Kyrgyz: Kambarata 1 Hydropower Power Project Feasibility Study Update

Terms of Reference

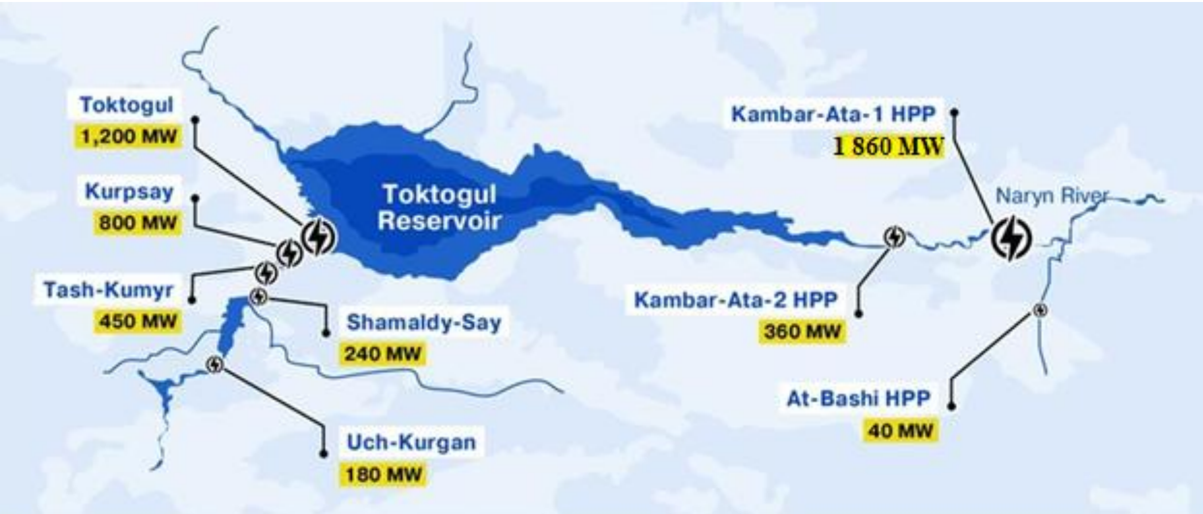
1 Background

Kambarata 1 HPP will be one of the largest hydropower projects in Central Asia with a capacity potential of 1,860 MW. Once constructed, it will fundamentally improve the energy security of the Kyrgyz Republic while providing the country with an added source of export revenue. Strategically, it is important to the entire water and energy complex of the region. The large reservoir of Kambarata 1 HPP on the Naryn river will improve the operation of the Toktogul HPP reservoir, which can provide a much-needed balance to the water management regime in the Naryn–Syr Darya Basin. The Project will be a critical building block toward achieving the government's vision of a green and affordable energy future.

Kambarata 1 HPP has been identified in the 2022 Energy Sector Masterplan as a priority project, and featured in each of the 17 simulation scenarios. In addition to its seasonal energy regulation benefits, Kambarata 1 HPP was judged to have the lowest energy cost of the major candidate hydropower plants.

The 2022 Masterplan of complex development of energy sector assumes that Kambarata 1 would start generation in 2032, a schedule that requires an immediate start to project preparation, and a rapid development and construction process.

Figure 1: Location of Major Hydropower Projects



Source: "Investment in the Water and Energy Complex of Central Asia", Report & Working Papers, EBRD, 2021

2 Objective of the Assignment

The objective of this assignment is to update and complete the existing techno-economic studies and implementation evaluation of Kambarata 1 HPP, with the aim of developing a "bankable" feasibility study that will allow financing of the Project, and provide the technical parameters and characteristics for the bidding.

The Services will be provided in two Phases:

The first phase (Phase A tasks) will include undertaking a gap analysis of the existing studies and data and selection of the layout of the hydroelectric complex with various types of dams.

The second phase (Phase B tasks) will include carrying out of additional work as identified and recommended in the first phase, where inadequate or missing studies/surveys/site work are required to update/complete the feasibility study.

The original design concept for Kambarata 1 HPP included a “blast-fill” dam. In 2014 SNC Lavalin-ENEX carried out a feasibility study that concluded an asphaltic core rockfill dam (ACRD) would be more appropriate. Under the Services in this assignment the Consultant will review and justify the options for other types of dams, including roller compacted concrete (RCC), and select the preferred type of dam based on the global experience in dam construction of similar parameters, taking into account the geological and seismic conditions already identified at the site, maximum use of local materials with economically optimal expenses.

Other tasks to be undertaken in this assignment include:

1) Detailed review and analysis of the documentation and data from the existing 2014 feasibility study undertaken by the consortium “SNC Lavalin-ENEX” prepared with the participation of Electric Power Plants OJSC.

