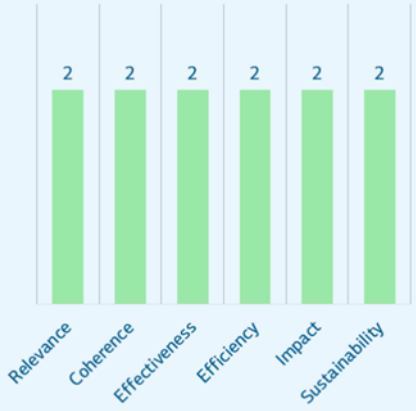
Ex-post evaluation
Rehabilitation of Zvornik hydropower plant, Serbia

Title	Promotion of efficiency and environmental measures in the energy sector (Rehabilitation of Zvornik hydropower plant)				
Sector and CRS code	Hydropower (CRS 23220)				
BMZ number	2008 66 293				
Commissioned by	Federal Ministry for Economic Cooperation and Development (BMZ)				
Recipient and executing agency	Elektroprivedra Srbije (EPS) and Drinsko-Limske Hidroelektrane (Zvornik hydropower plant)				
FC financing volume and instrument	EUR 69.2 million / low-interest loan				
Project duration	2009-2020	**Reporting year**	2025	**Year of random sample**	2025

Overall rating

successful



1: very successful –
6: completely unsuccessful

Project objectives and implementation

The objective at the outcome level was to improve the electricity supply for consumers connected to the Serbian grid. At the impact level, the objective was to make the energy supply in Serbia more sustainable. The Zvornik hydropower plant was rehabilitated and expanded through the comprehensive replacement of electromechanical components and structural measures.

Key findings

The project made an important contribution to the maintenance and modernisation of existing power generation facilities in Serbia and thus to a sustainable energy supply. The following aspects were decisive for the successful overall result:

- The project was highly relevant and addressed the modernisation of Serbia's inadequate energy generation capacity, which was characterised by outdated infrastructure and low energy efficiency. This fitted in well with Serbian-German political priorities.
- The project was successfully integrated into Serbian-German development cooperation and built on previous projects such as the rehabilitation of the Bajina Bašta hydropower plant, which contributed to effective planning and implementation.
- The project objectives were achieved. The average annual electricity generation of the rehabilitated power plant even slightly exceeded the target of 500 GWh. The technical availability of at least 93% was also achieved.
- The institutional, personnel and financial situation of the project executing agency is appraised as positive, which helps to ensure the sustainability of the power plant and maintain the development policy impacts.
- The planned overarching developmental impact of a more sustainable electricity supply in Serbia has been achieved. The target value for CO_2-emissions savings has been achieved.
- As a result of climate change, a 10% decline in the amount of water available has been observed to date. If this trend continues, it will affect the amount of electricity that can be generated and thus the sustainability of the project.

Conclusions

- The rehabilitation of energy infrastructure in countries undergoing processes of liberalisation and transformation is crucial for maintaining renewable energy generation capacities.
- The deterioration in hydrological conditions caused by climate change can have a significant impact on the sustainability of hydropower plants. It is essential to take this into account in planning and operation in order to anticipate negative effects on electricity generation.
- A highly qualified team and continuity of management at the project executing agency contribute significantly to the high quality of implementation.

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List of abbreviations

BMZ	German Federal Ministry for Economic Cooperation and Development
DAC	Development Assistance Committee
EARS	Energy Agency of the Republic of Serbia
EBRD	European Bank for Reconstruction
ECA	Export Credit Agency
EPE	Ex-post evaluation
EPS	Elektroprivreda Srbije
EUR	Euro
EZ	Development Cooperation
FC	Financial Cooperation
FC E	FC Evaluation
GDP	Gross domestic product
GEF	Grid Emission Factor
GHG	Greenhouse gas
GIZ	German Society for International Cooperation
GWh	Gigawatt hour
HPP	Hydropower plant
LCOE	Levelised Cost of Electricity
MDG	Millennium Development Goal
MP	Module proposal
MWh	Megawatt hour
PA	Project appraisal
PCR	Project completion report / Final inspection
SCADA	Supervisory Control and Data Acquisition
SDG	Sustainable Development Goal
SEEA	Serbia Energy Efficiency Agency
TC	Technical Cooperation
USD	US Dollar

Overview

General conditions and classification of the project

After the Second World War, the Federal Republic of Yugoslavia underwent a comprehensive modernisation offensive in the 1950s, which included the construction of numerous large-scale facilities and investments in energy infrastructure.[1] One example is the Zvornik hydropower plant, located in western Serbia on the border with Bosnia and Herzegovina on the middle reaches of the Drina River. It was used to generate both base load and peak load and forms the lowest stage in a chain of six hydropower plants along the river.

In the 1990s, political unrest and wars led to inadequate maintenance of the infrastructure, which had a negative impact on its condition and energy production.[2] Many plants that had previously played a central role in energy supply were neglected, jeopardising generation capacity and reliability of power supply. After the end of the Miloševic regime in 2000, Serbia embarked on a comprehensive reconstruction and reform process that also included the energy sector. The adoption of the Energy Sector Development Strategy in 2005 and the subsequent implementation programme in 2007 highlight the priority given to expanding renewable energies and improving energy efficiency. The political strategies addressed issues such as greenhouse gas (GHG) emissions, energy efficiency and renewable energies.[3] Despite the political measures taken in the early 2000s, Serbia's energy sector was still undergoing reform at the time the project was appraised in 2009. Most of the electricity generated from renewable energy sources came from hydropower, with a small proportion coming from biomass and geothermal energy.

As part of the transformation process, the project executing agency, the vertically integrated state-owned energy supply company Elektroprivreda Srbije (EPS), was restructured in 2005 and converted into a holding company with several subsidiaries covering various areas such as coal mining, electricity generation and distribution. In practice, however, the subsidiaries operate only to a limited extent independently. EPS's total installed capacity was 7,124 MW, with hydropower plants accounting for 2,835 MW. Domestic electricity generation from all energy sources amounted to around 32 TWh in 2000 and around 37 TWh in 2024 (Figure 1).

