ENVIRONMENTAL IMPACTS ASSESMENT OF HYDROPOWERPLANT

Nenad NESIC[1]Petra TANOVIC[2]Bratimir NESIC[3]Luka NESIC[4]

Abstract: Recognizing the reality that coal as one of the most significant energy resources is limited both quantitatively and temporally, hydropower production and the use of water energy resources, with all associated impacts, will become even more important for the following reasons: water is a renewable energy resource, which means that the available reserves water for energy production are not exhausted, so, that is one of the reasons that more energy is engaged in order to conserve energy reserves of coal, most other classical energy sources are becoming more expensive, production of energy from other sources mainly requires the provision of hydropower ie water for cooling, quenching and slag transport, low utilization of coal in thermal power generation and introduction of new transformation methods (eg gasification and liquefaction of coal), the need for more rational use of coal reserves with the need for greater valuation of hydropower, built reservoirs for hydropower can have significant multi-purpose effects, both positive and negative.

Key words:environment, impact, hydropower, energy efficiency.

1. INTRODUCTION

Water energy or hydropower is generated by the transformation of water potential energy (most often by water "falling") into other forms of energy. Power plants that transform hydropower into electricity are called hydropower plants. The typical structure of a hydropower plant implies the existence of an accumulation lake for the collection of water, which is most often realized by blocking river flows. From the lake and due to the slope, under the influence of gravitational force, water flows to the turbines, which, with the help of a generator, transform the energy of water into electricity [6]. Compared to the energy generated by burning fossil fuels, hydropower is a relatively safe source of energy for the environment. On the other hand, hydropower also has negative impacts such as: damage to land, destruction of human settlements, erosion, etc.[2].

2. ENVIRONMENTAL IMPACTS ASSESMENT

Hydropower or water energy is certainly not without its drawbacks. In addition to dams posing a serious threat to fish populations and ecosystems of streams and rivers, the use of water energy can have a negative impact on water flow and quality. Lower oxygen content in water is a threat to wildlife. These problems can be solved by providing passages through which the fish can move smoothly and the water can be regularly enriched with oxygen to maintain the oxygen content in the water needed for the safe survival of wildlife. Water flow should be carefully monitored to prevent hazards arising from frequent straining of water masses. These dangers can be avoided by temporarily switching off pumping water into the reservoirs, thus ensuring the balance of damaged ecosystems [5].

2.1. Environmental Impacts Aspects

The construction of hydropower plants has a significant impact on the environment and the complexity of these impacts can be systematized from several aspects: physical aspect, environmental aspect, social and economic aspect, safety aspect, human health aspect and life culture aspect [1].

The physical aspect includes: change of the regime of water flow, change of water quality, qualitative and quantitative change of groundwater, erosion and land collapse on the shores of the lake, sediment deposition, erosion of the riverbed downstream of the dam and the possibility of seismic effects. Due to the filling and emptying of the accumulation lake, erosion of the shores and possible destruction of the surrounding land occur. As a consequence of dam construction and accumulations,

[1]B. Sc., Facultyof Agriculture, University in Pristina, nesic77@gmail.com;
[2]Ph. D., Higher Education Technical Schoolof Professional Studies, stevanovic@vtsns.edu.rs;
[3]Ph. D. Student, Faculty of Occupational Safety, University in Nis, bratimir@gmail.com;
[4]B. Sc. Student, Faculty of Occupational Safety, University in Nis, lukanesic19111@gmail.com

seismic activity occurs that is not directly related to the mass of accumulated water but to the height of the water column. Also, in the lake zone there are floods of settlements and arable land, the stability of the coasts is reduced, the level of groundwater is changed, etc.

Environmental aspects include impacts on: flora and fauna and climate. The construction of a hydropower plant changes the hydrological regime of watercourses and tributaries, the physical and chemical properties of water, all of which are reflected in the flora and fauna. The large water surface of the accumulation lake influences the change of the microclimate of the region, the temperature regime of water and air, increases the humidity and causes fog.

Social and economic aspects include: population relocation, employment, energy production, land flooding, impact on agriculture, flood control, impact on water supply, and tourism. The social and economic implications of hydropower plant are of particular importance. Negative implications are emerging: the flooding of significant areas of arable and fertile land, as well as the economic and social problems of population displacement. There are also positive implications: economic effects of electricity production, elimination of floods, release of large areas for agriculture and tourism and new employment.