2) Identification of gaps and deficiencies in the existing feasibility study to achieve globally recognised international standards of feasibility study for a project of this size and nature, including verification of the technical feasibility, effective use of the hydropower potential of the site, safety of the design in respect of engineering, geological and physical environment conditions at the site and adequacy of data.

3) Detailed assessment of the data, calculations and documentation relating to the tectonic and seismic conditions in the region and at the project site and analysis of the stability of the principal structures to ensure safe future operation of Kambarata 1 HPP.

4) Review of various options for the layout of the hydroelectric facilities to ensure reliability, safety, technical feasibility and economic design, maximising the use of the natural resources in the construction area and nearby territories of the Kyrgyz Republic and optimising the potential of the site. The studies should include forecasting the expected hydrological and water management regime of the Naryn River and its reservoirs after construction of the hydroelectric facility, and the flood flows and design of the river diversion system and related temporary works

5) During the selection of dam type, the assessment should take account of international experience of the use of the technology and construction method in such high dams and in climatic conditions similar to those of the Kyrgyz Republic. The analysis shall include detailed calculations and schemes and where appropriate, laboratory testing as a result of site inspections.

6) On the basis of the updated feasibility study, development of a phased implementation concept for Kambarata 1 HPP construction to allow early generation and potentially phased development of the project. The phased concept should not prejudice the technical feasibility of the design or the long-term safety, and should take account of the economic performance of the project.

7) An assessment of the project financing options for Kambarata 1 HPP is being undertaken separately, considering corporate structuring, financing sources and revenue potential; information from this study may be made available to the Consultant for use in the financial analysis.

8) In its proposal the Consultant shall prepare a detailed workplan for each of the tasks in Phase A, defining the approach, methodology and software to be used. The workplan for Phase B may be more generic, but will be given a good indication of the Consultant's approach and methodology, and will be sufficient to demonstrate the knowledge and understanding of the Consultant of the requirements of this assignment. The Phase B workplan will be revised and expanded in the Phase A Gap Analysis and Scoping Report.

9) The deliverables and outcome of this assignment will assist Electric Power Plants OJSC with preparation of documents for the promotion and start of implementation of Kambarata 1 HPP.

3 Project Information

3.1 Electricity System of the Kyrgyz Republic

The great majority of electricity in the Kyrgyz Republic is generated by hydropower, with almost all of the generation coming from the Lower Naryn Cascade. The total capacity of Toktogul and the four downstream schemes of the cascade is 3,110 MW (including the upgrade of Toktogul currently in progress). Other hydro capacity includes 80 MW at Kambarata 2 (restricted by the transmission link, although this will soon be upgraded to allow the full 120 MW of capacity to be dispatched), 44 MW (when upgraded) at At-Bashy, and some 54 MW of small HPPs. The only other generation is from the CHP plant in Bishkek, with an installed capacity of 812 MW.

At present the Kyrgyz grid is linked to the Central Asia Power System (CAPS) grid that includes Southern Kazakhstan, Uzbekistan and Turkmenistan. Apart from CAPS, some local low voltage interconnections exist with China, and with the planned commissioning of CASA-1000 in late 2024, the Kyrgyz Republic will be interconnected with Pakistan.

3.2 Water Resources of the Naryn River

The Naryn is a highly seasonal river: for example, at Toktogul some 77% of the annual inflow occurs during the six summer months from April to September. This is counter-seasonal to the electricity demand, which is higher in winter than summer due to electric heating demand. The mid-winter daily energy demand in the Kyrgyz Republic is 2.5 times the mid-summer demand.

Since around 2000, the priority for water release from Toktogul reservoir has been to generate electricity in the winter months, while providing a minimal level of irrigation flow in the summer. Under the current mode of operation some 7 billion of cubic metres (bcm) of water, out of an average summer inflow of 10 bcm is conserved in Toktogul during the summer months for use during winter to generate electricity.

Construction of Kambarata 1 with its seasonal storage will allow more electricity to be generated in winter, as well as production of more energy for export during the summer months.

3.3 Location and Access

The proposed Kambarata 1 project is located some 15 km upstream from the existing Kambarata 2 HPP, and some 20 km from the top end of Toktogul Reservoir. The dam site is located at approximately 41.77N, 73.44E.

The site is accessible from the main Bishkek-Osh road by following the main access road to Kambarata 2, and then an unpaved road on the south bank of the Naryn River. This road, which crosses an unstable scree slope, has recently been reconstructed.