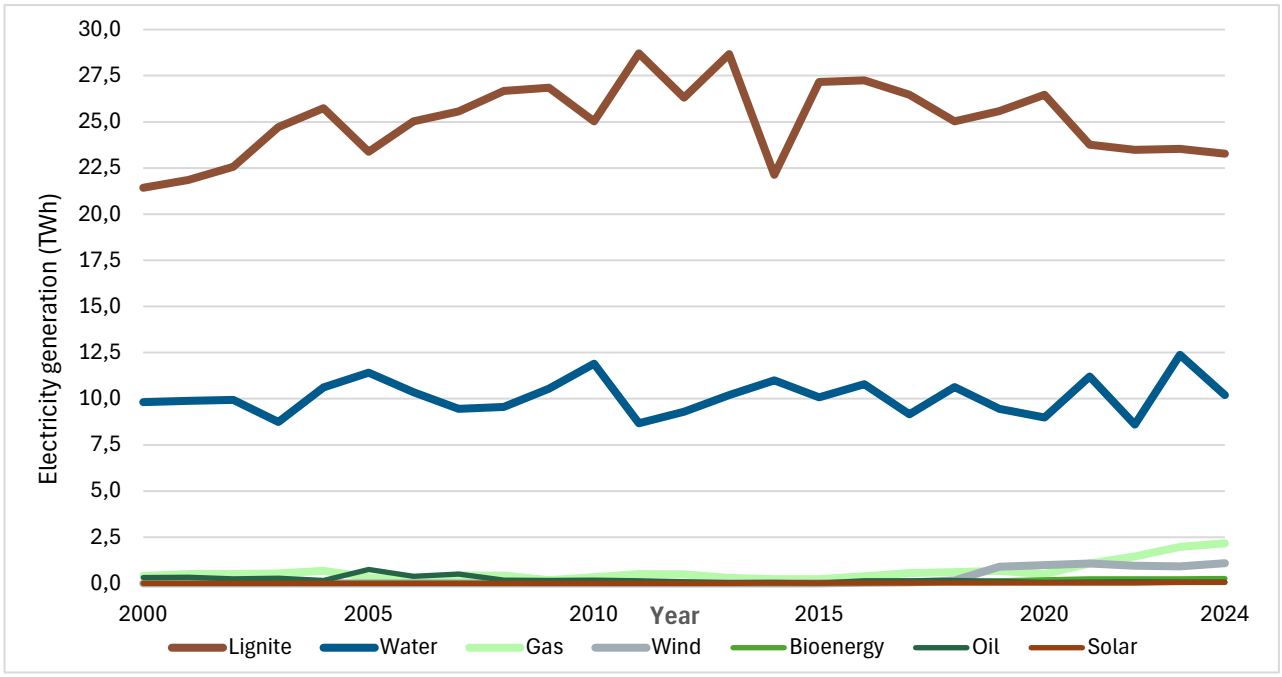

***Figure 1**: Electricity generation in Serbia by energy source, 2000–2024.*
***Source**: Ember (2025); Electricity generation from other renewables, excluding bioenergy; OurWorldinData.org/energy | CC BY*

The governance structure of the energy sector in Serbia comprised several ministries and institutions with specific responsibilities. The Ministry of Mining and Energy is responsible for establishing legal frameworks and approvals, in particular the approval of tariff

[1] See Vucetic, I. (2018), p. 47.
[2] See Evans, B. and Webster, M. (2008), p. 7.
[3] See Golousin et al. (2020), p. 1478.

systems. Furthermore, the Ministry of Environment and Spatial Planning is responsible for environmental impact assessments and for the sustainable use of resources. The Serbian Energy Agency (EARS) sets pricing and tariff systems, while the Serbian Energy Efficiency Agency (SEEA) creates incentives for efficient energy use and the use of renewable energies. In addition, there are regional centres for energy efficiency and an environmental protection fund that support the implementation of energy policy. A World Bank study in 2007 identified a shortfall in energy generation capacity of 15,000 MW. There was a significant need to modernise outdated facilities in order to increase energy generation efficiency and maintain generation potential.

Brief description

The project aimed to rehabilitate and expand the outdated Zvornik hydropower plant by comprehensively replacing the electromechanical plant components and implementing structural measures. The hydropower plant is located in western Serbia on the border with Bosnia and Herzegovina on the middle reaches of the Drina River near the town of Mali Zvornik, about 150 km southwest of Belgrade. It is a run-of-river power plant with two separate blocks and was commissioned between 1955 and 1958. The project executing agency is the Serbian state-owned energy supply company Elektroprivreda Srbije (EPS).

Specifically, the project involved the following measures: replacement of the turbine rotors and renewal of the digital and hydraulic turbine control system, rehabilitation and replacement of generator components, installation of new excitation systems and a generator control system, replacement of high-voltage components, replacement of electrical and mechanical auxiliary systems, replacement of protection, control, monitoring, control and safety systems (SCADA); restructuring of the buildings and rehabilitation and conversion of the substation components (new 35/110 kV switchgear). The project executing agency was to carry out the following measures in advance at its own expense: rehabilitation of the overhead crane on the dam crest, rehabilitation of the trash racks on both sides of the dam, rehabilitation of the general auxiliary facilities of the power plant, and deepening of the riverbed downstream of the dam, provided this is compatible with the new turbine runners.

The target group of the project includes all consumers connected to the Serbian electricity grid, with a focus on productive consumers. The project is the follow-up project to the successful rehabilitation of the Bajina Bašta HPP (BMZ No. 2004 65 237), which was also carried out in cooperation with EPS.

Breakdown of total costs

At the time of the appraisal, the total cost of the project was estimated at around EUR 95 million, of which up to EUR 70 million was to be provided as a low-interest loan from the German financial cooperation (FC). Serbia's own contribution was planned to be EUR 25 million.

The actual total cost amounted to around EUR 79.5 million. The costs financed by the FC loan total EUR 69.2 million. The project executing agency EPS's own contribution amounts to EUR 10.3 million.

	Phase 1 (plan)	Phase 1 (actual)
Investment costs (total) in EUR million	95.0	79.5
Own contribution in EUR million	25.0	10.3
External funding in EUR million	70.0	69.2
of which BMZ funds in EUR million	70.0	69.2

Table1 : Breakdown of costs

Map of the project region

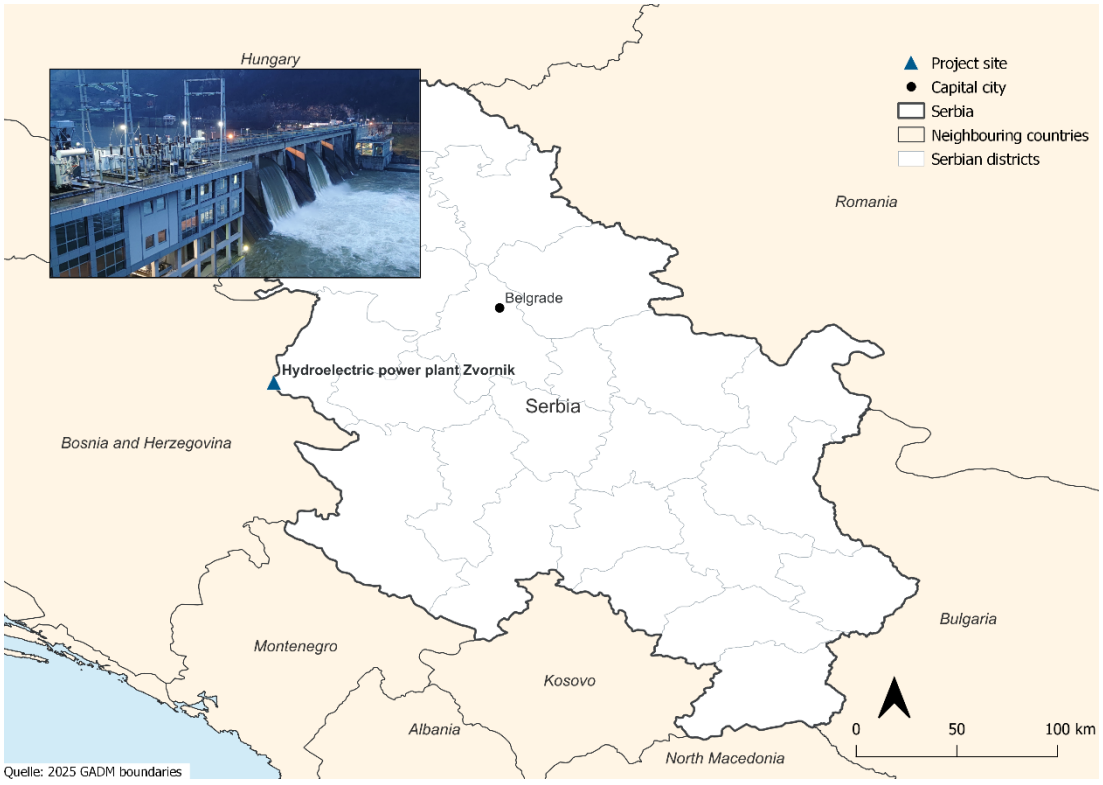

***Figure 2**: Map of Serbia including the project location of Zvornik hydropower plant.*
***Source**: Own illustration based on GADM 2025 (see map). photo: G. Bajic.*