Aspects of human health and safety relate to: the possibility of the existence of a source and the spread of diseases and the risk of dam destruction. With regard to the safety of life and human health due to the possibility of the existence of source of disease and the eventual demolition of the dam, with careful design and construction, it is possible to completely control these problems [7].

The cultural aspect includes: influence on aesthetics and the possibility of flooding of cultural monuments and archeological sites. The construction of dams and accumulation lakes can affect the aesthetic appearance both in terms of influencing the culture, as there is the possibility of submerging cultural monuments or the need to displace them. In addition to all the positive environmental impacts of hydropower plants, negative impacts cannot be ignored, and they remain eliminated or reduced to tolerable limits by careful study and design.

2.2. Positive Environmental Impacts

The key advantage of hydropower as a renewable energy source is the reduced or completely eliminated greenhouse gas emissions. The main reason is that fossil fuels are not used as a starter for a turbine or electric generator. Because they do not use fuel, especially not fossil, hydropower plants have a positive environmental impact. That is why electricity generated in hydropower plants is more cost effective because there is no dependence of the price of produced energy on the price of oil, gas and other fossil fuels on the market.[4].

The hydropower plant also has a longer life expectancy than a fossil fuel power plant such as a thermal power plant. There are hydropower plants that have been in operation for over 50 years. For example, near Leskovac, on the Vučjankariver, below the Kukavica mountain, there is the Vučje hydropower plant, which is an incredible combination of nature and human hands. This hydropower plant and 17 km long transmission line to Leskovac, mark the beginning of the electricity transmission system in Serbia. The start of using electricity in Leskovac was a miracle, and this more than 100-year-old hydropower plant began its work on a special day - the Day of Liberation of the City from the Turks, December 24, 1903,[8].

Now the hydropower plant "Vučje" is a part of the world heritage in the field of electrical engineering. The IEEE (Institute of Electrical and Electronics Engineers) has included it in the Milestone program [9].

Image 1 – Hydroelectric Power Plant ''Vucje'' from 1903, on the VučjankaRiver, near Leskovac, in Serbia

The accumulation lakes upstream of the dam have the greatest impact. When considering hydropower plant from an economic point of view, is that today's, modern, hydropower plants require very few employees because of the high percentage of automation. Also, the cost of investing in the construction of a hydropower plant returns within 10 years.

Greenhouse gas emissions are completely eliminated if only the electricity generation process is observed. However, interesting studies were carried out in collaboration with the University of Stuttgart [10], which showed that, of all energy sources, hydropower plants are the smallest greenhouse gas producers. They are followed by wind farms, nuclear power plants, photovoltaic power plants, etc.It is important to note that these tests were performed for climatic conditions in Europe and can therefore be applied to areas in North America and North Asia. Hydro-accumulation lakes of hydropower plants can have several other positive aspects in addition to their primary function. By their size, they can attract tourists, or contribute to the development of tourism, so various water sports can take place on their surface. Large dams can also play a significant role in irrigation and in the regulation of river flows and have a positive impact on the ability to control flood waves, irrigation, water supply and fisheries.

2.3. Negative Environmental Impacts

In addition to the positives, there are negative environmental impacts. In the situation where the accumulation lake is on the lowland river, then the upstream flow is slowed down and groundwater levels rise, which is the case with the Djerdap hydropower plant. The great lake makes the microclimate change in a smaller area by increasing the humidity, so it happens that supporters of the protection of cultural values do not allow the construction of acccumulation lakes near objects with sensitive fresco painting [6]. Also, the dams interrupt migratory pathways of fish species that spawn upstream, unless there are specially provided fish passes at the dam. An example of this is the Sturgeon fish that have not appeared in the Danube River since the Djerdap Dam was built.

Mountain rivers that create canyons and gorges are suitable for making accumulation lakes with a great decline and potential for hydropower, but at the cost of complete flooding and alteration of ecosystems. In addition, there is a lot of river alluvions in the accumulation lakes, with organic

material that begins to decompose over time leading to the appearance of methane, a gas that is much more dangerous than carbon-dioxide in terms of the greenhouse effect.

A key part of a hydropower plant is its dam. Damage to the dam can lead to major disasters for the entire ecosystem downstream of the dam. The quality of the dam's building, construction and maintenance alone is not a sufficient guarantee that the dam is damaged from damage. Dams are a very attractive target during military operations, acts of terrorism and the like.

