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SUSTAINABLE TECHNO-ECONOMIC UTILIZATION OF HYDRO POTENTIAL BETWEEN SERBIA AND ROMANIA

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Abstract: The subject of the research is the water potential of the Danube River in Serbia, predominantly in the inter-border section shared with Romania, and implemented and planned models of hydro potential utilization, in techno-economic terms and in the context of CO_2 emission reduction and environmental impacts. The first cascade, shared between Serbia and Romania, is the hydropower and navigation system (HPNS) Djerdap 1. It is a complex, multi-purpose facility constructed at km 943 of the Danube, from its confluence with the Black Sea. HPNS Djerdap 2 is another shared hydropower plant on the Danube, on the Serbian-Romanian border, at the Kusjak – Ostrovul Mare profile, at km 863 of the Danube. Both water management facilities, using the renewable water resources, apart from energy and navigation, also have a crucial impact on the development of agriculture, tourism, road and railway traffic in both states. A project of a specific pumped storage hydropower plant (PSHPP) Djerdap 3 is currently being elaborated in Serbia. PSHPP Djerdap 3 would use the head between 400 m asl and 68 m asl, and the water would be taken from Djerdap 1 reservoir at km 1,007 of the Danube. If funds for PSHPP Djerdap 3 would be provided, it would be the largest pumped storage plant in Europe. The project bears a strategic significance for Serbia, among other because it would make the potential construction of solar and wind power plants sustainable in the electric power system in Serbia, towards low carbon society.

Key words: sustainability, techno-economic, hydropower potential utilization, environment, costs.

Hydropower Potential of the Danube Through Serbia

Corridor VII, i.e. the Danube water course through Serbia, is unique for: the Djerdap gorge – the largest and most beautiful river gorge in Europe, oases of untouched nature, and two national parks - Fruška Gora and Djerdap (Todic and Vukasovic (2009)). The Danube stretch through Serbia is 588 km long, and it runs along the state border over 230 km. The cultural and natural heritage is also comprised of seven big medieval fortresses, archaeological sites such as Lepenski Vir, Vinča, Viminacium and Tabula Traiana (Ratkaj et al. (2011)), as well as the diversity of the landscape and abundance of traditional customs of the Serbian and 17 minority nations.

Hydropower Plants Djerdap 1 and 2

Further to the Agreement on Construction and Exploitation between the former SFRY and Romania, the main facility of HPNS Djerdap 1 was designed and constructed so that each side comes into possession of one power plant, one navigation lock, one half of overflow dam and one non-overflow dam, with appurtenant structures. Construction of HPNS Djerdap 1 officially began on 7 September 1964. The first generating units were put into operation on 6 August 1970, simultaneously on both Yugoslav and Romanian side. The Romanian navigation lock started operating on 3 August 1969, and the Yugoslav one in

October 1970. Final damming of the Danube took place on 13 August 1969. During construction of the main facility, 13.4 million cubic meters of gravel and river sediment and 7.2 million cubic meters of rock were excavated, 3.2 million cubic meters of concrete, 167,000 tons of reinforcement and steel structures and 69,000 tons of equipment were incorporated.

HPNS Djerdap 2 is the other shared Serbian-Romanian hydropower plant on the Danube (Arsić et al. (2012)). During construction, 2.5 million cubic meters of earth and sediment were excavated and 948,000 cubic meters of concrete and 70,000 tons of rebar incorporated. HPNS Djerdap 2 consists of the main plant, two additional plants, two overflow dams, two navigation locks and two switchyards. One each of the listed structures belongs to each of the parties. The main plant, as a structural unit, is divided in two equal parts. In the main and additional plant on the Yugoslav side, 10 submerged bulb units are housed, with total installed capacity of 270 MW. The turbine is Kaplan type, with a horizontal shaft.

New Djerdap 3 Project

Djerdap 3 is a specific hydropower plant which shall store water and generate pure energy, at times when the electric power system needs it the most – so called peak consumption periods. The project covers the construction not only of a hydropower plant on the bank of Djerdap Lake but also large storage reservoirs at suitable locations in the valleys of the small rivers of Pesača and Brodica. Electric power industry and economy in general, including households, shall enjoy huge benefits from utilization of potential PSHPP energy. That is why thus produced electric power is given the attribute "quality", even "high quality". It operates right in the hours of peak electricity consumption and, when its assistance is no more needed, it gets disconnected from the grid and stops operating. This makes up for deficiencies in thermal power plants' operation. According to the feasibility study prepared in 2010, phase one would cost about 400 million Euros. Estimated total costs of this project are 4 to 6 billion Euros. Despite the high required investments, the project has not been abandoned, it has been worked on; however, the major problem is not of technical but of economic nature, because the required funds have not been raised yet.

Sustainable Utilization of Potential and Environmental Impacts of Djerdap 1, 2 and 3

Surveys have indicated to changes in aquatic ecosystems in reservoirs and riparian area, of permanent nature, requiring permanent monitoring and undertaking of particular environmental protection measures. There are ongoing processes in HPP reservoirs implying significant water quality degradation, most contributed to by organic matters and waste imported to the reservoirs (Stevanovic et al. (2003)). Possible impacts of HPPs within HPP Djerdap extend to about 18,000 ha in the riparian area. For protection of these areas, huge systems of drainage channels and pipelines, pumping stations and piezometers have been constructed, requiring high tangible investments for investment and current maintenance. Due to exceptionally difficult economic circumstances, these systems have not been properly maintained in the last ten years, so that part of them is not functional.

Within a multi-disciplinary program of monitoring, measurement and assessment of environmental impacts, measurements and analyses are conducted through: Program I – Surface Water Regime, Groundwater Regime Observation and Monitoring, Supplements to the Existing Observation Network, Monitoring of Backwater Impacts and Operation Regime of Existing Drainage Channels, Analysis of Chemical Composition of Groundwater, Analysis of Data from Monitoring of Groundwater Regime and Drainage System Effects and Groundwater Regime Study; Program II – Monitoring and Analysis of Sediment Regime (BABIC MLADENOVIC et al. (2013)); Program III – Ice Observation, Measurement and Analysis; Program IV – Observation, Analyses and Measurement of Impacts on Agriculture; Program V – Analysis of Impacts on Forests; Program VI – Identification of Impacts on Embankment Stability; Program VII – Monitoring and Analysis of Surface Water Quality and Ecosystems and Program VIII – Slope Stability Monitoring and Analysis.

Conclusion

The two techno-economically justified and implemented hydropower and navigation systems Djerdap 1 and 2 represent sustainable models of synergic hydro potential utilization between Serbia and Romania. Investing in utilization of hydro potential, as a renewable resource, serves the purpose of sustainable and holistic development. Planned investment in pumped storage plant Djerdap 3, on the right Danube bank in Serbia, constitutes a contribution to CO_2 emission reduction on planet Earth, directly and indirectly. Being a specific project, this plant participates in balancing of the daily electricity consumption diagram. As there are two distinct consumption peaks in daily electricity consumption in Serbia – the morning and the evening one, and the latter one being, in terms of load, 2.5 times the minimum one which takes place after 10 pm until morning hours, it is clearly concluded that the construction of the techno-economically justified plant Đerdap 3 serves the purpose of electric power system sustainability. Being a project of strategic significance, PSHPP Đerdap 3 enables inclusion of other power plants which use renewable energy sources in region (Ivanovic et al. (2013)), while contributing to environmental protection and sustainability of energy utilization, towards low carbon society.

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