Project-specific strengths and weaknesses of the project

The strengths include in particular:

- The identification of problems and the associated rehabilitation measures are appraised as being appropriate and targeted. They have been successfully implemented.
- The project's integration into Serbian-German development cooperation is appraised as good and complements earlier projects such as the rehabilitation of the Bajina Bašta hydropower plant. It made use of existing structures and relationships, which facilitated preparation and implementation.
- As part of the project, the project executing agency deployed a highly qualified internal team of experts, supported by experienced consultants, who accompanied the project from start to finish, which contributed significantly to its successful implementation.
- The cost plan was adhered to or slightly underspent, indicating the efficient use of funds. The total costs were estimated at EUR 95 million, while the actual costs amounted to EUR 79.5 million. The rehabilitation costs were EUR 0.52 million per MW, which is a favourable ratio.
- The project objectives were achieved, including increasing energy production and improving the technical availability of the hydropower plant. Annual electricity production exceeds the original targets.
- The generation capacity of the hydropower plant has been successfully maintained, and the average share of electricity generated by the Zvornik hydropower plant will contribute approximately 1.35 % to Serbia's total annual electricity production between 2020 and 2024, accounting for 3.96% of the country's renewable energy production.

The weaknesses include in particular:

- The original formulation of the project objectives and indicators was only partially appropriate and has been adapted in line with current quality standards.
- No specific gender issues were taken into account in the project design. To date, gender aspects are considered internally in the EPS' Human Resources Department and a separate organisational unit within EPS.
- The project experienced delays due to the detailed nature of the tender documents and the associated delays in the tendering process (clarification of a complaint) and the application period for export credit agency (ECA) cover. However, the delay in the contract between EPS and the contractor was minimal.
- Due to climate change and the associated decline in runoff volumes, the sustainability of the plant could be compromised in the future. This trend could lead to an unforeseen reduction in electricity production.
- Given the current market situation in the Serbian electricity sector, the units at the Zvornik hydropower plant have to be switched on and off more frequently than planned, which could have a negative impact on the service life of the equipment.

General conclusions/lessons learned

- Building institutional management capacity in the partner country is crucial. A highly qualified management team can ensure the effective implementation of the measures associated with a project and thus contribute significantly to its success.
- Continuous cooperation with the project executing agency enables the targeted use of synergy effects, promotes knowledge transfer and supports efficient project management.
- The use of cover through an export credit agency (ECA cover) makes sense from an economic and political risk perspective. It has been found that finalising the ECA contract documents, including the necessary financing and hedging processes, can take longer than originally anticipated.
- The impact of climate change on runoff volumes must be taken into account even more closely in future hydropower projects, as this can have a negative impact on electricity production levels and thus on economic sustainability in the long term.

Assessment according to OECD DAC criteria

Relevance

1. Alignment with policies and priorities

The project's objectives take into account the political priorities and existing framework conditions in Serbia at the time, as well as the priorities of Germany's bilateral development cooperation with Serbia.

With Serbia's transformation after the end of the Miloševic regime and the accompanying structural reforms, including in the energy sector, various strategies and laws were developed. In this context, the Serbian Energy Sector Development Strategy 2005 was presented by the Serbian Parliament in accordance with the new Energy Industry Act, which came into force in 2004. This had a planning horizon until 2015. The Serbian Energy Sector Development Strategy aimed to diversify energy production capacities and increase the use of the potential of renewable energy capacities. The Energy Efficiency Agency (SEEA), newly established following the adoption of the Energy Act, plays a central role in this regard. In addition, the government presented an implementation programme for the period up to 2012 in 2007. To this end, support strategies for renewable energies and energy-efficient and environmentally friendly technologies were launched. At the time of evaluation, the objectives of the project are still largely in line with the strategic objectives of the Serbian government. The Republic of Serbia's energy sector strategy for 2025 to 2030 positions energy security as a key objective.[4] At the same time, the energy transition and the associated decarbonisation of the energy sector are recognised as important conditions. It should be noted critically that the subsidisation of the coal sector in Serbia worsens the relative economic efficiency of renewable energy sources, which fundamentally runs counter to the approach of the project. At the same time, Serbian renewable energy generation is subsidised through feed-in tariffs, which in turn increases the relative economic efficiency of renewable energy. Whether and to what extent these effects balance each other out and what influence this has on "optimal" loan conditions cannot be determined within the scope of the evaluation.

The energy sector is also a priority area of German development cooperation with the Republic of Serbia, which began in 2000 and has gradually developed since then. Initially, the focus was on emergency aid measures. The aim of Germany's financial cooperation (FC) in the energy sector was to contribute to economic growth, sustainable energy supply, improving the quality of life of the Serbian population and environmental and climate protection as a whole through projects in the field of renewable energies and environmentally friendly measures in thermal power plants and district heating. The emphasis was on efficient and sustainable supply of electricity and heat energy. Bilateral development cooperation now focuses on supporting Serbia in the EU accession process.

The Zvornik hydropower plant, which has been in operation since the 1950s, had exceeded its technical and economic service life. The existing electromechanical equipment was prone to malfunctions, which could have led to increased maintenance costs, damage and potential total failure of the power plant. Rehabilitation of the Zvornik hydropower plant therefore made sense from a technical and economic perspective, and thus also from an overarching development policy perspective. The modernisation aimed to increase energy production efficiency and reduce dependence on environmentally harmful thermal energy production. The aim of renewing the electromechanical equipment was to reduce susceptibility to faults and the likelihood of damage, and to exploit the site's hydropower potential. Additional measures, such as deepening the riverbed, were also intended to increase electricity generation.

The objectives of the project are in line with the current objectives of Germany's bilateral development cooperation with Serbia, as set out in the concept for development cooperation with the transition partners in South-Eastern Europe, Eastern Europe and the South Caucasus. The objective of the project was in line with the BMZ's sector concept at the time, "Sustainable Energy for Development".[5] Furthermore, the objectives of the project then and now correspond to a) the German Federal Government's current objective of protecting the global climate and the environment, and b) the BMZ's current core theme strategy "Responsibility for our planet – climate and energy" (action areas 1 "Climate protection and adaptation to climate change" and 2 "Renewable energies and energy efficiency").[6] The thematic core strategy aims to meet rising energy demand with a climate-neutral energy supply and contribute to the complete decarbonisation of the energy sector by 2050.

