Ex post evaluation – Bosnia and Herzegovina

Sector: Energy 2321000 (Energy generation, renewable sources – multiple technologies)
Project: Refurbishment of Rama hydropower plant (BMZ no. 2005 65 838)*
Implementing agency: Elektroprivreda Hrvatske Zajednice (EP HZHB)

Ex post evaluation report: 2020

All figures in EUR million	Project (Planned)	Project (Actual)
Investment costs (total)	23.00	27.70
Counterpart contribution	6.00	10.70
Funding	17.00	17.00
of which BMZ budget funds	7.00	7.00

*) Random sample 2019

Summary: The project was designed to refurbish the Rama hydropower plant (HPP), which has an installed capacity of 160 MW and average annual power production (2015–2018) of 664 GWh per year, making it one of the largest hydropower plants in Bosnia and Herzegovina (BaH). As part of the project, the Rama hydropower plant's turbines, generators and transformers were refurbished or replaced and the power plant's substation was expanded. The project's measures included the installation of a new turbine runner, the refurbishment of two existing runners, the refurbishment of the generator stand, an increase to the generators' output from 90 to 100 MVA, the installation of two new block transformers, and the expansion of the power plant's high-voltage substation to include two new switch panels.

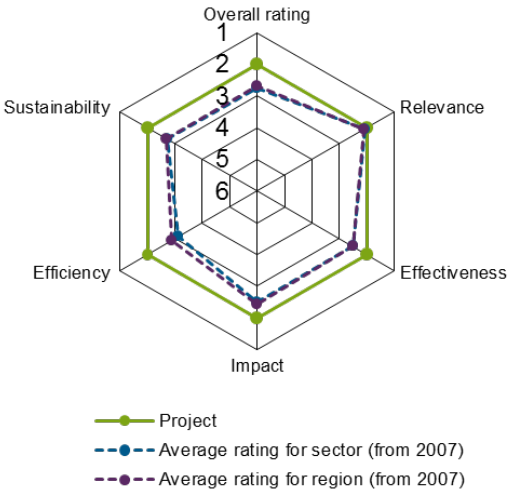
Development objectives: The outcome-level objective was to ensure the use of the Rama hydropower plant at the 2006 level for at least 20 more years and to make sure that electrical energy produced in the power plant is transmitted safely. This was intended to contribute to sustainable macro-economic development in Bosnia and Herzegovina (impact level).

Target group: The project's target group is all Bosnian power consumers, particularly consumers using power for production purposes.

Overall rating: 2

Rationale: The Rama hydropower plant produced the intended amount of electricity with a very high availability rate. The project was implemented with reasonable delays and additional costs. However, all of the project's objectives were achieved and sustainability is ensured.

Highlights: The implementing agency performs the plant's operating and maintenance processes to a high standard. In terms of its power supply, the Rama HPP is very important to both the region and the implementing agency since the power plant provides roughly 36% of the total production in the implementing agency's area of responsibility. Providing 4% of BaH's total power production, it is one of the most powerful and important HPPs in BaH and, beyond its production capacities, makes an important contribution to supply security in BaH as it is also used to regulate frequency and voltage stability in the electricity grid.



Rating according to DAC criteria

Overall rating: 2

Ratings:

Relevance	2
Effectiveness	2
Efficiency	2
Impact	2
Sustainability	2

Relevance

At the time of the project appraisal (PA), the Rama hydropower plant (HPP) had an installed capacity of 160 MW and average annual power production of 550 GWh, making it one of the largest and most powerful HPPs in Bosnia and Herzegovina (BaH). This remains true today with an installed capacity of 180 MW and a multi-year average of 664 GWh. BaH had an installed capacity of around 4,000 MW at the time of the PA and this level is more or less unchanged today. At the PA, total power production in BaH was just below 14,000 GWh and is currently around 17,000 GWh. Both now and at the time of the PA, 50% of this power is generated by hydropower and 50% is generated in coal-based power stations.