3.4 Previous Studies

Kambarata 1 HEP was designed by the hydraulic institutes of the Soviet Union as part of the Kambarata cascade (with Kambarata 2) in the 1980s. Investigations were carried out at that time, including drilling and other ground investigation and topographic survey.

The construction of the power plant was planned to begin in the 1990s by centralized capital investments of the Ministry of Energy of the USSR by the Kyrgyz and Russian institutions. A study was undertaken by SNC Lavalin of Canada, and ENEX of Russia, and a feasibility study report (The Feasibility Study) was produced. Five boreholes were drilled at the site to confirm the results of the previous investigations. The study considered alternative low and high dam heights, different types of dam construction and installed capacities up to 1,900 MW. The higher dam height was preferred by the Kyrgyz energy institutions, since although the cost of energy is higher, it allows water to be stored in summer to be used to generate electricity in winter when it is most needed.

No construction work has been undertaken since the feasibility study was completed, although the access road was reinstated in 2022, and the main 500 kV transmission link between Toktogul and Bishkek that will evacuate power to the grid is now complete.

Among the relevant studies relating to the Project are the following:

- Feasibility Study of Kambarata 1 and 2 HPPs, Sredazgidroproekt Institute, Tashkent, 1988.
- Development of Justification (Feasibility Study) of Investment for Kambarata-1 Hydro Power Plant on Naryn River (Kyrgyz Republic), SNC Lavalin and ENEX, 2014.
- Master Plan for Complex Development of the Energy Sector of the Kyrgyz Republic, CESI & CAIC, 2022 (including Rapid Assessment of Kambarata 1 HPP)
- Other materials, submitted by Electris Power Plants OJSC

The subject of this assignment is to update the 2014 Feasibility Study by SNC and ENEX, taking into account data from these and other existing sources, along with the necessary engineering surveys and studies to update the Feasibility Study. The Consultant shall take into account the proposals in the Master Plan for the Complex Development of the Energy Sector of the Kyrgyz Republic, CESI and CAIC, 2022.

3.5 Project Description

Kambarata-1 is a proposed 1,860 MW hydropower project (HPP) on the Naryn River in the Kyrgyz Republic. The proposed HPP is estimated to generate some 5,640 GWh of electricity per year, and includes a 256 m high dam and live storage volume of 2.9 bcm (active storage), which allows nearly 3 bcm of flow to be accumulated in summer for use to generate in winter.

The key characteristics of the Project in previous studies are as follows:

		SNC High dam	**SNC Low dam**	**Planned in 1988**
Dam Height (m)		256	160	275
Full supply level (m asl)		1,198	1,113	1,190
Minimum operating level (m asl)		1,138	1,093	1,098
Operating range of reservoir drawdown (m)		60	20	92
Live storage volume (10^6 m^3)		2,870	491	3,550
Installed capacity (MW)		1,860	800	1,900
Annual energy generation at Kambarata 1 (GWh)	Firm	4,455	2,795	3,535
	Secondary	1,185	605	1,465
	Total	5,640	3,400	5,015

The parameters developed by SNC in 2014 are as follows:

	HIGH DAM	**LOW DAM**
Catchment area	47,000 km^2	
Average annual precipitation	330 mm / year	
Average annual flow	10,500 million m^3	
Long-term mean annual runoff	333 m^3/s	
Average annual suspended sediment load	14.9 million t/year	
Reservoir surface area at full supply level	61.7 km^2	27.3 km^2
Length of the reservoir at full supply level	68 km	42 km
Dam type	Rockfill dam with asphalt concrete diaphragm	

	HIGH DAM	LOW DAM
Elevation of the crest above sea level	1,200 m	1,116 m
Crest length pf the dam	579.3 m	428.8 m
Volume of fill in the dam body	27.8 million m^3	9.8 million m^3
Spillway design discharge	3,264 m^3/s	3,323 m^3/s
Powerhouse type	surface	surface
Powerhouse dimensions	96.0 x 53.0 m	90.0 x 51.0 m
Turbine type	Francis	Francis
Design head	210 m	143 m
Number of units	4 no.	4 no.
Design discharge of one hydraulic turbine	244 m^3/s	160 m^3/s
Unit capacity	465 MW	200 MW
Transmission voltage	500 kV	500 kV

3.6 High and Low Dam Alternatives

The 2014 SNC study considered high and low dam alternatives: the 256 m high dam provides considerable active storage – around 27 percent of the mean annual runoff at the dam location. This provides seasonal regulation to enable flow to be saved during the high-flow summer months for later use to generate electricity to meet the high winter demand. The low dam alternative provides storage of around 400 hours of mean runoff, which is insufficient for significant seasonal transfer, although it would provide daily or weekly peaking capacity.