Furthermore, the objectives of the measure were in line with the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs). For example, the measure falls under MDG 7 (Ensure environmental sustainability) and continues to

[4] Energy Sector Development Strategy of the Republic of Serbia for the Period by 2025 with Projections by 2030; Government of the Republic of Serbia (2024), p. 5 ff.
[5] See (i) BMZ strategy paper "BMZ Concepts 145 – Sector Concept Sustainability Energy for Development" (01/2007) and (ii) BMZ information brochure: "Sustainability Energy for Development (01/2014)."
[6] BMZ thematic core strategy: "Responsibility for our planet – climate and energy" from June 2021.

support the SDGs, in particular SDG 7 (Affordable and clean energy), SDG 13 (Climate action) and SDG 9 (Industry, innovation and infrastructure).

2. Alignment with the needs and capacities of stakeholders and beneficiaries

The target group comprises all consumers connected to the Serbian electricity grid. The total installed capacity in Serbia was approximately 10,333 MW in November 2009. Of this, 4% came from combined heat and power, 63% from conventional thermal power plants (mainly lignite) and 33% from hydropower. The electricity supply thus consisted of a poorly diversified energy mix, in which thermal (coal) generation clearly dominated, followed by hydropower generation.

The 1990s in Serbia were marked by a decline in economic performance, particularly in the energy sector. This was due to a lack of maintenance, a lack of reinvestment and low efficiency, and was characterised by high environmental pollution. In particular, hydropower plants such as the Zvornik HPP and the Bajina Bašta HPP were outdated, with declining efficiency and increasing susceptibility to malfunctions. Overall, there was a considerable need for rehabilitation in the Serbian electricity sector. At the time of the appraisal, the Zvornik HPP had an installed electrical capacity of 4 x 24 MW, i.e. a total of 96 MW. It had been in operation since the 1950s and had exceeded its technical and economic service life. The existing electromechanical equipment was prone to malfunctions, which could have led to increased maintenance costs, damage and potential total failure of the power plant. The core problem was correctly identified.

At the time of the project appraisal, the rehabilitation measures were aimed at achieving a 22.5% increase in capacity.

The design of the measure did not explicitly take into account vulnerable or disadvantaged sections of the indirect target group (population in the project region). From an ex-post perspective, however, the measure could possibly have developed additional gender impact potential by specifically taking gender aspects into account in its design. In this context, a gender analysis could have been carried out in advance of the appraisal.[7] This applies in particular to the level of the project executing agency. For example, a gender quota at project executing agency level could have been considered as a sub-goal or accompanying measure. At a higher level, greater involvement of women in decision-making processes and project implementation could have been conceivable.

3. Appropriateness of design

Based on their position in the Serbian energy sector and their market knowledge, technical capacities and operational experience, EPS and the operating company Drinsko-Limske-Hidroelektrane were the most suitable project partners at the time of the project appraisal as well as from today's perspective.

From an organisational perspective, the concept was also appropriate. The formation of an internal team of experts at EPS, the establishment of a rehabilitation department at the Zvornik hydropower plant, and the hiring of additional consultants for specific technical matters adequately supported the implementation of the individual measures. The design of the measure, including its technical, organisational and financial structure, is considered appropriate from both a contemporary and a current perspective in terms of contributing to the solution of the core problem described. The capacities of the partner government and the project executing agency were assessed realistically and taken into account appropriately in the design of the project.

Conceptually, the financing of the rehabilitation of the Zvornik hydropower plant was fundamentally suitable for addressing the core problem, namely the extensive rehabilitation and modernisation needs in the Serbian electricity sector, particularly in the area of hydropower plants. However, the cause-and-effect relationships postulated during the project appraisal were only partially precise and plausible. The overarching objective formulation at the impact level was not very specific. The outcome indicators formulated in the log-frame are plausible and quantitatively measurable. The wording of one outcome indicator was modified, and the impact-level objective was adjusted to "Energy supply in Serbia is more sustainable". However, the impact indicators are not clearly or directly measurable. From the perspective at the time, the formulation of the target system was comprehensible, but from today's perspective, a more precise definition of the target system is appropriate. These were therefore adjusted as part of the ex-post evaluation. In addition, an impact indicator was established and a suitable target value defined.

The evaluation of the project was based on a slightly adjusted theory of change. Through input factors such as consulting services, tenders, provision of financing, concrete rehabilitation work and the replacement of important plant components, the rehabilitation measures were successfully implemented (output 1) and the capacity of the Zvornik hydropower plant was increased (output 2). Specific output factors include the rehabilitation of generators, transformers and turbines, the installation of new turbine runners with a larger diameter and the dredging of the riverbed. The original aim was to achieve a technical availability of 93% for the power plant and an average electricity generation of 500 GWh (outcome). The overarching developmental impact

[7] For gender aspects in the energy sector, see, among others, IEA (2025) c: (n.d.) or World Bank (2025).

is that the substitution of emission-intensive coal-fired power generation and the associated reduction in greenhouse gas emissions will make energy supply more sustainable (impact).

The ex-post impact chain is as follows:

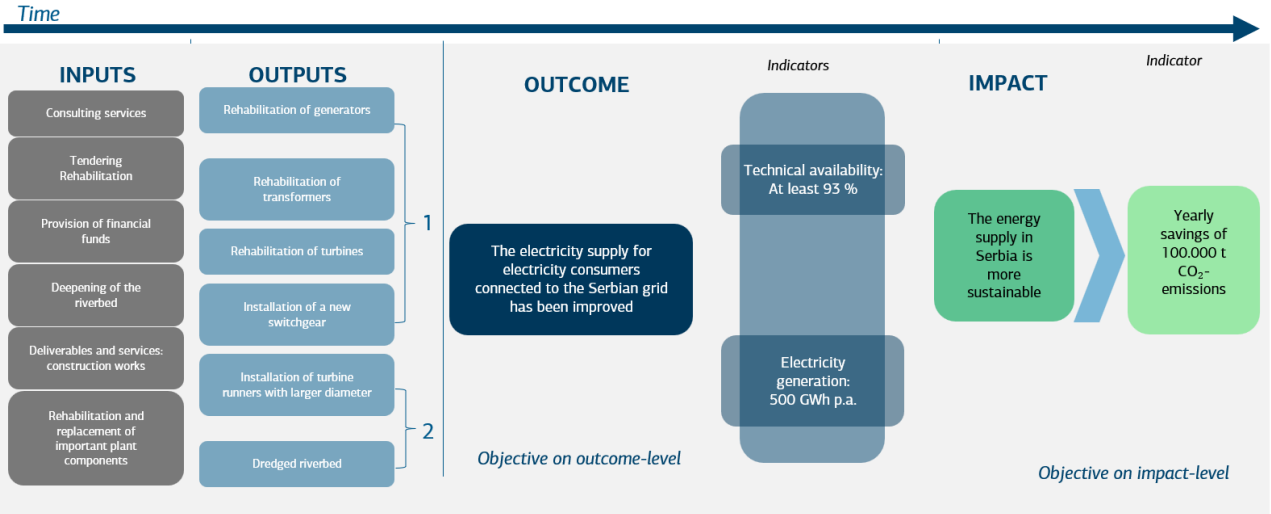

***Figure 3**: Theory of Change - Zvornik hydropower plant.*
***Source**: Own illustration.*

4. Adaptability – response to change

The project was not adapted during its implementation phase. Changes only occurred in relation to the schedule (delay in signing the contract) and total costs (lower own contribution).

