Energy Contribution of the Major Water Basin for the Hydro Power Plants of the Cascade

Goce Bozinovski[1] and Atanas Iliev[2]

[1]Goce Bozinovski is with the AD ELEM-Skopje, Branch HES
"Crn Drim"-Struga, Plostad na revolucijata bb, 6330 Struga, p.fax 83
R. Macedonia
goce_boz@yahoo.com

[2]Faculty of Electrical Engineering and Information Technologies
Skopje, Karpos II, 1000 Skopje, R.
Macedonia
ailiev@feit.ukim.edu.mk

ABSTRACT: *In this work we have analysed the energy contribution of the major water basin and studied how the hydro power plants of the cascade on hydroenergy system works. The studied hydro energy system consists of two cascade hydro power plants and three reservoirs, but the operation experiences and the site location give the possibility to upgrade the system with additional hydro power plants. We did the technical calculations and power improvement are the base platform to make the economical evaluation of the NPV, B/C, PBP values for each power plant from all over integrated hydro energy system. The geographical configuration of the terrain and hydrological conditions of the region, especially the tributaries of the studied river, and allow construction of more hydropower plants. These hydro power plants would improve the energy situation, and also would regulate the operating mode of existing HPP. This study analyzed more the hydropower projects in the studied basin which are analyzed and planned for long time. The testing data is presented in the paper which are the energy production and economic viability of the construction and operation in power system.*

Keywords: Economy, Hydro Power Plant (HPP), Energy

Received: 10 September 2021, Revised 22 November 2021, Accepted 1 December 2021

DOI: 10.6025/jism/2022/12/1/8-12

1. Introduction

The main feature in the analysis of projects of hydroelectric plants is a high degree of uncertainty and imprecision of input parameters. Therefore, in order to perform an economic analysis of the projects, it is necessary to analyze multiple scenarios to determine the likelihood of certain option and meet investor risk investments of the HPP. As a challenge to show the many projects of hydroelectric determine those that are economically viable and feasible to consider those who the developer would guarantee the quickest return on investment. For this purpose, will be determined and analyzed the financial performance of the planned investment of small hydropower on HS Black Drin.

The economic value of the power plants representing the following categories: NPV (Net Present Value), BCR (Benefit Cost Ratio), PBP, (Pay Back Period), IRR (Internal Rate of Return).

2. Basic Parameters for the Small HPP

This includes all projects of hydro power plants with installed capacity below 10 MW, which according to their projected energy parameters are treated as small hydropower plants with a reduced price of electricity in high tariff from 50 to 65 € / MWh and the low tariff of 45 € / MWh in correlation with preferential prices from Energy Regulatory Commission (ERC) of RM. In that group of potential small planned include: HPP Tresonce, HPP Gary, HPP Selce, HPP St. Petka and HPP Kosovrasti. These new hydropower plants are mostly tributaries of the supply to be used for filling the reservoir of potential HPP Boskov Most of Mala reka, and the existing reservoir of Debar Lake.

	P_{inst}	W_{year}	CF– Capacity Factor	Economic analysis
	[MW]	[GWh]		
Tresonce	8	21	**0.30**	Indiv. project
Gari	2.7	9	**0.38**	Indiv. project
Selce	3.3	9	**0.31**	Indiv. project
Sv.Petka	1.2	4	**0.38**	Indiv. project
Kosovrasti	5.4	18	**0.38**	Indiv. project

Table 1. Technical Parameters for the Planned Small HPP on Hydro Sistem Crn Drim

$$CF = \frac{W_{year}}{8760 \cdot P_{inst}} \quad (1)$$

Where is:

W_{year} - Annual production of electricity,
P_{inst} - Installed power units.

3. Financial Indicators for the Planned Small HPP of HS CRN DRIM

Small hydropower plants are having the following common input parameters: operation life of 20 - 25 years of the loan repayment of 10 years.The following table 2. presents an overview of the economic indicators (NPV, B/C, CF, T_{kred}, T_{oper}, C_{ht} and C_{lt}) of the project analyzed the Small HPP hydro system Crn Drim. This presents economic indicators after all discounted benefits and costs. Where: T*kred* - time of repayment of the loan in years; T_{oper} - operating life of the plant, number of years of operation for economic profit; C_{ht} -work in high tariff (peak load); C_{lt} - work in low tariff (base load).