The 2022 Masterplan has selected the high dam option to meet the needs of the system, and this selection has been endorsed by the government of the Kyrgyz Republic. Hence only the high dam alternative will be considered in this study.

3.7 Environmental and Social Issues

The High Dam option has a reservoir over 60 km long. However, there is no habitation within the reservoir basin, and only two farms would be inundated. Construction of Kambarata 1 should have limited impact on fish life, since the Naryn River is already blocked by the five large dams of the Toktogul cascade, and by Kambarata 2 dam which has been in place since late 2009. However, it would create a similar environment to that which existed in Toktogul reservoir before Kambarata 2 formed a barrier between the reservoir and the upper reaches of the Naryn River.

The limited environmental and social impact studies undertaken in 2014 do not indicate any major detrimental impacts, although the barrier to fish movement, inundation of flora and pasture lands, and obstruction of routes between seasonal pastures is noted. A full assessment of the environmental and social impacts will be undertaken in separate studies. The Consultant is not required to undertake any environmental and social assessments. However, the impacts relating to environmental and social issues should be considered in all aspects of this Update Study, and the Consultant should be available to liaise with the consultants undertaking the ESIA.

4 Scope of Services

4.1 Overview of Services

The Services will only be provided for the high dam design of the hydroelectric facility and will be completed in two phases:

- **Phase A** comprises a review and analysis of the existing studies and documentation, and assessment of the missing or inadequate studies (gap analysis) required for development of a bankable feasibility study. In parallel with this analysis, an initial review of the potential dam types will be carried out, taking account of the existing data available, and previous analysis of dam types. Reporting of Phase A will include the Consultant's proposed Work Plan and detailed inputs for Phase B, together with scoping and cost estimates for the survey and site investigations to be carried out in Phase B.

  Tasks under Phase A include:

  Task A.1: Data Collection and Collation of Documents

  Task A.2: Review of Existing Studies and Gap Analysis

  Task A.3: Analysis and Review of Dam Options Studies and Report

  Task A.4: Scoping of Phase B Studies

  Task A.5: Gap Analysis and Scoping Report

Following submission of the Dam Options Report in Task A.3, a workshop will be held in Bishkek at which the Consultant will present the outcome of the study to key stakeholders. Following this the Client will confirm the dam type(s) to be taken forward for consideration in Phase B.

Following submission of the Phase A Report, the Client will review and appraise the studies to agree the scope of services to be carried out in Phase B.

This will require a break of 1 to 2 months between the two phases during which discussions will be held between the Client and Consultant to clarify and agree the scope of Phase B, without increase in the budget.

In order to progress the surveys and site investigations, the Consultant may be instructed to proceed with work on specification and procurement of the third-party contracts during the review period.

- **Phase B** comprises the update of the feasibility study, including physical modelling, surveys, site investigation and laboratory testing required to bring the feasibility study up-to-date and make it “bankable”.

Tasks under Phase B include:

Task B.1:	Topography
Task B.2:	Meteorology, Hydrology and Sedimentation and the study of sedimentary rocks in the area of the construction site and the variable zone of the reservoir
Task B.3:	Geology, Geotechnics and Construction Materials
Task B.4:	Seismology and Geohazards and assessment of the presence of potential faults on the construction site
Task B.5:	General Arrangement and Layout of main buildings of Kambarata-1 HPP
Task B.6:	Justification and Confirmation of Dam Type
Task B.7:	Optimisation of installed Capacity and Storage
Task B.8:	Engineering Design
Task B.9:	Diversion and Temporary Works
Task B.10:	Access and Logistics
Task B.11:	Energy Estimates and Operating Regime
Task B.11:	Cost Estimate and Construction Schedule
Task B.12:	Economics and Financial Analysis
Task B.13:	Recommendations for Supplementary Investigations
Task B.14:	Feasibility Study Update Report
Task B.15:	Preparation of ToR for engagement of consultant for preliminary design and technical specification preparation

4.2 Phase 1: Gap Analysis and Scoping

Task A.1: Data Collection and Collation of Documents

The Consultant will investigate the availability of documents and data, and will collect and collate documents and data required for the Services.

Subject to copyright rules, documents and data collected, together with all documents produced under this assignment, will be catalogued and stored on a document management system that will remain accessible to the Client after completion of this assignment.

Task A.2: Review of Existing Studies and Gap Analysis

The Consultant will undertake a review of the existing data and documentation to determine what surveys, investigations, studies, analysis and design activities are required to bring the existing Feasibility Study (i.e. the 2014 Feasibility Study by SNC Lavalin and ENEX) to "bankable" status (i.e. to a level that would be expected by international financial institutions to demonstrate the technical and economic feasibility of the Project, and to define the Project sufficiently for tender design and procurement to proceed).