At the time of the PA, important parts of the Rama hydropower plant (HPP) were at the end of their economic lifespan. The two 80-MW units of the Rama hydropower plant were originally commissioned in 1968 and were almost 40 years old when the PA was carried out. If the machinery units at the Rama HPP had not been refurbished, it is likely that they would have broken down in the foreseeable future and the power plant would have had to be shut down. As a result, the project's implementing agency, the public utilities service provider (EP HZHB), would have had to import an equivalent volume of energy at significantly higher cost and pass this cost onto its customers via higher tariffs. It is also highly likely that the power generated using alternative technology would have had significant negative effects on the environment as it would have mainly been produced using thermal technology. Given this state of affairs and the significance of a secure supply of electricity as a prerequisite for economic development (assumed effect) and the importance of the Rama HPP in the context of Bosnia, the project addressed an important element of development policy. Given that the war had ended 10 years before the PA, it was assumed that consistent economic development might also have made an important contribution to the peace process. The project's design and the underlying interrelated effects are regarded as plausible and were suitable for contributing to the achievement of the project objectives.

The civil war (1992–1995) ended with the Dayton Agreement. In the years that followed, the World Bank assumed responsibility for coordinating the creation of the overarching Power I–IV programme. In view of the delicate situation after the war, the BaH government was not in a position to create a national sectoral strategy and instead adopted Power I–IV as its overarching strategy. The overarching strategy was a sector rehabilitation programme for restoring infrastructure in the electricity sector (distribution, transmission, production). During a donor conference in 2005, the Federal Ministry for Economic Cooperation and Development (BMZ) declared that Germany would finance the refurbishment of the Rama HPP under Power IV. According to the project's implementing agency, the Rama HPP refurbishment project fully corresponds to its objectives and priorities and those of the country of BaH. Despite the aforementioned coordination by the World Bank, there was very little synchronisation and harmonisation between the donors. However, this does not call the project's relevance into question. This is rated as high, even from today's perspective.

Relevance rating: 2

Effectiveness

The outcome-level objective was to ensure the use of the Rama hydropower plant at the 2006 level for at least 20 more years and to make sure that electrical energy produced in the power plant is transmitted safely. The achievement of the project's objectives was measured using the following indicators:

Indicator	PA target value	Ex post evaluation
(1) Average amount of electricity produced annually	550 GWh	Between 2015 and 2018, the Rama plant produced an annual average of 664 GWh. The indicator is achieved (4-year average).
(2) Unscheduled downtimes of Rama hydropower plant	< 90 hours per year	In the period 2015–2018, the Rama plant had downtimes of between 0 and 74 hours per year. The indicator is achieved.
(2) Unscheduled downtimes of the 220 kV substation	0 hours per year*	In the period 2015–2018, the substation had unscheduled downtimes of between 0 and 1 hour. Over the 4-year average, this results in an annual average of 0.26 hours (available 99.99% of the time). The indicator is achieved.

* A situation with 0 hours of downtime is an unrealistic goal.

All indicators for the project target achievement at outcome level are achieved.

Looking at the production values for the period 2015–2018, the average values have consistently been above the desired target value. Only 2017 had low power production of just 429 GWh. However, this was caused by hydrological issues and did not relate to poor maintenance or damages. Over the past few years the hydrological situation has been generally stable with sufficient water resources, with the exception of low rainfall in 2017. Otherwise, the average water supply for the past few years has allowed for unlimited power production by the HPP. Prior to its refurbishment, the Rama HPP produced an annual average of around 665 GWh of power in the period 1997–2011. The average amount of power produced in the period 2015–2018 corresponds to this value. The plant mainly runs during the day and therefore also covers peaks in power demand in regional distribution systems.

The plant's technical availability rate is more than 99.7% with very few downtimes during the year, which reflects the high quality of the equipment. Even before refurbishment, availability was at a similarly high level, which means that the refurbishment measures thereby also contribute to the achievement of objectives relating to extending the plant's usage.

Unscheduled downtimes at the substation are very low (annual average downtime 0.01%). The Rama plant has constant access to the public electricity grid and can therefore easily feed its produced power into the grid.

