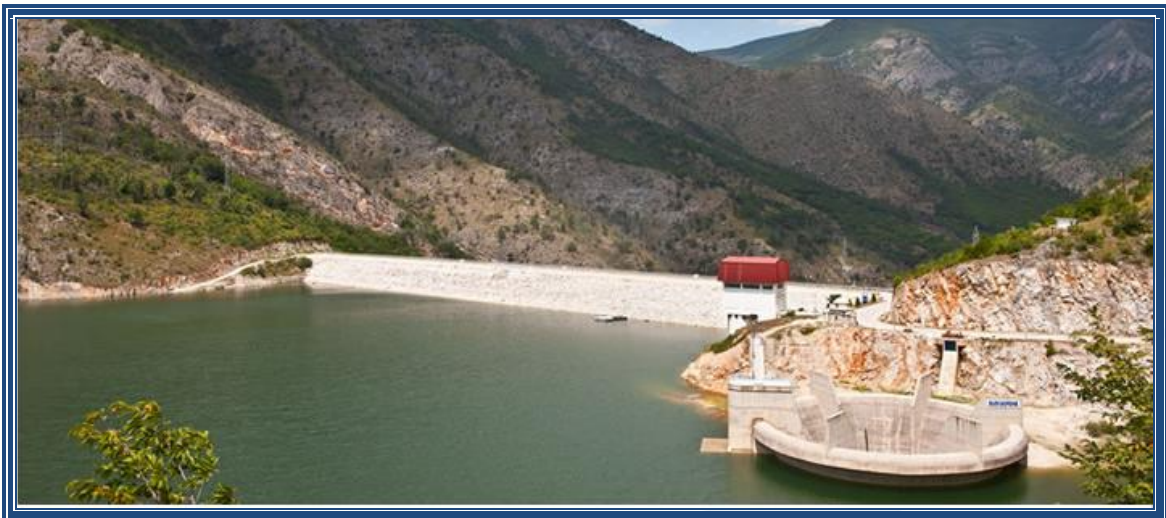


## **PROJECT FOR OPTIMAL UTILIZATION OF WATERS FROM RAVEN HPP TO KOZJAK**



*Prepared by: Department of Development and Investments*

## INTRODUCTION

**Type of project:** Electricity generation

**Planned annual electricity generation:** 110 GWh

The idea of a tunnel that will divert some of the water from the river Vardar into the river Treska, i.e. from the location of Tenovo to the reservoir of Kozjak, is more than 50 years old. Based on the first Study regarding this idea, developed by a Norwegian consulting company, technical documentation was prepared only regarding the Tenovo-Kozjak Tunnel, which provides energy indicators and some financial analysis at today's prices and in Macedonia's power system completeness.

By the construction of Mavrovo Hydro-system and all its facilities, since 1957 year, Mavrovo Lake has been an artificial reservoir for capturing Korab Mountain and Shar Mountain's waters in the Adriatic Basin on a drainage area of 257 km<sup>2</sup>. Mavrovo Lake has a reservoir capacity of 270 million m<sup>3</sup>, and the water from Mavrovo Reservoir (after being used for power generation in hydro-power plants Vrben, Vrutok and Raven) flows into the river Vardar with a maximum outflow of 32 m<sup>3</sup>/s. This means that all these waters are not natural to the Vardar River, but there are additional quantities which before the construction of Mavrovo Hydro-power System did not naturally flow into the Vardar River. From Mavrovo Reservoir after Raven HPP, the Vardar receives an average annual inflow of around 310 million m<sup>3</sup> of water.

The construction of Lukovo Reservoir will enable additional amounts of water of about 60 million m<sup>3</sup> on average per year, which would total in about 370 million m<sup>3</sup> annually. All these waters would go into the river Vardar.

In further support of this idea to build a diversion tunnel in order to divert water from the Vardar into the Treska and use it for power generation, is also the completion of Treska Hydro-system. By building Kozjak HPP (2004 year) and Sveta Petka HPP (2012 year) with their reservoirs, as well as with the revitalized and upgraded Matka HPP, the water diverted from the river Vardar would be additionally used in these three hydro-power plants, and it would be pumped into the river Vardar at the estuary of the river Treska before Skopje. This endeavor of building a tunnel would actually divert part of the waters of the river Vardar, instead through the Polog Plain and Vardar River, to move through the river Treska after being used for energy generation in Treska Hydro-system (HS), and flow into the Vardar before Skopje.

The tunnel envisaged to be build from the location of Tenovo (on the Gostivar-Tetovo stretch) to the Kozjak Reservoir is about 14.5 kilometers long, which is the shortest distance to divert part of the waters from Vardar River to Treska River.