The assessment should not cover the environmental and social aspects of the Project which will be studied by other consultants, but should include the physical environment such as topography, meteorology, hydrology, sedimentation, climate change, geology, seismicity and geo-hazards.

The physical scope of the Project should include temporary and permanent access roads, transmission interconnectors to the existing grid, temporary works and borrow areas, as well as the hydropower project itself.

Assessment of geo-hazards should cover the site of the main project components, the reservoir and its periphery and the basin upstream in the case of hazards such as glacial outburst and landslide induced floods that might affect the Project.

Task A.3: Review of Dam Options

A review of the options for the dam type will be carried out under this task, taking into account the available data. The 1988 studies recommended a blast-fill dam, and the 2014 studies selected and asphalt-concrete core rockfill dam (ACRD). Other dam-type options will be considered, including concrete gravity (conventional and roller compacted concrete), concrete-faced rockfill and other types of rockfill dam.

The 1988 studies included considerable geotechnical investigation at essentially the same project location. However, these studies were focused on the blast-fill concept. The 2014 studies included further investigation including five boreholes, 2.2 km of geophysical survey, sample recovery and laboratory testing, aimed at verifying the 1988 observations and investigating the abutments and foundations for the alternative dam types. These investigations will be taken into account in this assessment of the dam type.

The 2014 investigations identified the presence of high strength rock in the foundations and abutments, but found that this is highly fractured. However, the in-situ borehole tests indicate low water permeability for this rock. The foundation analysis will need to pay particular attention to this anomaly in the design of the foundations, cut-offs and filters.

A comparison of the dam types will be presented in the form of a multi-criteria and comparative analysis, including expenses during construction and maintenance, to either confirm the selection of the ACRD, or propose an alternative to be studied in Phase B. The assessment will include a range of criteria including safety / risk, cost, constructability, sustainability, geohazard performance (seismic, GLOF etc) and schedule.

A report on dam options (the Dam Options Report) will be prepared and submitted to the Client. Following this, a workshop will be held in Bishkek at which the Consultant will present to stakeholders the work undertaken in this study, and discuss the conclusions and recommendations of the dam options assessment. The intent is to identify a single type of dam to be investigated in Phase B.

Task A.4: Scoping of Phase B Studies

Based on the assessment of the gaps and deficiencies in the Feasibility Study and the results of the Dam Options Study, the scope of surveys, investigations and studies required in Phase B will be developed.

The Consultant's Work Plan for undertaking these studies will be presented, together with estimates of staffing requirements and expenses.

For the surveys and site investigations it should be assumed that the Consultant will design and specify the surveys and site investigations to meet the "bankability" requirements, will assist the Client with procurement of the survey and investigation contractors, and will supervise the survey and investigation works. The surveys and site investigations, including laboratory testing will be undertaken by third parties directly contracted with the Client.

Task A.5: Gap Analysis and Scoping Report

The final deliverable of Phase A is the Gap Analysis and Scoping Report. This document will summarise the work undertaken during Phase A including:

- List of data and documentation collected and reviewed
- Identification of gaps and deficiencies in the Feasibility Study to be rectified in Phase B
- Summary of the dam options review, workshop and conclusions
- Scope of work for Phase B studies, including surveys and site investigations
- Work plan and revised budget estimate for Consultant's Phase B activities

4.3 Phase B: Feasibility Study Update

The tasks and scope of services listed below are indicative of the requirements, and should be updated based on the gap analysis undertaken during Phase A.

Task B.1: Topography

The Consultant will specify, assist the Client with procurement and supervise any additional topographic surveys needed for the Feasibility Study Update and for preparation of tender designs.

If needed, the Consultant shall assist the Client with procurement of remote sensing data required for the Project.

Task B.2: Meteorology, Hydrology, Sedimentation and Climate Change

The Consultant will update the meteorological, hydrological, sediment and climate-change studies as appropriate, using newly acquired data covering the period since the 2014 studies, including review of the flood return periods for temporary and permanent works and generation flows.

It is noted that the average flow in the Naryn River has been increasing over time, reportedly due to permanent melting of glaciers in the upper catchment. The Consultant will take account of this dynamic situation in the analysis starting from 2014 till now and 50-year forecast.

Task B.3: Geology, Geotechnics and Construction Materials

The Consultant, based on existing and new surveys, will update the geology, geotechnics and construction materials studies as required by the gap analysis and dam type review.

The site investigation and laboratory testing contractors will prepare factual reports on their work, and the Consultant will prepare a report interpreting the results in relation to the Project.

It is expected that a geotechnical baseline report (GBR) will be required, but this will be prepared under a future assignment.