However, this is not due to the two switch panels added as part of the project. The substation was in fact expanded by two switch panels as part of the project with the aim of using them to connect two existing 220-kV lines. Connecting these lines would have provided an additional option for distributing the power produced across the region. However, for political reasons, neither of these two lines have been connected to date (disagreement between members of the management committee at the transmission company/grid operator regarding the priority of investment measures). Nevertheless, the current connection to the grid still guarantees that all of the power produced can be fed into the grid. The implementing agency confirmed that supply security was and still is guaranteed without restriction both before and after refurbishment. The lines are expected to be connected in future.

Thanks to the refurbishment – in particular the installation of a new turbine runner with better hydraulic contours which led to improved efficiency, and also the refurbishment of the generator – the output of machine 2 at maximum gross head was increased from a maximum of 92.3 MW to 103.8 MW. Machine 1 remained at a maximum output of 92 MW because the runner was not replaced. While the additional output cannot increase the annual output, it can still improve the peak power capacity.

The capacity of the Rama HPP combined with its very high availability enables peaks in power demand to be covered and also provides reserves for frequency control and the summer months. The power produced by the plant depends on the hydrology of the year in question, which is reflected by the annual (fluctuating) power production figures. At the moment, a general negative trend related to hydrology cannot be determined by looking at the annual fluctuations (see Sustainability).

The on-site inspection of the refurbished plant revealed that the quality of the work completed corresponds to international standards. There has been no serious damage since the refurbishments, which can be attributed to the fact that the refurbishment measures were implemented in accordance with internationally recognised standards.

In summary, the refurbishment of the machinery increased the power plant's service life and therefore extended the use of the Rama HPP by at least 20 more years.

Effectiveness rating: 2

Efficiency

The implementation of the project was originally proposed to take 34 months from the signature of the loan agreement. The loan agreement was due to be signed in June 2007 and the project was scheduled for completion by mid-2010, whereby the preparatory work (creation of the tender documents, tendering process, conclusion of contracts) was to take ten months and the implementation of the measures 24 months. However, the project's implementation was delayed: The loan agreement was signed one year later than planned and significantly more time was needed for the subsequent tendering process for goods and services, which meant that the goods and services contracts were not signed until mid-2011. The implementation of the refurbishment measures following the signature of the contracts was subject to further delays of roughly 11 months, though this is acceptable given the complexity of refurbishment work of this kind. The project measures were completed in early 2015. The project was therefore completed almost 5 years later than intended. However, even from the perspective at that time, the schedule drawn up during the PA was too ambitious; the project appraisal report (PAR) itself stated that the plan to sign the loan agreement in 2007 was risky. Furthermore, the planned approach of selecting the consultant at the same time as coordinating the loan agreement often proves to be unfeasible for FC projects.

The total refurbishment costs were 20% higher than the original cost estimates. In an international comparison for this kind of refurbishment measures, the increase in costs is often much higher during the implementation phase. This indicates good planning in the case of the Rama HPP. The additional costs were incurred due to unforeseeable but fully justified work and engineering services. The additional costs of EUR 4.7 million were assumed by the project's implementing agency. However, the two additional switch panels installed during the project have yet to be used (see Effectiveness). These costs amounted to almost 16% of the total costs.

In an international comparison, the specific costs for refurbishing the Rama HPP are at a very good level of EUR 173/kW This leads to the conclusion that, from the current perspective too, refurbishing the plant was the more cost-efficient alternative when compared to building a new hydropower plant or even building a new coal-based one. Constructing a new HPP of a similar capacity would cost around EUR 3,000/kW. The refurbishment costs are therefore just 5% of a new plant.

Refurbishment is by far the more economical alternative: The capital value is very positive and the dynamic production costs, calculated on the basis of actual figures, are at a low EUR 0.023/kWh, which results in a short repayment period of no more than 6 years. The production costs are also below the energy costs specified in the PA of EUR 0.03/kWh. The Rama HPP has been operating at a profit since its refurbishment. Cash flow is very positive; spending on operations and maintenance and repayments on residual debt can be covered without any financial difficulty.