Rating summary of relevance: successful (2)

The project was designed to be precisely tailored and appropriate in order to contribute to solving the core problem. At the time of evaluation, the measure was and continues to be embedded in both Serbian and German political strategy. Only specific gender aspects could have been included. The relevance of the project both at the time of the appraisal and at the time of the ex-post evaluation is considered as fully in line with expectations and therefore as successful.

Coherence

5. Internal coherence

Bilateral German-Serbian development cooperation in the energy sector comprises a large number of projects, both within the framework of technical cooperation (TC) and within the framework of financial cooperation (FC). Among other things, there were ongoing programmes in the field of energy efficiency in buildings from 2008 to 2017 in the area of TC. At the time of the evaluation, there are also a large number of TC projects in the fields of renewable energies and energy efficiency. The impact of the FC project in this regard is appraised as complementary.[8]

The measure complements the FC project on the rehabilitation of the Bajina Bašta hydropower plant, which is located 90 km upstream of the Drina from the Zvornik hydropower plant, and was ongoing at the time the Zvornik rehabilitation project was proposed. The FC project was able to build on experience gained from previous cooperation and benefited in particular from the existing structures and institutional relationships with EPS. For example, EPS employees from the Bajina Bašta HPP worked in the team of experts involved in the rehabilitation of the Zvornik HPP. In addition, some of the same companies/subcontractors from Serbia were involved in both projects.

The project complies with the international norms and standards adhered to by German development cooperation, including the 2015 Paris Climate Agreement and the corresponding follow-up agreements. An environmental and social impact assessment was carried out, which did not identify any significant negative impacts of the project. The study was approved by the responsible Serbian ministry in April 2013.

[8] GIZ (2024): Worldwide – Serbia. German Agency for International Cooperation.

6. External coherence

EPS has made considerable efforts to rehabilitate and modernise its thermal power plants and to implement individual rehabilitation measures on its own. The Serbian government has also given and continues to give very high priority to expanding the electricity supply and is endeavouring to develop and preserve the potential of renewable energies. The principle of subsidiarity is thus guaranteed.

Apart from German FC, no other relevant donors were identified at the time of the project appraisal or during implementation. Activities in the energy sector are generally closely coordinated among international donors. In this project, joint financing with other donors was deliberately not planned, as the scope of the measure was clearly definable and could be represented by German FC.

At the time of the evaluation, a large number of other donors (in particular the World Bank, EIB, EBRD, AFD, SECO) are active alongside German development cooperation. The portfolio is broad and includes energy efficiency and renewable energies project/programmes, but also topics such as climate-friendly reforms of Serbian policy. In some projects, EPS is the direct project partner of these donors.

The project also contributes significantly to the implementation of EU energy and environmental standards. Since 2006, Serbia has been a member of the Energy Community, an international legal framework that obliges countries in South-Eastern Europe and the European Union's eastern neighbourhood to implement standards even before accession. These include expansion targets for renewable energies and CO_2-emissions reduction targets.

Rating summary of coherence: successful (2)

The measure is closely integrated into existing country strategies and development cooperation programmes in the energy sector and complements previous projects, in particular the rehabilitation of the Bajina Bašta hydropower plant. It thus makes use of existing structures and institutional relationships, which supports planning and implementation and promotes synergy effects. Coordination with other donors takes place primarily within the framework of the Energy Community. In addition, the measure is embedded in the broader context of international norms, standards and targets and also supports alignment with the EU legal framework. Coherence is therefore appraised as successful.

Effectiveness

7. Achievement of objectives

At the time of the project appraisal, the outcome-level objective was to extend the productive life of the Zvornik hydropower plant by at least 25 years, increase the capacity of the hydropower plant and provide efficiently produced energy from renewable energy sources.

The following indicators were agreed with EPS at the time of the appraisal of the project:

1. Average annual production of at least 500 GWh after implementation of the project (indicator 1).
2. Availability of at least 95% per year and unit on average (indicator 2).

By today's standards, the original wording of the objective and the choice of indicators were only partially appropriate. They were therefore adjusted for the purposes of the evaluation. The objective at outcome level adjusted as part of the ex-post evaluation is "The electricity supply for electricity consumers connected to the Serbian grid has been improved." The target value for the indicator for the technical availability of the HPP was reduced from 95% to 93%.

Indicator	Status at time of review	Target value at EPE (review)	Actual value at PCR	Actual value at EPE
(1) Electricity generation at the Zvornik hydropower plant	440 GWh	500 GWh	593 GWh	509.625 MWh (2021-2024) Target value achieved
(2) Technical availability 93%	Approximately 90% on average over recent years at the time of the PA	93%	95%	94% (average 2021–2024) Target value achieved

***Table 2** : Outcome target achievement*
***Source**: Own illustration.*

According to current standards, a third indicator would need to be defined. However, the ex-post evaluation was unable to identify a meaningful complementary indicator that could adequately measure the project's success. For this reason, the use of two indicators will be retained.

8. Contribution to the achievement of objectives

The rehabilitation involved replacing the electromechanical plant components (output 1) and increasing the power plant's production capacity (output 2). The replacement measures included the rehabilitation of the generators, step-up transformers and turbines, and the installation of a new switchgear. To increase capacity, new turbine runners with a larger diameter were installed and the riverbed was deepened. The capacity of the plant was increased by about 30% of its original capacity. The outputs were delivered as planned.

Indicator 1:

The hydropower plant is fully operational, has been running smoothly since commissioning and is making a significant contribution to achieving targets by maintaining and increasing generation capacity. The Zvornik hydropower plant is used to generate both base and peak load. This improves annual generation and, in particular, supports capacity during peak loads. With a production of 387,062 MWh (2020), 591,083 MWh (2021), 446,365 MWh (2022), 618,315 MWh (2023) and 382,735 MWh (2024), the Zvornik hydropower plant contributed approximately 1.35% to Serbia's total annual electricity production during this period[9] and accounts for 3.96% of the country's electricity production from renewable sources.

Indicator 2:

At the time of the ex-post evaluation, technical availability was 94%, slightly below the target value of 95% originally defined during the project appraisal. The calculation includes planned shutdowns and maintenance work, which take up to 19 days per unit per year and result in an annual loss of availability of 5.2%. However, as this maintenance is specifically carried out in months with low production, there is no relevant loss of planned annual production. From an operational and maintenance perspective, it would be possible to carry out the maintenance work more quickly, but this is not necessary. For this reason, the target value for technical availability was reduced to 93% as part of the evaluation, taking into account approximately 5% downtime due to planned maintenance and 2% downtime due to unplanned maintenance (7% in total).

Overall, the target achievement can therefore be rated as high, especially since the loss of availability had no significant impact on production.

9. Quality of implementation

The quality of implementation of the project by all project participants was targeted and characterised by a high level of commitment. The construction and other measures were implemented to a high standard.