Task B.4: Seismology and Geohazards

The Consultant will update the seismological and geohazard studies as appropriate including new impact analysis of seismogenic faults located in the project area

Task B.5: General Arrangement and Layout

The Consultant will confirm or revise the general arrangement and layout of the Project. It is expected that the arrangement and layout will not be altered unless deficiencies are found with the current design, or significant improvements can be achieved.

Task B.6: Confirmation of Dam Type

It is intended that the selection of the dam type will be confirmed in this study, following the preliminary analysis in Phase A, and any necessary site investigation, testing and surveys in Phase B. Hence sufficient analysis is required to demonstrate the feasibility of selected option.

Task B.7: Optimisation of Installed Capacity and Storage

It is envisaged that the installed capacity and active storage will remain in accordance with the 2014 Feasibility Study, unless deficiencies are encountered in the previous studies.

If viable, consideration should be given to starting generation early, before the full height of the dam is completed, providing this can be achieved safely and without prejudicing the long-term operation of the Project.

Kambarata 1 provides an ideal opportunity for future integration of variable renewable energy with full regulation downstream by Toktogul reservoir. Hence consideration should be given to future expansion of installed capacity, and also to the provision of ancillary services such as fast ramping, synchronous condenser operation and black start capability.

In view of the huge depth of excavation and height of cofferdam that would be required for construction of future intakes, consideration should be given to their construction as part of the initial scheme.

The consultant should make calculations based on forecasts of the growth dynamics of total energy and water consumption for the future by studying the available data up to 50 years (2023-2073) in the Kyrgyz Republic and the Central Asian Region.

Task B.8: Engineering Design

All aspect of the works should be updated or verified to produce an integrated feasibility level design of the Project. A tender design stage will follow the feasibility study when design parameters may be refined, but a robust design is required to give confidence in the technical viability of the Project. The design should ensure that the major components are viable, including sufficient analysis to verify parameters such as:

- Static and dynamic stability analysis of the dam under certain combination of loading conditions, including seismic loads, as well as settlement analysis and assessment of the foundation and abutment conditions, excavation and processing of materials for the construction of impervious devices requirements

- Calculation of filtration and filtration strength and requirements for the elimination of insufficient filtration strength
- Spillway capacity and operating characteristics during maximum flows, taking into account international guidelines for large dams taking into account possible ice processes in the downstream of structures
- Intake capacity and avoidance of air-entrainment
- Hydraulic transient analysis and design of control structures, gates and their closure times.
- Assessment of river channel erosion potential downstream of the spillway outlets and in the tailrace.
- Turbine stability analysis based on the waterway parameters and turbine inertia characteristics (acceleration)
- Determination of the working and operational parameters of the turbine and operating ranges, with a particular focus on avoidance of cavitation
- Parameters of peak efficiency and permissible ratios of calculated and maximum turbine heads (high efficiency most valuable during winter operation)
- Turbine sizing relative to other units on the system and spinning reserve requirements
- Hydroelectric unit maintenance, including provision for in-situ runner repair
- Potential for remote operation from Kambarata 2 control centre
- Maintenance of underground equipment and structures

Recommendations and substantiation of the requirements will be provided for physical model testing, including the operation of the spillways.

Such design and operating parameters should be discussed and agreed with the Client before finalisation of the Feasibility Study Update.

Task B.9: Diversion and Temporary Works

The Consultant will verify or design the river diversion at feasibility level, taking particular account of the seasonality of the Naryn River, the updated flood return periods and the need for rapid construction. The Feasibility Study should provide details and arrangements for each stage of river diversion, construction of water-pressure structures (banquette and lintels), and for the temporary works structures that are required.

Based on the results of the final recommendation on the layout of structures and the selection of the type of dam, the consultant will technically design the possibility of starting work on the project by constructing construction and operational spillways to divert the river and starting work to prepare for the construction of the dam.

The consultant will develop a list of mandatory surveys and the scope of possible design work to start construction

The locations of the major temporary works should be identified, including offices, storage areas, accommodation, borrow areas, crushing and batching plants and temporary access roads. These should be sufficiently detailed to allow land acquisition to be initiated.

Task B.10: Access and Logistics

Feasibility level design of the access roads and bridges should be verified or confirmed. In particular the access from downstream needs to be designed to avoid the area of landslides on the left bank, considering a bridge over the Naryn River or a tunnel.

A logistics assessment should verify the ability to deliver the major project components to site, and the results of this assessment should be considered alongside the design and sizing of the major components.

Task B.11: Energy Estimates and Operating Regime

Revised energy generation estimates should be produced, based on the updated hydrology and any revised project characteristics. The generation modelling should be based on a proposed reservoir operation strategy aimed at maximising the amount of energy available during the winter months.