## TECHNICAL DESCRIPTION OF PROJECT

The Project envisages the construction of a dam near Tenovo and a tunnel with a length of 14.5 km to divert water from the river Vardar at Tenovo location into the Kozjak HPP's reservoir.

These additional diverted waters would increase the inflow of water into Kozjak Reservoir, thus also increasing the annual electricity production of the three power plants: Kozjak, Sv. Petka and Matka.

The quantity of diverted water is calculated from water data on Tenovo location. The drainage area is 612 km<sup>2</sup>, while the flow of water for the analyzed period amounts to an annual average of about 10.6 m<sup>3</sup>/s, or a total of about 330 million m<sup>3</sup> per year.

The inbound tunnel operation to divert the water from Vardar River into Treska River is located at Tenovo along the upper stream of the Vardar in Polog Valley, about 40 km southwest of Skopje.

Tenovo Reservoir is at a maximum operating level elevation of 467 m a.s.l. and a minimum of 464.5 meters above the sea level, with a useful volume of 0.9 million m<sup>3</sup>.

The dam has an earthen embankment with a volume of 160,000 m<sup>3</sup>, dam's crest elevation is 470 meters above the sea level, its height is 10 m and its length is 1800 m.

The tunnel has a length of 14.5 km, cross-section area of 15.5 m<sup>2</sup> (acceptance of maximum outflows of 32 m<sup>3</sup>/s). The upper tunnel elevation is at 463 meters above the sea level (Tenovo dam) and the lower output elevation is at 438 meters above the sea level (Kozjak Reservoir).

### Options for Energy Utilization of Waters on the Stretch from Raven HPP to Kozjak Reservoir

As possible options to be explored in the Study for Optimal Utilization of Waters from Raven HPP to Kozjak Reservoir, Alternatives A1 and A3 have been given according to the ToR, while Alternative A2 has been given with a possibility to expand it with new hydro-power plants on the Raven-Tenovo stretch, which is not covered in Analysis.

#### *Alternative A1*

Intervention near Raven HPP at an elevation of 485 meters above the sea level  
 Diversion of water through a combined system of tunnels / pipes / channels to Kozjak Reservoir with a total length of 26.5 km  
 Underground powerhouse of the hydro-power plant in order to use the maximum gross elevation drop before entering Kozjak Reservoir

#### *Alternative A2*

Intervention down the river Vardar (Tenovo location) at an elevation of 475 m above the sea level  
 Minor Tenovo Reservoir with 0.9 to 1.0 million m<sup>3</sup> to reduce and control the outflow  
 Tenovo-Kozjak Tunnel, with a length of 14.5 km and diameter of about 3.5 m  
 Possibility to build new hydro-power plants on suitable locations on the upper Raven-Tenovo stretch (Lokojca HPP and Tenovo HPP)

#### *Alternative A3*

Intervention near Raven HPP at an elevation of approx. 485 m a.s.l.  
 Minor reservoir with 0.9 to 1.0 million m<sup>3</sup> downstream of Raven HPP to regulate water drain  
 Moving the water through a combined system with a total length of about 31 km, i.e. 2.5 km (Tunnel / pipeline) + 16 km (channel) + 12 km (Tunnel)  
 Underground powerhouse of the hydro-power plant in order to use the maximum gross elevation drop before entering Kozjak Reservoir

### Investment Estimation and Financial Analysis

Estimates of construction works for this design of the Tenovo-Kozjak Tunnel are based on present prices taken from other hydro-power projects currently active by ELEM.

The estimated investment cost is about 57 million Euros. This value of the investment is the basis to obtain the economic indicators of the Project.

### Further researches of project

1. Preparation of Pre-feasibility Study for Optimal Utilization of Waters from Raven HPP to Kozjak Reservoir (September 2017 year).
2. AD ELEM's Decision on the acceptable option according to the prepared Pre-feasibility Study.
3. Preparation of ToR for a Pre-feasibility Study on the accepted option by AD ELEM.
4. Preparation of a Feasibility Study on the accepted option by tendering.

### Project benefits

The realization of this Project would connect both Hydro-power Systems Mavrovo and Treska and round up the energy use of the upper stream of the river Vardar. The benefits of this Project would be the following:

#### Energy Benefits

- Additional power generation of power plants at Treska River of about 110 GWh annual average.
- Higher engaged power of Kozjak HPP due to the increased higher elevation operating time of Kozjak Reservoir.
- Operational work of hydro-power plants on the river Treska in high tariff periods as operational plants in a liberalized electricity market, which means a higher income for the power plant and ELEM as an operator.
- Opportunities for additional production in newly built hydro-power plants on the Raven-Kozjak stretch.