The entire project was implemented in accordance with the legal and regulatory procedures applicable in the Republic of Serbia. Before work began, all necessary permits and approvals were obtained from the relevant state authorities (electricity permit, water permit, permit from the Ministry of the Interior, permits from the Firefighting and Emergency Situations Department, permit from the Institute for the Protection of Cultural Heritage, the distribution network operator, etc.). In addition, a feasibility study, an environmental impact study, a detailed design and an implementation design were prepared.

Important control mechanisms that were used to support the achievement of objectives included the formation of an internal team of experts (EPS Expert Team) to monitor project implementation. This enabled continuous monitoring and adjustment of

[9] Based on the weighted averages of electricity produced in Serbia and electricity produced by the Zvornik hydropower plant between 2020 and 2023. The production data for electricity produced by the Zvornik hydropower plant was provided by the operator EPS. The relevant data on the total electricity produced in Serbia is taken from the 2024 working report of the Serbian Energy Agency.

the measures financed, allowing problems to be identified at an early stage and solutions to be implemented quickly. In addition, a specialised rehabilitation department was established at HPP Zvornik, staffed with technical personnel and engineers. The role of the FIDIC engineer was also performed by engineers from HPP Zvornik, who carried out the supervision of the works. The addition of further consultants for specific technical areas enabled the project team to draw on comprehensive specialist knowledge. Furthermore, experience gained from previous projects (rehabilitation of the Bajina Bašta HPP) contributed to the implementation of best practices and helped to avoid mistakes made in the past. These control mechanisms resulted in efficient project implementation, accelerated decision-making processes and significant financial savings, as the need to commission external companies was limited.

Weaknesses in implementation were mainly due to the partly imprecise wording of the tender documents with regard to technical specifications for the generator and the cooling water system, which were not detailed enough. This led to some misunderstandings and difficulties during implementation. The lack of clarity in the regulations on price changes was also a possible cause of uncertainty and conflict between the client and the contractor. In addition, the definition of the use of the client's equipment and personnel, such as crane operators and cranes, was unclear, which presented additional challenges. To avoid or mitigate these weaknesses, the tender documents could have been drafted more precisely and in greater detail in some cases.

10. Unintended effects (positive or negative)

During the evaluation mission, no information has become known about unintended positive or negative effects or about further complaints or major accidents, neither during implementation nor after completion. According to reports prepared annually by EPS for EBRD, there were no known negative environmental impacts neither during the implementation of the rehabilitation work nor after completion. In addition, EPS maintains an integrated management system in accordance with the requirements of ISO 9001:2015, ISO 14001:2015 and ISO 45001:2018.

Rating summary of effectiveness: successful (2)

In summary, it can be stated that the objectives of the project were achieved at the outcome level. Annual electricity generation exceeded the target value and technical availability reached the (during the evaluation adjusted) target of 93%. The involvement of a qualified management team and external consultants contributed to the quality and efficiency of the implementation. The overall effectiveness of the project is assessed as successful.

Efficiency

11. Production efficiency

The total cost of the project was estimated at around EUR 95 million at the time of the appraisal. The total loan amount of EUR 69.2 million was paid out to the implementation consultant (~ EUR 1.4 million) and the contractor (~ EUR 67.8 million). At the time of the project appraisal, EPS's contribution to the project costs was estimated at up to EUR 25 million. This estimate included various measures such as construction work, consulting services, taxes and customs duties. EPS's own contribution directly related to the project could not be finally determined within the framework of the evaluation because not all information was available. The proven own contribution amounts to around EUR 10.3 million. This includes, among other things, the excavation of the riverbed (EUR 0.8 million), the procurement of new multifunctional rake cleaning machines (EUR 1.6 million) and the rehabilitation of the hydromechanical equipment (EUR 1.6 million). The difference between the actual contribution made by EPS and the original cost estimate of EUR 25 million is mainly due to deviations in the costs of guarantee coverage, taxes and import duties. The total cost of the project is therefore approx. EUR 79.5 million. The services provided by local service providers amount to approximately EUR 17.5 million, which represents around 22% of the project.

The specific refurbishment costs were estimated at EUR 0.52 million per MW of installed electrical capacity, which is favourable compared to similar projects. Compliance with the loan financing framework and the fact that the costs of own contributions were lower than expected also demonstrate the cost-efficient use of funds.

According to the loan agreement, the originally planned duration of the construction phase was five years. At a later stage, this term was adjusted to approximately six years in the agreement between EPS and the contractor. In fact, the planned outputs were completed at the beginning of 2020, approximately nine years after the loan agreement was signed. This represents a deviation of approximately four years from the completion date of 2016 originally planned in the appraisal document. The delays occurred primarily in the preparation of the tender documents, the tendering process and the finalisation of the guarantee coverage.

A comparison with the previous measure for the Bajina Bašta hydropower plant shows that the consulting costs were similar. In this project, the total costs amounted to EUR 79.93 million, of which EUR 1.21 million was attributable to the implementation

consultant. This corresponds to 1.5% of the total costs. The total cost of the rehabilitation of the Zvornik HPP is EUR 79.5 million, of which EUR 1.4 million was spent on consulting services, corresponding to 1.8%. The costs of the implementation consultant are considered reasonable in comparison with similar rehabilitation projects.

12. Allocation efficiency

The project aimed to make the electricity supply more sustainable for all consumers connected to the Serbian electricity grid. To achieve this goal, the existing infrastructure of the Zvornik HPP was to be rehabilitated. This was appropriate at the time the project was designed and also at the time of the evaluation. The production gains achieved and the preservation of the existing infrastructure were cost-effective.

In this context, alternative technologies for sustainable electricity generation, such as solar and wind energy, would most likely have incurred higher investment and operating costs. Therefore, the rehabilitation of the hydropower plant was a cost-effective solution at the time and meets the criterion of allocation efficiency. This is also underlined by the levelised cost of electricity (LCOE) per kWh. At USD 0.043/kWh (as of 2010), the LCOE for hydropower was the lowest among the various generation technologies, such as solar PV, bioenergy and geothermal energy. This made it one of the most cost-effective options for electricity generation, especially since the generation potential already existed.

Internal project factors that were decisive in achieving the intended objectives of the measure included a highly qualified management team supported by experienced consultants. In addition, the competition that took place during the tendering process contributed to efficient awarding of contracts. It should be particularly emphasised that EPS carried out part of the work itself, thereby contributing significantly to the success and high quality of the project. In view of the high level of own contribution, the use of public funds appears appropriate.

Rating summary of efficiency: successful (2)

The production efficiency of the project is rated as successful. The cost plan was adhered to and the own contribution was lower than originally estimated, so that the objective is considered to have been achieved economically. However, there were delays in adhering to the schedule. At the same time, allocation efficiency is appraised as having been achieved. The production gains achieved and the preservation of the existing infrastructure contributed to a sustainable electricity supply for all consumers connected to the Serbian electricity grid. The implemented measures are considered economical compared to alternative measures.

Impact

13. Overarching developmental changes

At the time of the appraisal, the overarching impact objective was defined as "Sustainable economic growth in Serbia and protection of the climate and the environment, preservation of ecologically compatible hydropower potential". At the time of the appraisal, no indicator for the overarching developmental impact of the project had been defined.