Image 2 – Three Gorges Dam in China

Another example of the dangers to human life is the Three Gorges Dam hydropower dam in China.The Three Canyon Dam is the largest hydropower plant in the world and is located on the Yangtze River in China. This river is the richest in water, which justifies the construction of a hydropower plant. However, the accumulation lake of this dam is so large that it weighs the crust with its mass. Given that the area is geologically unstable, ie. that it is at the junction of the lithospheric plates, it is clear that there is a justifiable risk. While scientists fear earthquakes and dam collapsing, politicians argue that there is no such risk [4].

The river carries with it water material in the form of sand and silt. This eventually leads to the deposition of this material in the accumulation lake, which contributes to the reduction of lake depth. Due to this, the lake loses its role of accumulation of water mass during rainy periods and its use during dry periods of the year. This can be avoided by building a variety of channels that act as a bypass for sediment drainage. Each hydropower plant has its own lifetime, after which it becomes uneconomical.

Also observed, a negative aspect during the construction of dams is the necessity to destroy economic, cultural and natural resources. When filling a hydro-accumulation lake, it is necessary to flood everything below the surface of the lake. The fauna of the area is forced to relocate, as are humans. As for the flora, the situation is slightly different, primarily in the tropics. In those areas, where the temperature is higher, when rotting, decaying, plant debris trapped under water, under

anaerobic conditions, gases are produced that result in a greenhouse effect. Carbon dioxide and methane are primarily produced [3].

Generation of carbon-dioxide is not really a concern. It was already circulating in the atmosphere, so the plants incorporated it into their tissues during the process of photosynthesis. It is not a newly released carbon-dioxide as it is produced by burning fossil fuels. It is interesting to say that the emission of carbon-dioxide, which is released in hydro-accumulation lakes, will be higher than in power plants that burn fossil fuel, if the forests had not been cut down and removed before filling the lake with water. A much bigger problem is the generation of methane, which, by going into the atmosphere, contributes significantly more to the greenhouse effect.

2.4. Environmental Impacts – Experiences from Norway

A study from Norway [11]compared the accumulated environmental impacts from 27 small-scale hydropower plants with 3 largehydropower projects. The results show a slight tendency that large hydropower has a lower degree of impacts thanmany small-scale projects, but lack of precision in the data and weak methodological foundation introducesuncertainty in the results. Taking into account other benefits such as the provision of regulated power, it is reasonableto assume that a few large hydropower projects will produce electricity to a lower environmental cost compared tomany small projects, which should be considered when realizing renewable energy policy objectives.Table 1 presents all the environmentalimpacts identified in the EIAs from the 27 small-scale hydropower plants. The impacts are listed by howfrequent they are reported in the EIAs, and not explicitely linked to the individual plants.

Table 1 – All reported environmental impacts from the 27 small-scale hydropower plants and how often (in %) the various impactsare reported[11]

Type of environmental impact	% of cases impact reported
Reduction in water flow	100
Fish fauna affected by the project	78
Areas with no prior & major encroachments	67
Anadromous fish present in affected part of river	56
Cultural heritage sites affected	44
Anadromous fish present on bypassed river stretches (reduced flow)	15
Pipe lines causing landscape encroachment/impacts	11
Changed water quality	11
Organisms living in or close to water/cryptogams by water falls negativelyaffected due to reduced flows	7
Reduced production of invertebrates reducing habitat qualities water ouzeland fish negatively	7
Area protected due to landscape values	7
Changed water temperature	7
Nature with local value negatively affected	4
Locations with valuable deciduous forest negatively affected	4
Marsh areas negatively affected	4
Reduced humidity affecting mosses negatively	4

In table 2, This section presents the impacts identified for the three large hydropower projects andcompares them with the accumulated impacts from the small plants. The impacts are classified in impact categories, varying from ''Very large negative impact''' to ''Very large positive impact''.