Given the importance of the Rama HPP in the context of Bosnia (see next section), its contribution to a secure electricity supply as a prerequisite for economic development, its contribution to environmentally friendly power production and the aforementioned expensive alternative power imports, the use of funds is regarded as appropriate, even from a macroeconomic perspective.

Given the very good production and allocation efficiency, the efficiency is rated as good even though part of the investment has yet to be used (see above).

Efficiency rating: 2

Impact

The impact-level objective was to contribute to sustainable macroeconomic development in BaH.

The Rama HPP's output makes up 4% of the total power production in BaH. It is one of the most powerful HPPs and contributes to supply security in BaH due to its demand-oriented production output. A secure power supply and sufficient production are important prerequisites for economic development. In terms of its power supply, the Rama HPP is very important to both the region and the implementing agency since the power plant provides roughly 36% of the total production in the implementing agency's area of responsibility. Furthermore, depending on the supply and demand situation (changes during the day and between seasons), the Rama HPP is very important with regard to regulating the frequency and voltage stability of the Bosnian electricity grid. In recent years, transmission and distribution losses were at a low 2.7% and therefore did not restrict the dissipation of electricity.

The project therefore contributes to the achievement of the impact-level objective. Between 2015 and 2018, economic growth in BaH amounted to 20%. Even though it is not possible to directly attribute or reliably quantify the project's contribution to macroeconomic development in BaH, the relationship between power supply and economic development is plausible (see Stern, D. I, Burkes, P. J, and Bruns, S. B. (2017). The Impact of Electricity on Economic Development: A Macroeconomic Perspective. UC Berkeley: Center for Effective Global Action.). Quantification is not possible for the following specific reasons:

- The distribution of power produced by various power plants within BaH is dynamic and subject to daily changes and seasonal fluctuations. It is not feasible to create an overall picture that assigns which power plant produced what amount of power at what point and to which parts of the distribution grid it was transmitted or which power consumers (households, business enterprises, others) received it over the course of the year.
- Over the course of the days and year, BaH imports different amounts of power for various regions in the country. This distorts the overall picture.
- Furthermore, HPPs are subject to hydrological conditions. These vary between years and change over the medium term. This results in different levels of power production.
- Various additional factors have a significant impact on the features of economic growth: local/regional/global market movements, tariff systems, etc.

Beyond the positive effects on macroeconomic development, it is also important to highlight the positive environmental effects, which enabled the project to contribute to global climate change mitigation. The refurbishments meant that BaH's potential for environmentally friendly hydropower was maintained. They also prevented the HPP's production capacity being substituted both then and now by the burning of fossil energy sources with correspondingly negative effects on the environment. The annual carbon emissions avoided by the Rama plant amount to 570,000 t of CO2 per year.

The refurbishment of the Rama HPP did not have any additional negative effects on the environmental or social issues because the project did not involve a new building or extension being constructed but was merely a refurbishment measure, involving the replacement of machinery and parts and the expansion of switch panels for connecting existing KV lines.

Impact rating: 2

Sustainability

In the context of hydropower plants, sustainability means the long-term reliable production of a required amount of power without any losses or with a high level of availability; this can be achieved through proper and high-quality maintenance.

All of the Rama plant is currently in operation; since the completion of the refurbishment measures in 2015, it has been successfully and consistently producing the expected amount of power.

The technical availability rate of the Rama HPP and the substation of over 99% is proof of the high quality of the operating and maintenance processes performed by EP.

As the owner of the Rama HPP, the implementing agency – the public utilities service provider EP HZHB – is responsible for the HPP's operation and maintenance and has many years of experience in the planning and structuring of operation and maintenance processes at plants like this. This was confirmed during the visit to the power plant. The implementing agency has sufficient liquidity to provide funds for operating materials and spare parts. According to the figures provided by the implementing agency, around EUR 10.8 million is spent on operations and maintenance every year. This is relatively high and is due to factors including the plant's age and location in a cavern, though it also attests to the high quality of operations and maintenance.

With a total of 79 employees, the implementing agency has sufficient personnel resources to maintain and run the plant. This is done by applying a three-shift model. Staff are suitably well trained and have the required certifications. The level of qualification corresponds to the requirements for this technically sophisticated plant. The implementing agency also ensures there is sufficient training in all sectors (mechanics, electrics, operations, control, high power, etc.). Materials and tools needed to successfully run and maintain the plant are available.

