Sustainable Energy Connectivity in Central Asia

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ROUND TABLE

Development of Small Hydropower in Kyrgyzstan: First steps taken

Bishkek, 4 February 2025

Results of the pre-feasibility study for Karakol-1 Small Hydropower Plant

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Project Objective

To develop a comprehensive pre-feasibility study that explores various options for the construction of the "Karakol-1" Small Hydropower Plant, located in the Ak-Suu district of the Issyk-Kul region, Kyrgyz Republic, and serves as a benchmark for stakeholders by:

- ❑ Covering all critical aspects of the project, including:
  - **Technical** feasibility
  - **Economic** viability
  - **Environmental** sustainability
  - **Legal** compliance
- ❑ Providing stakeholders with actionable insights and a structured framework for decision-making
- ❑ Establishing best practices to ensure consistency, quality, and relevance in future pre-feasibility studies, contributing to better project planning and execution in the energy sector

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Contents of the pre-feasibility study

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River Basin Identification

The river basin for the proposed project was identified with the support of the Green Energy Fund of Kyrgyzstan, ensuring alignment with sustainable energy priorities

The original "Karakol" Small Hydropower Plant (SHPP) was commissioned in 1948 and operated until 1970, demonstrating the site's historical viability for hydropower generation

Strategic Location:

- Situated 1 kilometer from the city of Karakol, the regional center
- Easily accessible via an asphalt road that also connects to the city's ski resort
- Proximity to infrastructure reduces logistical challenges and supports project feasibility

This site provides an optimal combination of accessibility, historical relevance, and natural resources for the successful development of the new "Karakol-1" SHPP

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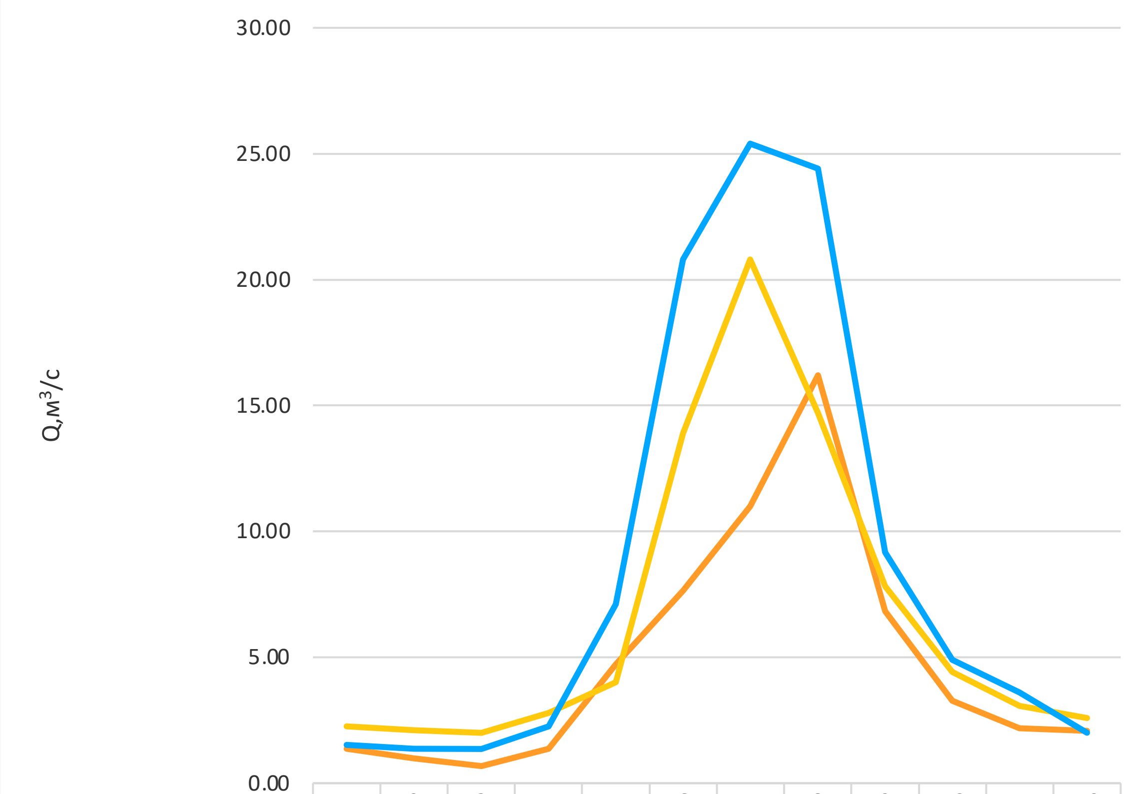
Site visit