The energy modelling should present the energy production estimates on a monthly basis. In addition to presenting average generation estimates, the probability of high and low production shall be estimated, including presentation of P90 (i.e., 90% dependable), P75, P50 and P10 levels of generation for both summer and winter energy.

Estimates shall also be provided for the early years of generation, including early (pre-completion of the dam) generation and generation during impoundment.

Task B.11: Cost Estimate and Construction Schedule

A revised construction schedule should be provided, taking into account any changes to the project characteristics, especially the type of dam. The schedule shall make realistic assumptions of the rate of construction, taking into account the seasonality of the weather and hydrology and the logistics of working in this location. The critical path for construction shall be identified.

Consideration will be given to achieving early generation – i.e., start of generation before the dam is complete to its full height, and before the reservoir is fully impounded.

Revised capital cost estimates are required, based on international standard methodology taking into account the level of costs generated by local conditions, to reflect current cost levels, and any changes to the project characteristics. Typical feasibility levels of accuracy are required, including contingencies for unmeasured items and for price uncertainty (including the impact of unforeseen circumstances and the impact of winter conditions).

Revised operating cost estimates should be provided based on typical operating costs of similar plant in similar environments, including provision for consumables, spares and insurances.

Costs should be separated into foreign and local costs.

An investment schedule should be provided, based on the revised construction schedule developed under this task.

Task B.12: Economics and Financial Analysis

Economic cost-benefit analysis shall be undertaken based on the updated costs and schedules. The analysis is aimed at establishing the benefit of the project to the Kyrgyz nation, and will use the least-cost alternative generation technology for comparison.

The financial performance of the project shall also be assessed, taking into account the likely funding structure, cost of funds, tenor of loans and expected return on equity, assessment of possible risks. The revenue stream used in the modelling should be based on tariff levels agreed with the Client.

Appropriate downside and upside scenarios should be presented in addition to base cases (optimistic and pessimistic scenarios).

Task B.13: Recommendations for Supplementary Investigations

It may not be possible to undertake the full range of investigations needed of the tender design within the schedule of the Feasibility Study Update. Despite that, the Consultant shall list and describe any supplementary investigations, and advise on the timing for this work. The investigations may include additional ground investigation and testing, physical model studies or computational analysis such as finite element method (FEM) analysis of the dam, computational fluid dynamics of hydraulic components, dynamic seismic analysis or power grid and interconnection studies.

Task B.14: Feasibility Study Update Report

The Feasibility Study Update Report shall be prepared to present the results of the updating studies undertaken during Phase B.

Although the report may refer to the previous studies, and in particular the 2014 Feasibility Study, the Feasibility Study Update Report shall include summaries of the previous work and sufficient drawings, graphics and data that the Update Report may be read without constant reference to the prior reports.

Task B.15: Preparation of ToR for engagement of consultant for preliminary design and technical specification preparation

The Consultant will prepare the Terms of Reference (ToR) for the selection of a technical consultant, which based on the feasibility study will: (i) prepare the preliminary design for the construction of the hydropower plant; (ii) recommend the procurement strategy and approach, including packaging, for the various civil works, hydraulic structures, mechanical and electric equipment, and installation works; and (iii) prepare technical specifications , bill of quantities and detailed cost estimation for the various packages.

5 Qualifications of the Consultant and Team Composition

5.1 Consultant's Qualifications and Experience

The Consultant will be an international, well-recognized firm or consortium with extensive experiences in feasibility study and design of large hydropower projects and high dams.

In the adjudication of the Consultant's tender, consideration will be given to the experience of the consultant on similar assignments within the last 20 years, including experience of:

- Study or design of large dams (> 150 m height and maximum head of the dam – 220 m)
- Study or design of large hydropower projects (>500 MW)
- Study or design of spillways with design flow at least 2,500 m^3/s including construction period.
- Leading major hydropower feasibility studies
- Major hydropower projects in similar climate and seismic environments
- Hydropower projects outside the Consultant's home country

The relevance as well as the number of qualifying projects will be taken into account in the adjudication.

For consortia, previous experience of having worked together will be considered an advantage. Qualifying projects of the lead firm in the consortium will be given additional weighting.

5.2 Consultant's Team Organisation

The Consultant's team organisation structure shall clearly show the leadership roles and reporting hierarchy within the team, and external liaison roles including with the Client and with the ESIA consultants. The responsibility of each team member shall be clearly identified, preferably in the form of a staff-task matrix.

All key team members of the consultant should be able to communicate in English or Russian freely. The technical requirements of the key team member are described below. The Consultant's team shall have adequate Russian language capability for assessment of previous studies, data and public domain documents.