#### Other Benefits (Flood Protection, Needs for Water Supply and Irrigation)

- Avoidance of overflows and floods of the river Vardar into the Polog Valley in periods of high water level, where part of the waters would be diverted to Treska River.
- Additional water for water supply of settlements in the Valley of Polog.
- Flow of the river Vardar regulated in its upper stream and a possibility for irrigation of Polog agricultural region.

**ATTACHMENTS:**

**Figure 1. Situation at the location of the Project for a Diversion Tunnel between Tenovo and Kozjak Reservoir**

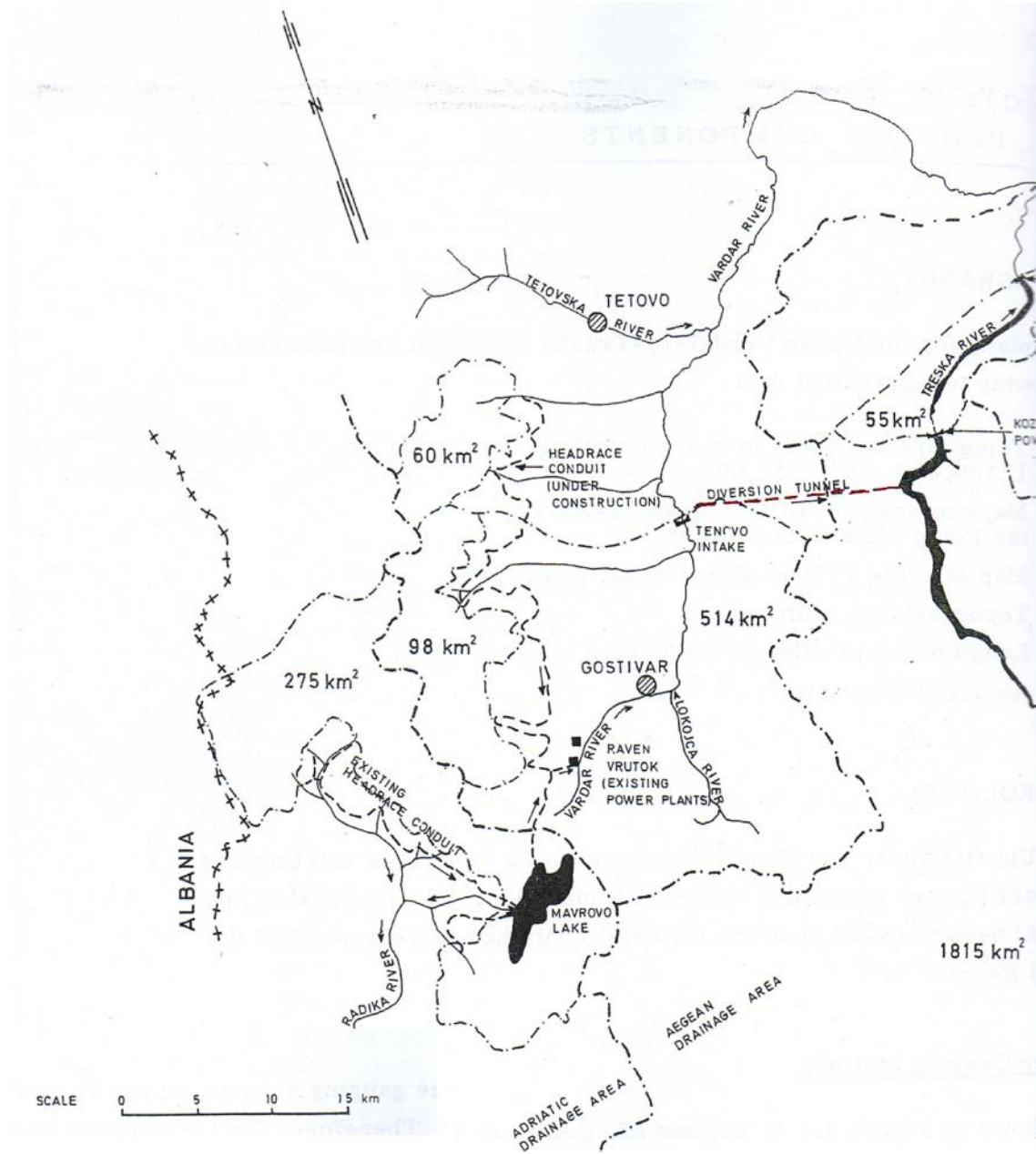


Figure 2. Schematic presentation of energy use of waters from Mavrovo HS diverted through the Tunnel into Treska HS