The experts of the SECCA project and a representative of the Green Energy Fund of Kyrgyzstan visited the Karakol-1 Small Hydropower Plant (SHPP) project site

Water Regime

The average monthly discharges of the Karakol River at the mouth of the river during the low water period range from 4.42 to 2.0 m³/s, while during the flood period, the discharges range from 2.8 to 20.8 m³/s in an average flow year.

During the observation period from 1932 to 1992, the highest annual discharge was recorded in 1942 (Q0 = 8.66 m³/s), while the lowest was in 1947 (Q0 = 4.86 m³/s).



	1	2	3	4	5	6	7	8	9	10	11	12
маловодный, 1972	1.38	0.99	0.68	1.36	4.71	7.64	11.00	16.20	6.82	3.28	2.19	2.08
средний,1935	2.25	2.11	2.00	2.80	4.00	13.90	20.8	14.70	7.81	4.42	3.06	2.58
многоводный,1942	1.53	1.38	1.36	2.27	7.12	20.8	25.4	24.4	9.16	4.91	3.61	2.00

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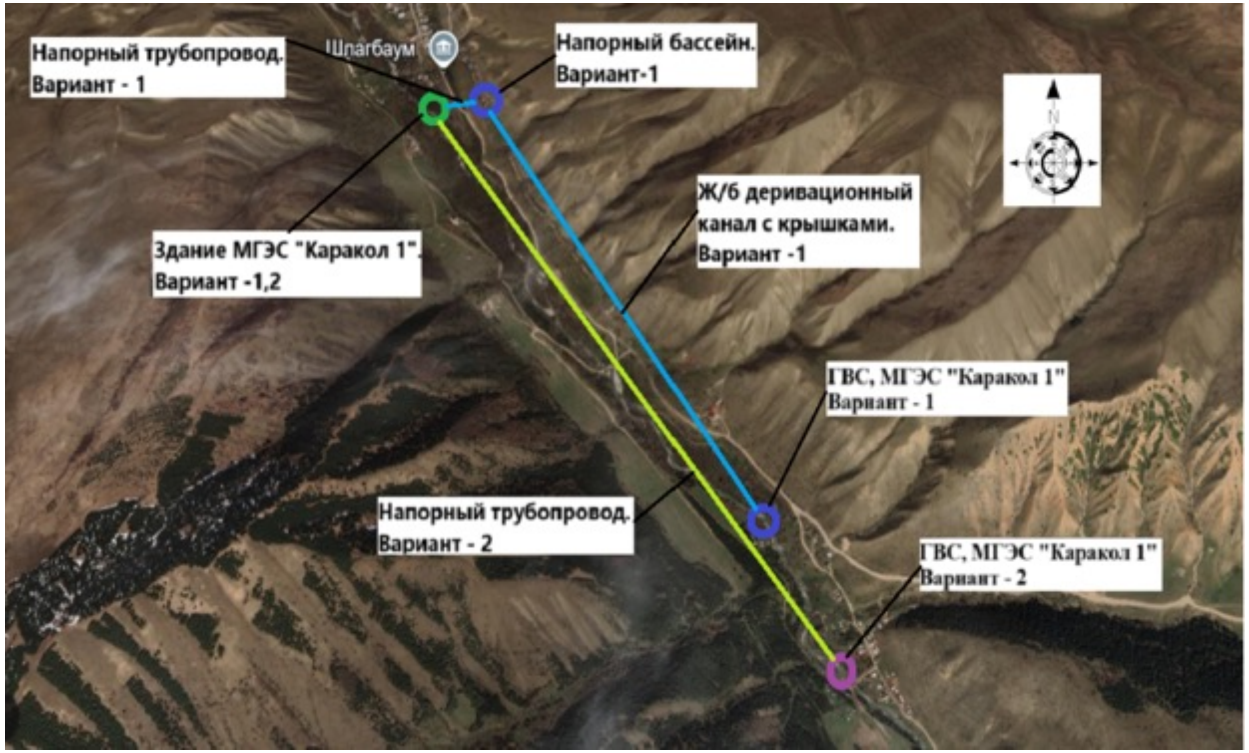
Option 1 – Construction of the SHPP Based on the Previously Built Scheme

