from promotions (trips, workshops); • expansion of district heating using wood biomass to a larger region; • with good management of the wood biomass district heating system, the municipality would gain prestige.
WEAKNESSES	**THREATS**
• in case of unsuccessful leadership, the project may affect the negative financial balance of the municipality.	• weather conditions greatly affect the demand for heat; • incorrect assessment of the demand for heat; • possible weakening of the relationship between customers and providers of heat.

Timetable of activities - In accordance with the plan, the implementation of the heating system would take four years. First, the project should be evaluated; then the approval of the board of directors must be obtained for the implementation of the project. Finally, it is necessary to provide financial resources that would enable planning and project duration. If the entire documentation enumerated in the first three points was obtained, then it would be possible to start the project and its implementation in a particular territory. If everything goes as planned, the project would be completed in four years.

Table 5: *Timetable of activities*

ACTIVITIES	TIME
Assessment of the project	1st half of the first year
Approval of the board of directors	2nd half of the first year
Loan contract	By the end of the first year
The beginning of the project	The beginning of the second year
The end of the project	The end of the fourth year.

Investment part of the project

- EBRD (European Bank for Reconstruction and Development),
- the municipality of Pljevlja;

The main contributor would be the Vektra Jakic wood processing plant.

Demand for heat

The most important task of examining the feasibility of the project is to evaluate heating requirements, which depend of the number of users, regarding the revenue we expect in the final stage.

Table 6: *Before and after the installation of a biomass boiler*

	Number of existing boilers	Number of individual coal stoves	USE OF BIOMASS **(tons)**	Maintenance (€)	CO_2 emissions (tons)
Current state	18,345	69,455	-	10,000	33,359
After installation of a biomass boiler	-	-	32,941	10,000	371

Assumptions about prices of energy

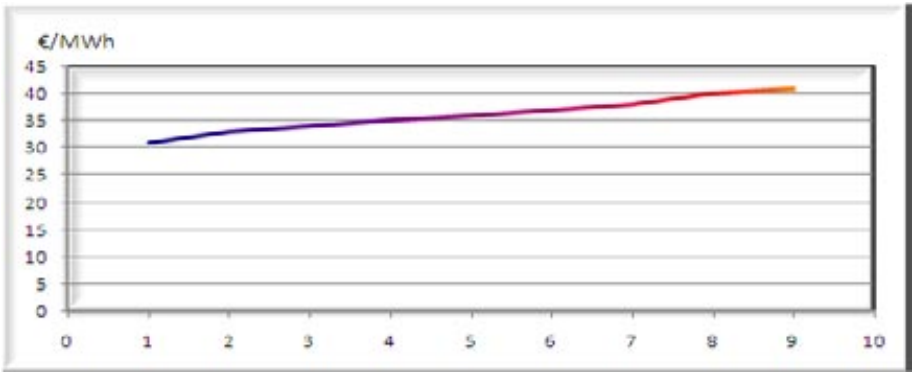

Figure 5: *Display of price growth in the following period*

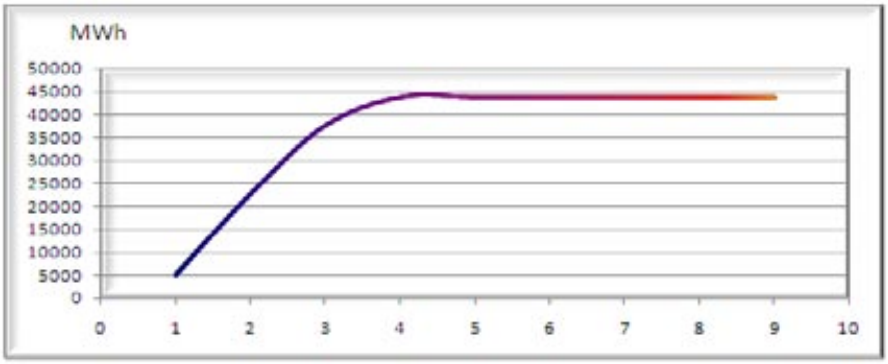

Figure 6: *Sales of heat from the district heating system*

The ratio of financial costs and anticipated savings, time feasibility of project

The costs of the financing of priority investments consist of debts, interest and compensation for debt financing, as well part of the financial capital. When the negative elements of cash flow are compared with the projected income, it is possible to calculate the time of repayment. The time when the project will be paid off is longer than the total project duration. Roughly, it would be 15 to 16 years from the establishment of the project.

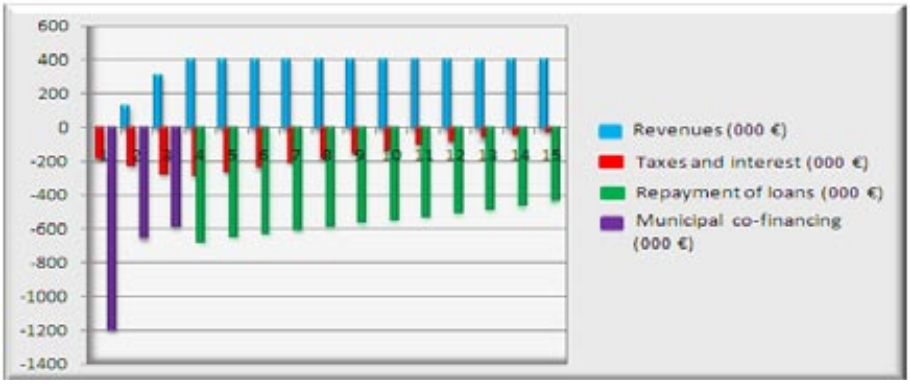

Figure 7: *The cost of financing and the anticipated savings*

Additional comments on the project *(duration, limitations, assumptions, risks, etc.)*

It is estimated that implementation of the project would take three to four years. The constraints that might arise in such a project are primarily financial.

Table 7: *Assumptions about the total investment costs*

PROJECT	INVESTMENT COSTS (€)
Total investment costs (distribution network, heating equipment, biomass boiler)	ca. 6,000,000
Total project costs (investment costs, technical assistance)	ca. 6,600,000

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4 CONCLUSION

Lack of funding and low awareness of the benefits of generating energy from renewable sources are the main culprits behind the poor use of these resources in Pljevlja. The municipality is supplied with electricity from a thermal power plant and therefore suffers negative consequences in the form of pollution. Use of the existing potentials of renewable energy sources would have a positive impact on the environment throughout the municipality. Moreover, the introduction of new technologies for the exploitation of energy resources in Pljevlja would open the possibility of new jobs, which is another positive aspect for citizens. This way of managing renewable energy sources would enable the more efficient and healthier use of electricity in Pljevlja.

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