Net Present Value (NPV) is obtained as:

$$NPV = NPV\,(B)_{1-n} - NPV\,(C)_{1-n} \quad (2)$$

$$BCR = \frac{NPV\,(B)_{1-n}}{NPV\,(C)_{1-n}} \quad (3)$$

Where is:

$NPV(B)_{1-n}$ - benefits for the whole operation life

$NPV(C)_{1-n}$ - costs during HPP operation life.

HPP	NPV (€)	B/C	CF	$T_{kred}\_T_{oper}$ (year_year)	$C_{ht}\_C_{lt}$ (%_%)
Tresonce	2.316.40	1,21	0,30	10_25	60_40
Gari	2.435.79	1,33	0,38	10_20	60_40
Selce	1.217.89	1,33	0,38	10_20	60_40
Sv.Petka	465.89	1,10	0,31	10_20	60_40
Kosovrasti	792.99	1,45	0,38	10_20	50_50

Table 2. Economic indicators for planned investment projects of small hydro power plant on crn drim basin

On figure 1. and figure 2. presents graphical representations of economic indicators NPV and B/C for evaluation of new hydro power projects HPS Crn Drim.

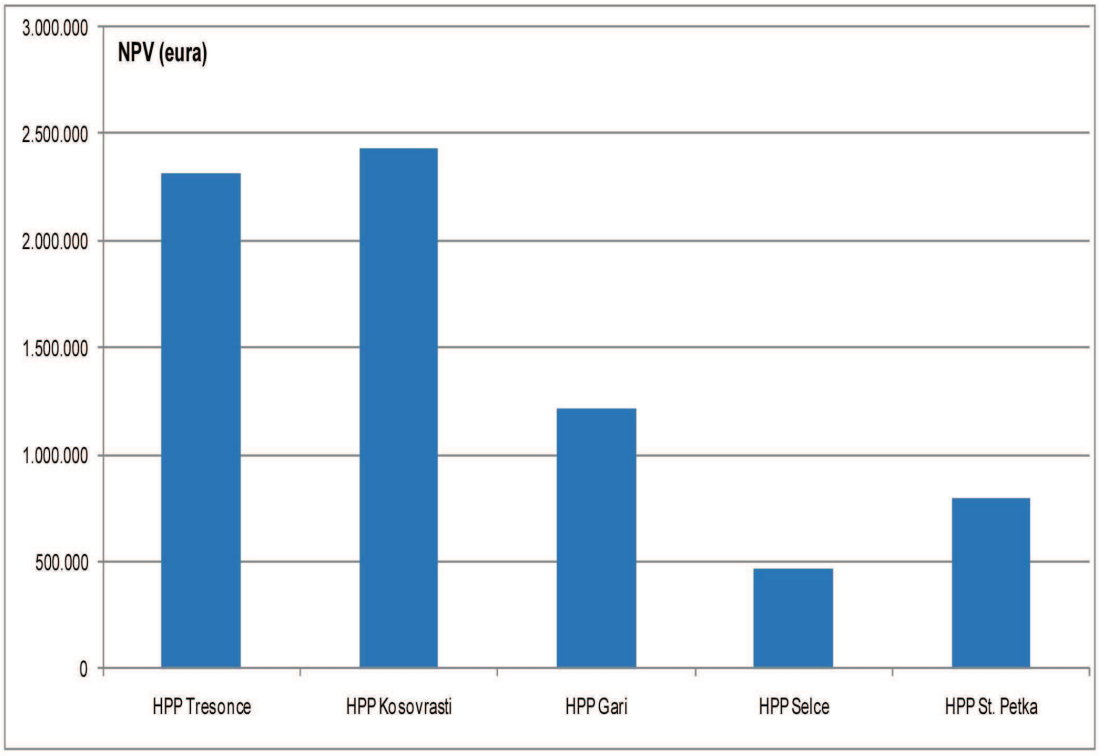

Figure 1. NPV value for hydro projects on Crn Drim

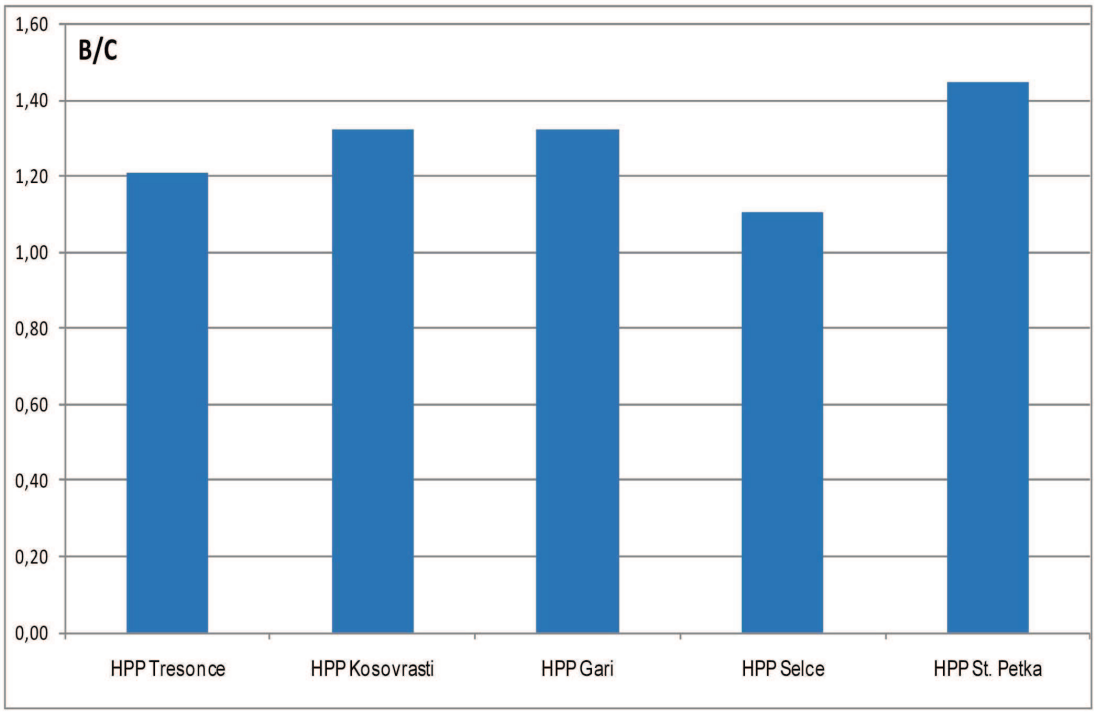

Figure 2. B/C ratio for hydro projects on Crn Drim

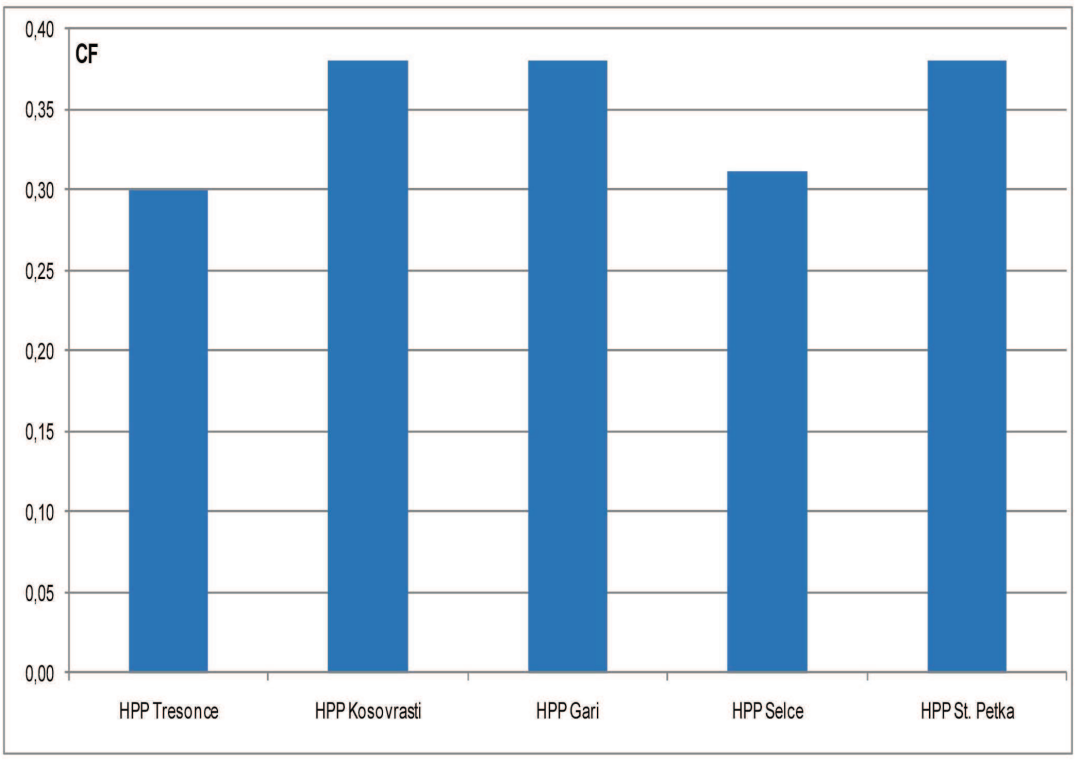

Figure 3. CF for new small hydro projects on Crn Drim

The table and graphical presentation clearly show which projects are the most attractive for investors, as the group of small HPP, such as: HPP Gari, HPP Kosovrasti and HPP St. Petka. These plants have the highest factors of NPV and