This option involves using water intake from the Karakol River. The existing water intake structure will be restored and reconstructed as necessary (a detailed restoration plan will be presented in subsequent stages of SHPP design).

Water delivery will be carried out along the route of the previously existing derivation channel with the following modifications:

- Water flow through the channel: 4.4 m³/s
- Channel cross-section: rectangular
- Channel covering: closed with lids
- Channel material: reinforced concrete
- A completely new pressure basin will be constructed at a new location, along with a pressure pipeline with a diameter of 1400 mm
- The SHPP building will also be new, with dimensions accommodating all the equipment to be installed within
- An outflow channel will be provided to discharge water from the hydro units back into the Karakol River



This SHPP option has the following specifications:

- **Installed capacity: 2109 kW.**
- **Design head: 57.5 m.**
- **Water flow: 4.4 m³/s.**
- **Number of hydro units: 2.**

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Option 2 – Construction of the SHPP at a New Location

This option involves constructing the SHPP at a new location with water intake from the Karakol River. The water intake will be situated upstream of the existing intake.

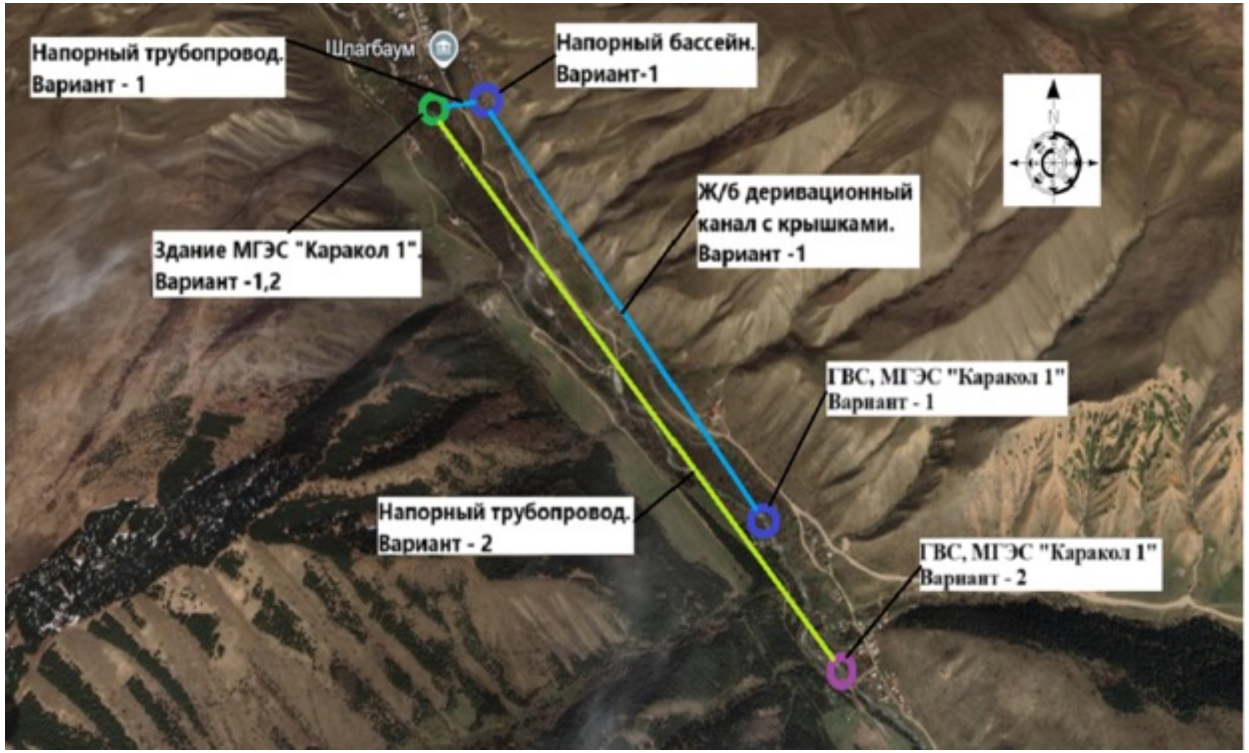
The option includes the construction of a new water intake structure and the installation of a derivation pressure pipeline designed for a flow rate of up to 4.4 m³/s.