Table 2 – All reported environmental impacts from the 27 small-scale hydropower plants and how often (in %) the various impactsare reported[11]

Type of environmentalimpact(energy production/ effect)	Average large HPproject	Sum of 27 small
Effect [MW]	54	112 (SUM)
Energy production [GWh]	350	390 (SUM)
Water temperature	Medium -	Small -
Ice condonsation/Local climate	Insignificant	Small -
Sediment transport/Erosion	Small -	Medium -
Landscape	Medium -	Medium -
Recreation	Small -	Medium -
Nature and environment	Medium -	Medium -
Hunting	Small -	Insignificant
Fish	Small -	Medium -
Cultural heritage	Small -	Small -
Nature resources	Small +	Insignificant
Water quality, watersupply and water pollution	Small -	Small -

3. CONCLUSIONS

Hydropower plants, which accounted for 16% of EU electricity production in the 1980s and 11% in the 2000s, represent a significant source of electricity. Although the share of hydropower is declining due to limited potential, it assumes the utilization of hydro potential practically as a whole, because this is supported by the following facts:

- that more and more remaining hydroelectric power plants for construction are becoming economically justifiable due to the constant and significant increase in fossil fuel prices;
- that hydropower plants, compared to other power plants - classic coal, oil and gas thermal power plants and nuclear power plants - are, from the point of view of environmental pollution, not considered to be environmental pollutants.

Considering the benefits of dam and accumulation lake construction, such as the elimination of floods and, in this connection, the need for more intensive cultivation of agricultural land, the need for irrigation and increased yields, to improve or limit navigation, to improve water supply conditions, electricity generation, etc. It is quite clear and accepted that hydroelectric power plants should be built, with a tendency to complexly address the multifunctional character of each watercourse in such a way that the benefits that can be achieved are also considered from an environmental point of view, with an aspiration for optimum within the broader interest of the community.

One global action is needed to begin addressing environmental issues because individual actions are not and cannot be sufficient globally. To succeed in this, there is no need for a strategy of extreme environmentalists who believe that the world should go back to the pre-James Watt era, or the first industrial revolution, and renounce all the benefits of modern technology. On the contrary, modern technologies should be used in such a way as to enable harmony between ecology and industry, which

means that the emphasis should be on the use of the least polluting and renewable energy sources. Modern technologies can be used positively in the prevention of environmental disasters, the control of endangered wildlife, and the overall development of ecosystems, only to be directed in these directions.

It is high time for humanity to fully commit to the preservation of its natural habitat, or planet Earth, which is so endangered by pollution and destruction, that we ourselves have witnessed the negative consequences, of which the most dangerous global climate change is gaining in recent times,a lot of media space. Appropriate legal support is also needed, which should keep pace with the development of new technologies by allowing the use of those technologies that either do not have at all or have minimal negative effects on nature or the environment.

4. REFERENCES

[1] Ćeranić, T. (2012), *Upravljanje malom hidroelektranom,* Zadužbina Andrejević, Beograd.

[2] Divac, D., Stojanović, Z., Milivojević, N. (2013), *Iskustva i perspektive korišćenja hidroenergije kod nas i u okruženju,* Beograd.

[3] *Izveštaj o strateškoj proceni uticaja Programa ostvarivanja Strategije razvoja energetike Republike Srbije do 2025. godine sa projekcijama do 2030. godine, za period 2017. do 2023. godine, na životnu sredinu*, (2017), Institut za arhitekturu i urbanizam Srbije, Beograd.

[4] James, P., Chansen, H. (1998), *Teaching Case Studies in Reservoir Siltation and Catchment Erosion,* Int. J. Engng Ed. Vol. 14, No. 4, p. 265-275, Printed in Great Britain.

[5] Nikolić, Z., Mihajlović, Z., Milanović, Š. (2003), *Ekonomika Energetike,* Ekonomski fakultet, Beograd.

[6] Pantelić, M., Jorgović, G., Brković, D. (2007), *Ekologija i zaštita životne sredine,* Tehnički fakultet, Čačak.

[7] Rabl A. et. a1. (2005), Final Technical Report, Version 2,*Externalities of Energy: Extension of Accounting Framework and Policy Applications*, European Commission.

[8] *Vučje, Hydroelectric Power Plant*, (1903), Retrieved in October, 2019, from:http://www.teslaways.rs/index.php? page = 7 & id = 47

[9] Milestones program (2005),*Vučje, Hydroelectric Power Plant, 1903*,List of objects, inventions and achievements of general importance for the development and history of electrical engineering in the world, Institute of Electrical and Electronics Engineers,Retrieved in October, 2019, from:https://ethw.org/Milestones:Vucje_Hydroelectric_Plant,_1903

[10] Study (2018), *Greenhouse Gas Producers*, Retrieved in October, 2019, from: https://www.uni-stuttgart.de

[11] Tor, H. B. Et al. (2012). *Development of small versus large hydropower in Norway - comparison of environmental impacts.* Elsevier: Energy Procedia 20. p. 185 – 199