B/C> 1,3. Fig.3 shows the operational energy parameter of CF (capacity factor) for each hydro power plant which is directly connected to the economical indicators. CF is certainly linked to economic indicators, or those projects that have high economic indicators have high energy production with CF about 0,4. The peak load power plants have low CF which is about 0.3, such as: HPP Tresonce, HPP Selce.

The following figure 3. presented is a graphic indicator of exploitation CF for all hydropower projects analyzed, which is of course directly related to the the economic indicators for each project.

approximately below 0.3 which means that they have to operate in the peak load.

4. Conclusion

The specific natural geographical position of the Crn Drim basin with all facilities (power plants, reservoirs and supply channels) plays an important role in the power system of Macedonia. With new hydro power facilities, the goal is to improve the energy value of the whole hydro system of Crn Drim as the followings:

- Increased installed capacity,
- Higher production of electricity,
- Reduce spillovers,
- Increased number of operation hours in peak load,
- Reduced number of operational work as base load power plant.

Improving the energy value of hydropower production complex will certainly contribute to the financial benefit of the whole hydro complex. The main benefit of the system is the increased installed capacity and increased electricity production as well as reducing the spillover. Operating on the hydro power plants in the high tariff of peak load is particularly important in dry hydrology, and wet hydrological conditions can be avoided or minimized the overflows.

References

[1] Olsson, M., Söder. L. (2003). Hydropower Planning including Tradeoff between Energy and Reserve Markets, Published in Proceedings of IEEE Bologna PowerTech 2003 June 23-26th Bologna Italy.

[2] Amir Pasha Zanjani Nasab. (2012). Financial Analysis of Small-Hydro Power Project in Malaysia from the Investor Perspective, 2012 IPCBEE Vol.33 (2012) Singapore.

[3] Technical documentation of hydro energy system of Crn Drim.

[4] Carmen L.T. Borges. (2008). Senior Member, IEEE, and Roberto J. Pinto: Small Hydro Power Plants Energy Availability Modeling for Generation Reliability Evaluation, *IEEE*, 23 (3) August.

[5] Bozinovski, G.., Iliev, A. (2014). Energy Contribution and Economical Evaluation of Hydro Energy Complex System of Cascade Power Plants – Renewable Energy Sources (OZE) 5th International Scientific Conference OZE 2014, High Tatras -Tatranske Matliare, May 20 – 22, Slovakia (467_OZE_2014, ISBN 978-80-89402-74-8).