The SHPP building will be new, with dimensions accommodating all the equipment to be installed within.

An outflow channel will be provided to discharge water from the hydro units back into the Karakol River.

This SHPP option has the following specifications:

- **Installed capacity: 2388 kW.**
- **Design head: 65.1 m.**
- **Water flow: 4.4 m³/s.**
- **Number of hydro units: 2.**



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Comparison of the option 1 and option 2

Annual Electricity Generation Calculation

Table 1: Determination of Annual Energy Production (Option 1)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MWh/month	547	491	485	873	1,519	1,519	1,519	1,519	1,519	820	550	426

Total Annual Production: 11 786 MWh/year

Table 2: Determination of Annual Energy Production (Option 2)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MWh/month	619	556	549	989	1,720	1,720	1,720	1,720	1,720	929	623	482

Total Annual Production: 13 344 MWh/year

Total Estimated Cost without Electromechanical Equipment

- **Option 1 Total Estimated Cost:** 119,470.419 thousand som
- **Option 2 Total Estimated Cost: :** 214 914.664 thousand som

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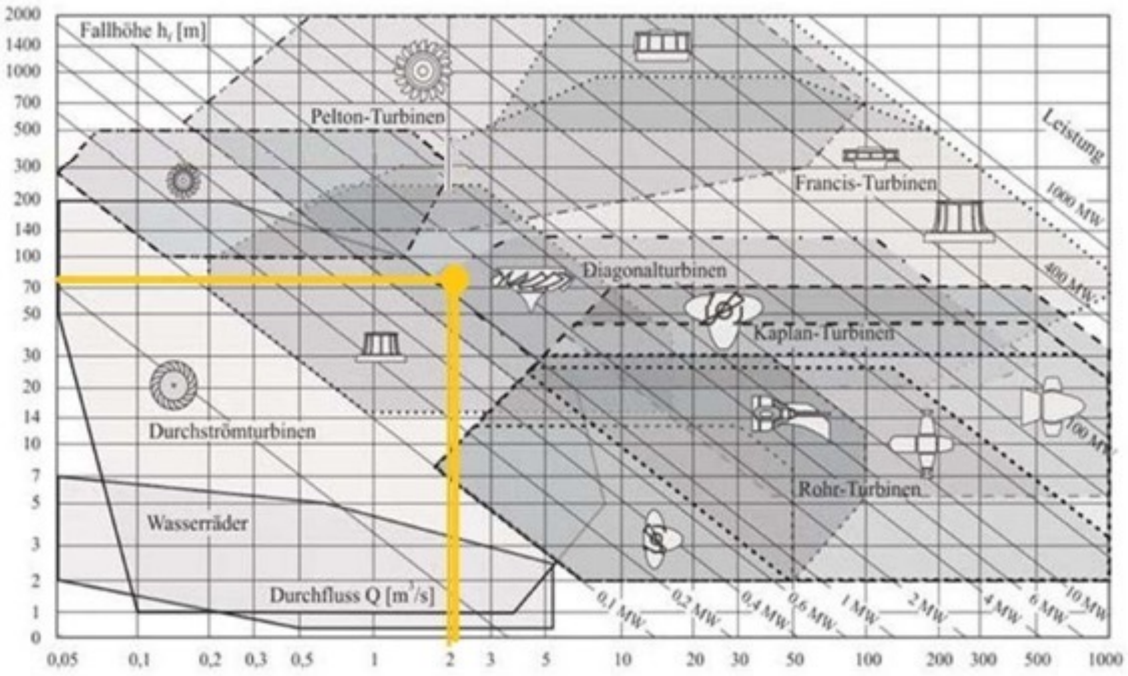
Electromechanical Equipment

The selection of the turbine type is driven by aspects such as operating conditions, turbine and civil works costs, ease of maintenance of the worn components, or transport.