In order to take into account the current BMZ requirements for the formulation of the objective and the indicators, the project's impact objective was reformulated for the evaluation and a corresponding indicator was defined. Accordingly, the adjusted objective at the impact level is "The energy supply in Serbia is more sustainable." The achievement of the objective can be summarised using the indicator newly formulated as illustrated in the table below.

Indicator	Status at time of review	Target value at EPE (review)	Actual value at PCR	Actual value at EPE
Greenhouse gas emissions saved	0 t CO_2	100,000 t CO_2 p.a.	100,000 t CO_2 p.a.	105,000 t CO_2/a Target value achieved

***Table 3**: Impact target achievement.*
***Source**: Own illustration.*

During the evaluation, savings of 105,000 tonnes of CO_2 per year were calculated. This exceeded the target value: the target value of the indicator was adjusted during the final control and quantified at 100,000 tonnes of CO_2 per year. The background to this is that, although no concrete impact indicator was quantified during the appraisal, a saving of 550,000 tonnes of CO_2 per year was assumed. However, the original calculation underlying this figure is based on the assumption that the hydropower plant

would be taken off the grid and the entire hydropower generation capacity would be replaced by fossil fuels.[10] At the same time, there has been a slight increase in the share of renewable energies in electricity production in Serbia. While this figure was 27.95% at the time of the project appraisal (2009), it stood at 33.5% in 2021. However, the fluctuating hydropower generation depending on annual water availability must be taken into account.

A fish ladder has been in place since the 1950s, enabling fish species living in the Drina (and Sava) rivers to migrate upstream from the Zvornik hydropower plant to Lake Zvornik, where they spawn. As part of the environmental and social study (E&S) carried out in 2013 in preparation for the project, the fish ladder was also examined and its functionality confirmed. The fish ladder was therefore not taken into account in the remediation measures.

14. Contribution to overarching intended developmental changes

The measure has contributed to a more sustainable electricity supply in Serbia. This was achieved through higher technical availability and an increase in electricity generation at the Zvornik hydropower plant to an average of 509,625 MWh. This in turn contributes to climate targets.

15. Contribution to overarching unintended developmental changes

No unintended effects at impact level have been identified during the evaluation.

Rating summary of impact: successful (2)

In summary, it can be said that the project has had a significant impact. Energy supply in Serbia has been made more sustainable. The planned CO_2 savings have been achieved. No unintended effects have been identified. The impact is therefore rated as successful.

Sustainability

16. Capacities of beneficiaries and stakeholders

Taking into account all available information and considering the institutional and personnel structure of the project executing agency EPS, it can be assumed that EPS will be able to ensure the positive effects of the measure in the future. The profitability of the power plant is also assessed as positive, so that economic sustainability is considered to be ensured. Furthermore, it can be assumed that EPS will continue to optimise operations. An appropriate budget for annual maintenance work by the project executing agency has been provided.

In view of environmental and climate risks, various factors could impair the functionality of the hydropower plant in the future. Extreme weather events such as heavy rain or snowfall can lead to unforeseen water levels that could disrupt the power plant's operations. Irregular snowmelt, especially during sudden temperature rises, can lead to an abrupt increase in water flow. This, in turn, can cause the weir to overflow, which affects the efficiency of power generation, as not all of the water can be used to produce electricity. Rapid snowmelt can also cause technical problems, such as increased clogging of the turbine inlet valves and difficulties in operating the unit's cooling water system. This can compromise the efficiency and safety of the power plant. At the same time, a reduction in snowfall in the mountains due to changing climatic conditions can also pose risks to the operation of the power plant. Less snowfall or early melting can reduce the amount of water available for power generation.

The responsible ministry of the Republic of Serbia regularly draws up water management plans, with the current plan covering the period 2021-2027. This plan is based on European Union Directive 2000/60/EC, which establishes a framework for Community action in the field of water policy. It takes into account relevant factors such as climate change, external environmental conditions and the mitigation of the effects of floods and droughts.

EPS also conducts periodic climate protection studies and prepares annual operational plans for flood protection as well as protection and rescue plans. As part of these measures, an early warning system has been implemented that operates via alarm stations upstream and downstream of the hydropower plant. In addition, EPS examines the sedimentation of the reservoir every five years and monitors the degradation processes in the reservoir.

In addition, samples are taken every three months and the water quality of the surface water is examined. The fish ladder is regularly opened for 2-3 months in spring to allow fish to migrate to Lake Zvornik during the spawning season, with the minimum flow rate increased to 100 m^3/s and the water level in the lake maintained at the maximum operating level.

[10] The target value of the indicator was calculated as follows at the time of the final inspection: Avoidance of losses (1/6 of 440 GWh/a): 75 GWh/a x GEF = 51,750 t CO_2 /a + Capacity expansion: 70 GWh/a * GEF = 48,300 t CO_2 /a; total: 100,050 t CO_2 /a (GEF: grid emission factor, for Serbia 0.690 t CO_2 /MWh).

Overall, the mission gained the impression that the facilities financed by the project are being managed and maintained in a sustainable manner. Environmental and social aspects are a high priority for the management and operating team at EPS. EPS also considers the maintenance of the facility to be extremely important. This is reflected in an adequate budget and an appropriate organisational structure. In addition, keeping technical spare parts on site helps to reduce plant downtime.

17. Contribution to supporting sustainable capacities

The EPS staff at the power plant have the necessary experience and have been trained accordingly. There is an ongoing programme for further training and education of the staff. During implementation, staff were trained in the use of the new plant components and, after completion, underwent internal exams on how to handle the new plant components. All specifications relating to operating and maintenance instructions have also been followed. Subsequent training courses for staff have also been carried out.

Furthermore, the new management system and the implementation of the SCADA system enable better monitoring of the power plant's operation from multiple locations.

18. Durability of impacts over time

Based on the impressions gathered during the on-site visit, acceptance in the local community is high. Around 80 % of the employees come from the region, which contributes to securing income for the local population.

It should be noted here that, due to the current market situation in the electricity sector, with an increasing share of non-conventional renewable energies (especially wind power), the units at the Zvornik hydropower plant have to be switched on and off more frequently. This could have a negative impact on the service life of the units in the long term.

Although part of the hydropower plant is geographically located in Bosnia and Herzegovina (Entity Republika Srpska), the power plant and the water flow are completely under the control of the Republic of Serbia. This situation arose as a result of the break-up of Yugoslavia in the 1990s. There is currently no usage agreement and Bosnia and Herzegovina does not participate in the power plant. Renewed political tensions could lead Bosnia and Herzegovina to demand participation in the power plant in the future, which could potentially have a negative impact on sustainability. However, no concrete indications or risks in this regard could be identified in the evaluation.

Furthermore, according to the available information, only one minor accident was recorded. No environmentally harmful events in connection with the project were documented. No measures specifically addressing gender impact potential are known.

Rating summary of sustainability: successful (2)

The sustainability of the project, in particular its financial sustainability, is appraised as successful. The institutional, human and financial capacities are highly resilient. In addition, EPS is aware of potential impact resulting of environmental and climate changes. However, regular monitoring measures supported by the competent authorities ensure effective control.