The refurbishment measures and the replaced machinery and parts are seen as having a high level of quality. In relation to the proper maintenance of the plant by qualified staff as observed during the visit, it can be assumed from today's perspective that the plant's service life has been extended by 20 more years as a result of the refurbishments and the partial replacement of machinery.

There is currently no indication that a sufficient supply of water will not be available in future, which would restrict the project's sustainability. However, an increasing number of extreme weather events have taken place over the past two decades. Between 2000–2014, BaH recorded six periods of drought and three floods. However, the inflow of water to the HPP over the years has remained stable on the whole. Even though climate projections up to 2030 assume that temperatures will increase and rainfall will decrease in the region surrounding the Rama HPP, it is assumed from today's perspective that, for the period from the end of the project to the end of the 20-year extended service life (to 2035), there will be no reduction to the water supply that will limit the sustainability of the impact.

At the time of the project appraisal, the dam exhibited signs of structural defects, which are due to be resolved as part of a project financed by the EIB. The dam refurbishments had not taken place at the time of the EPE (2019). There are currently some individual leaks, which are leading to very minor water losses. These have not affected the HPP's operations or output. According to the implementing agency, the dam is due to be refurbished with a geotextile membrane in 2020. The financing will continue to be secured by the EIB. The refurbishments will require the reservoir to be completely drained, which will lead to production losses. Since the leaks are only very small, there has yet to be an urgent need to carry out the work.

Furthermore, the implementing agency reported that the invitation to tender for refurbishment work on both rotary valves in the power plant will take place during 2020. The two activities demonstrate that the implementing agency has a clear concept for the long-term preservation of the plant's operations and safety.

Sustainability rating: 2

Notes on the methods used to evaluate project success (project rating)

Projects (and programmes) are evaluated on a six-point scale, the criteria being **relevance, effectiveness, efficiency** and **overarching developmental impact**. The ratings are also used to arrive at a **final assessment** of a project's overall developmental efficacy. The scale is as follows:

Level 1	Very good result that clearly exceeds expectations
Level 2	Good result, fully in line with expectations and without any significant shortcomings
Level 3	Satisfactory result – project falls short of expectations but the positive results dominate
Level 4	Unsatisfactory result – significantly below expectations, with negative results dominating despite discernible positive results
Level 5	Clearly inadequate result – despite some positive partial results, the negative results clearly dominate
Level 6	The project has no impact or the situation has actually deteriorated

Rating levels 1-3 denote a positive assessment or successful project while rating levels 4-6 denote a negative assessment.

Sustainability is evaluated according to the following four-point scale:

Sustainability level 1 (very good sustainability): The developmental efficacy of the project (positive to date) is very likely to continue undiminished or even increase.

Sustainability level 2 (good sustainability): The developmental efficacy of the project (positive to date) is very likely to decline only minimally but remain positive overall. (This is what can normally be expected).

Sustainability level 3 (satisfactory sustainability): The developmental efficacy of the project (positive to date) is very likely to decline significantly but remain positive overall. This rating is also assigned if the sustainability of a project is considered inadequate up to the time of the ex post evaluation but is very likely to evolve positively so that the project will ultimately achieve positive developmental efficacy.

Sustainability level 4 (inadequate sustainability): The developmental efficacy of the project is inadequate up to the time of the ex post evaluation and is very unlikely to improve. This rating is also assigned if the sustainability that has been positively evaluated to date is very likely to deteriorate severely and no longer meet the level 3 criteria.

The **overall rating** on the six-point scale is compiled from a weighting of all five individual criteria as appropriate to the project in question. Rating levels 1-3 of the overall rating denote a "successful" project while rating levels 4-6 denote an "unsuccessful" project. It should be noted that a project can generally be considered developmentally "successful" only if the achievement of the project objective ("effectiveness"), the impact on the overall objective ("overarching developmental impact") and the sustainability are rated at least "satisfactory" (level 3).