The areas of application of the various turbine types are shown in the following chart. For the project a Francis type turbine shall be selected.

The quality of hydro turbines is crucial for effective and reliable power generation. The benefits of high-quality turbines can be summarized as follows:

- High Efficiency
- Consistent Power Output
- Reduced Maintenance Costs:
- Longevity and Durability
- Operational Flexibility
- Safety and Reliability



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Conclusions on the Environmental Impact Assessment

The comprehensive environmental impact assessment of the proposed activities has led to the following conclusions:

Baseline Environmental Conditions:

The site designated for the construction of the small hydropower plant (SHPP) is located at a sufficient distance from industrial facilities, beyond their environmental influence zones. As a result, the existing environmental conditions at the site can be considered natural, with pollutant levels in the natural components reflective of background concentrations.

Impact During Construction:

The construction activities for the SHPP will have short-term impacts, limited to the duration of the construction phase.

Moderate impacts are anticipated on biological resources, primarily due to the removal of green vegetation, including some trees.

Minor impacts are expected on all other environmental components, with changes so insignificant that they are difficult to quantify.

Absence of Protected Areas:

The construction site does not overlap with any specially protected natural areas that hold environmental, scientific, cultural, aesthetic, recreational, or health significance.

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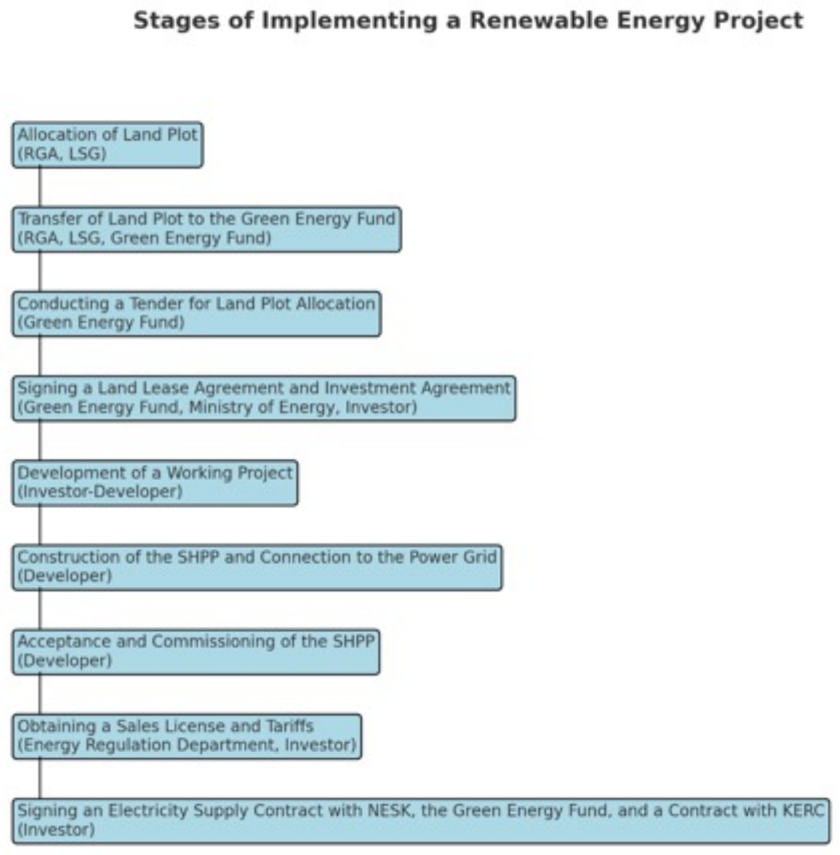
Mechanisms for Implementing Renewable Energy Projects