Overall assessment: successful (2)

At the time of evaluation, the project was and continues to be embedded in both Serbian and German political strategy. The project was designed to be precisely tailored and appropriate to contribute to solving the core problem. Although specific gender aspects could have been included, the relevance is assessed as successful. Thanks to the project's good integration into existing country strategies and development cooperation programmes, as well as the activities of the Energy Community, coherence as a whole can also be assessed as successful.

The project's outcome-level objectives were achieved. The involvement of a qualified management team and external consultants contributed to the quality and efficiency of implementation. Overall, the project's effectiveness is considered to have been successful.

The cost plan was adhered to and the own contribution was lower than originally estimated, so that the objective is considered to have been achieved economically. However, there were delays in adhering to the time-schedule. The production gains achieved and the preservation of the existing infrastructure led to a more sustainable electricity supply for all consumers connected to the Serbian electricity grid. The project’s measures are considered economical compared to alternatives. Overall, the two aspects of efficiency, production and allocation efficiency, are rated as successful.

The project has significant impacts. The impact-level objective, measured in terms of planned CO_2-emission savings, has been achieved. No unintended effects were identified. The impact is therefore also classified as successful. The sustainability of the

project, in particular its financial sustainability, is rated as successful. The institutional, human and financial capacities are highly resilient. In addition, EPS is aware of any environmental and climate changes.

Based on the successful appraisal of all criteria, the overall project is rated as successful.

Contribution to Agenda 2030

By rehabilitating a hydropower plant, the project contributes to the implementation of the goals of the 2030 Agenda, to which the German Federal Government is committed, as well as to the implementation of the Paris Climate Agreement. In particular, it contributes to SDG 7 (Affordable and clean energy). The hydropower plant enables clean, cost-effective and more reliable access to energy for consumers connected to the Serbian electricity grid and maintains the existing infrastructure. By reducing CO_2-emissions, the project contributes to SDG 13 (Climate action) by replacing the use of costly electricity from fossil fuels with electricity generated from renewable energy sources. Finally, SDG 7 is closely linked to and indispensable for the achievement of other SDGs such as SDG 3 (Good Health and Well-being), SDG 8 (Sustainable Work and Economic Growth) and SDG 10 (Reduced Inequalities).

Methodology

Evaluation methodology

The ex-post evaluation follows the methodology of a rapid appraisal, i.e. a data-based, qualitative contribution analysis, and represents an expert opinion. The project is attributed effects based on plausibility considerations, which are based on a careful analysis of documents, data, facts and impressions. Where possible, this also includes the use of digital data sources and modern techniques (e.g. satellite data, online surveys, geocoding). The causes of any contradictory information are investigated, attempts are made to resolve them, and the assessment is based on statements that are confirmed by several sources of information (triangulation), where possible.

The analysis of the effects is based on assumed causal relationships, documented in the impact matrix developed during the project appraisal and updated during the ex-post evaluation, if necessary. The evaluation report sets out arguments as to why certain influencing factors were identified for the effects observed and why the project under review probably made a certain contribution (contribution analysis). The context of the development measure is taken into account in terms of its influence on the results. The conclusions are put into relation to the availability and quality of the data basis. An evaluation concept serves as the reference framework for the evaluation.

The method offers a balanced cost-benefit ratio for project evaluations, on average, with a balance between knowledge gain and evaluation effort, and allows for a systematic assessment of the effectiveness of DFG projects across all project evaluations. Individual ex-post evaluations cannot therefore meet the requirements of a scientific assessment in the sense of a clear causal analysis.

The main objective of the evaluations (knowledge interest) is to measure impacts, provide accountability, promote transparency and enable institutional learning.

Type of evaluation:

Field visit to the project area.

Key questions of the evaluation according to the evaluation concept:

- Did the concept, the objectives of the measure, and the needs/priorities of the target group, the implementing agency, and the partners fit together?
- Was the concept of the measure appropriate and realistic (technically, organizationally, and financially) and fundamentally suitable for contributing to the solution of the core problem?
- Were the (possibly adjusted) objectives of the measure achieved?
- Which internal project factors (technical, organizational, or financial) were decisive for the achievement or non-achievement of the intended objectives of the measure?
- How would you appraise the quality of the management and implementation of the measure in terms of achieving its objectives?
- Are there any overarching development policy changes to which the measure was intended to contribute?
- Are the target group, implementing organisations, and partners institutionally, personally, and financially capable and willing (ownership) to maintain the positive effects of the measure over time (after the end of funding)?

Non-public (internal) documents

Internal project documents (contracts, separate agreement, project appraisal document, reporting, final control report, environmental and social impact analysis), secondary specialist literature, strategy papers, context, country and sector analyses.

Directory of public sources

Brnabic, A., & Turkovic, M. (2015). *A roadmap for deploying renewable energy sources in Serbia and the regional perspective.* Center for International Relations and Sustainable Development (CIRSD). https://www.cirsd.org.**Fehler! Linkreferenz ungültig.**

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IRENA (2023): Renewable Power Generation Costs in 2023. International Renewable Energy Agency. Abu Dhabi.

Ritchie, H. & Roser, M. (o.D.): Serbia Energy country profile. Our World in Data. [accessed at 08.08.2025].

Tsagkari (2022): The need for gender-based approach in the assessment of local energy projects. Energy for Sustainable Development, 68, 40-49.

Vučetic, I. (2018): The Impact of a Hydroelectric Power Station on the Development and Modernization of the Bajina Bašta Settlement During the Socialist Period, S. 47.

World Bank (2025): Gender & Energy Projects Public Private Partnership.

World Bank Group (o. D.): Data - Serbia. https://data.worldbank.org/country/serbia [accessed at 20.08.2025].

Data sources and analysis tools

World Bank, International Energy Agency (IEA), Our World in Data, and other databases, on-site data collection, interviews.

Project sites visited

Hydropower plant in Zvornik, Elektroprivreda Srbije (EPS) in Belgrade.

Interview partners and modality (in person, virtual/by telephone, in writing)

Representatives of the project executing agency, including a FIDIC engineer, KfW employees from the operational division, representatives of the Serbian Ministry of Energy and the German Embassy.

The following aspects limited the evaluation

None.

Assessment methodology

A six-point scale is used to assess the project according to OECD DAC criteria, with the exception of the sustainability criterion. The scale values are as follows:

Level 1 Very successful: results significantly above expectations

Level 2 Successful: results fully in line with expectations, without significant shortcomings

Level 3 Moderately successful: results below expectations, but positive results predominate

Level 4 Moderately unsuccessful: significantly below expectations and negative results dominate despite recognisable positive results

Level 5 Unsuccessful: despite some positive partial results, the negative results clearly dominate

Level 6 Highly unsuccessful: the project is useless or the situation has deteriorated

The overall rating on the six-point scale is based on a project-specific weighting of the six individual criteria. Levels 1–3 of the overall rating indicate a 'successful' project, while levels 4–6 indicate an 'unsuccessful' project. It should be noted that a project can generally only be classified as "successful" in terms of development policy if both the achievement of objectives at the outcome level (effectiveness) and impact level, as well as sustainability, are rated at least as "moderately successful " (level 3).

The annex to this report is available upon request (German only).

Imprint

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