Stages of Implementing a Renewable Energy Project According to the Regulation on the Procedure for Allocating Land for Renewable Energy Construction to the Authorized Institution in the Field of Renewable Energy (Green Energy Fund) (Cabinet of Ministers Resolution No. 429, August 28, 2023)



Tariffs

Type of Renewable Energy Source	Base Tariff, KGS/kWh	Coefficient	Renewable Energy Tariff, KGS/kWh	Renewable Energy Tariff, $/kWh
All types of renewable energy	3.4	1.3	4.42	0.05
Investment agreement or PPP agreement	Set individually for each project			

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Financial Analysis

Construction		
Pure Capex	$	3,683,291
Other costs	$	277,242
Total investment	**$**	**3,960,533**
Total investment per MW	***$***	***1,650,222***

Generation	
Confidence interval lower bound for	P50
Capacity (MWp)	2.4 MW
Capacity factor	56.06%
Long Term degradation Rate	0.00%
Annual Net Production (kWh)	11,785,700kWh

CFD		
CFD Switch		ON
Tariff	¢	5.10
Escalation y/y		1.50%

Capital structure			
Equity	$	1,584,213	40.00%
Debt	$	2,376,320	60.00%
Total Funding	**$**	**3,960,533**	**100.00%**

Financing	
Tenor	**17.00 Yr(s)**
Number of payment in a year	4.00
Interest DC	11.00%
Interest DO	10.50%
DSRA Funding Switch	OFF
DSRA mo	6.00 MO
Arrangement Fee (Upfront Fee)	0.50%
Financing method	Pro-rata

Internal Rate of Return (IRR)

Project IRR - 12.60%: This reflects the overall profitability of the project, taking into account the total investment, including both equity and debt financing. It indicates the expected rate of return on the total capital invested.

Equity IRR - 14.91%: This measures the return specifically on the equity portion of the investment. The higher equity IRR demonstrates the potential attractiveness of the project to equity investors.

Payback Period

Project Payback Period - 9.44 years: This indicates the time required for the total investment to be recovered through project revenues. It reflects the financial sustainability of the project over its lifetime.

Equity Payback Period - 10.00 years: This represents the time required to recover the equity portion of the investment, accounting for the distribution of revenues and debt repayments.

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Financial Analysis

Net Present Value (NPV)

Project NPV - $571,037: The NPV represents the present value of the project's net cash flows, discounted at the cost of capital. A positive NPV indicates that the project is financially viable and expected to generate value above the cost of investment.

Equity NPV - $401,129: This reflects the value created for equity investors after accounting for financing costs. A positive value suggests the project will provide a satisfactory return to equity stakeholders.

Levelized Cost of Energy (LCOE)

LCOE (USD¢ 5.13 for the project, USD¢ 5.21 for equity): The LCOE represents the average cost of generating electricity over the project's lifetime. It includes all capital, operating, and maintenance costs. A competitive LCOE indicates the project's efficiency in producing energy at a cost that supports financial viability and competitiveness in the energy market.

Conclusion

The presented financial metrics highlight the project's viability:

- The IRR values suggest that both the overall project and equity investment offer attractive returns
- Positive NPVs indicate value generation for both total investments and equity contributions
- The LCOE demonstrates cost-competitive energy production, making the project financially sustainable
- These results provide a strong basis for further development and investment in the Karakol SHPP project

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Key Tools and Recommendations Integrated into the Study

- **GO/NO-GO Decision Matrix:** A timeline-based decision-making tool specifically developed for the Karakol HPP. This matrix can also serve as a valuable framework for evaluating the feasibility of other hydropower projects

- **Expert Recommendations and Guidelines:** The report includes a detailed section highlighting critical considerations for preparing pre-feasibility studies. It provides expert insights and best practices to enhance the quality and relevance of project evaluations

- **Financial Model with User Manual:** A robust financial model is included, designed to assess the economic viability of the project. Accompanied by a comprehensive user manual, it enables stakeholders to adapt and apply the model to similar small hydropower projects for effective financial analysis

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