5.3 Key staff

The Consultant's team leader shall be an experienced professional civil engineer with the requisite expertise, who will be responsible for management the Consultant's multi-disciplinary team, and also shall be the primary point of contact with the Client's Project Manager. The team leader is expected to be resident in Bishkek and / or site for a significant portion of the assignment.

Other core team member shall include, but not limited to specialists in hydrology, dam, mechanical/electronic, control and protection, site survey etc. Main specialists must have at least 15 years of experience in conducting engineering surveys in hydropower, corresponding to their profile.

Post-graduate qualifications and/or membership of professional institutions are considered an advantage.

CVs shall be presented for all staff performing discipline leadership roles, as well as staff providing specialist support.

As a minimum the Consultant’s team shall cover the following roles. Roles may be split between one or more staff, and a role may be also be combined and covered by a single staff member with appropriate expertise.

ID	Staff Position / Expertise
1.	Team Leader / Hydropower Expert
2.	Dam Design Expert
3.	Geologist / Engineering Geologist
4.	Geotechnical / Materials Engineer
5.	Geohazards Engineer
6.	Hydrologist / Sediment Engineer
7.	Hydraulics Engineer
8.	Hydraulic Transient Engineer
9.	Structural Engineer
10.	Electro-mechanical Expert
11.	Hydromechanical Engineer
12.	Survey Engineer
13.	Cost Engineer / Construction Planner
14.	Economist / Financial Analyst

5.4 Staff Experience

The Consultant is responsible for provision of a team of engineers, scientists and other staff with the expertise and experience necessary for delivery of the scope of works defined in this ToR. The minimum qualifications and experience expected for the positions identified in section 5.3 above as follows:

5.4.1 Team Leader / Hydropower Expert

The Team Leader shall be a professional civil engineer with a minimum of a Bachelor degree in Civil Engineering or a related discipline. A post-graduate qualification will be considered an advantage.

The Team Leader shall have at least 20 years of relevant experience which should include management of at least 5 major feasibility studies. This experience will include team leadership, direction, coordination and supervision of multi-disciplinary teams, planning, organising and controlling the team’s work, coordination, editing and production of project deliverables and reporting to clients.

5.4.2 Dam Design Expert

The Dam Design Expert shall be a professional civil engineer with a minimum of a Bachelor degree in Civil Engineering or a related discipline and a post graduate qualification in dam engineering. It is expected that the Dam Design Expert will be a highly regarded international specialist in dam design.

The Dam Design Expert shall have at least 20 years of relevant experience which should include the study and design of a range of dam types, including dams with heights exceeding 150 metres, including projects in regions of high seismicity. This experience should include leadership of discipline teams responsible for dam type assessment, foundation investigation, diversion design, spillway design, assessment and treatment of foundation permeability conditions, cut-off and grouting requirements, filter design and all aspects necessary for the selection of dam type and feasibility study of the selected dam.

The Dam Design Expert shall have sufficient stature and expertise to make presentations and justify the selection of the dam type and the feasibility study analysis to the Client and any panel of experts appointed by the Client.

5.4.3 Geologist / Engineering Geologist

The Geologist / Engineering Geologist shall be a professional engineer / geologist with a minimum of a Bachelor degree in geology or a related discipline and a post-graduate qualification in a relevant discipline.

The Geologist / Engineering Geologist shall have at least 15 years of relevant experience which should include the study and analysis of the foundation conditions and abutments of dams exceeding 100 metres' height, and the geological conditions for other hydroelectric structures. This experience should include geological mapping, specification of ground investigations and laboratory testing, logging of borehole cores, analysis of test results and assessment of the results of ground investigations for the design of major structures including dams. This should include the analysis of foundation permeability in complex rock formations and calculation of pore pressures and piezometric head during construction and operation of the dam.

5.4.4 Geotechnical / Materials Engineer

The Geotechnical / Materials Engineer shall be a professional civil engineer with a minimum of a Bachelor degree in Civil Engineering or a related discipline. A post-graduate qualification will be considered an advantage.

The Geotechnical / Materials Engineer shall have at least 10 years of relevant experience which should include the investigation of geotechnical conditions and construction materials for hydropower projects. This experience should include the analysis of major natural and excavated slopes, and design of stabilisation measures.

5.4.5 Geohazards Engineer

The Geohazards Engineer shall be a professional civil engineer or geologist with a minimum of a Bachelor degree in Civil Engineering or a related discipline and a post-graduate qualification in a discipline relevant to geohazards.

The Geohazards Engineer shall have at least 10 years of relevant experience including the analysis and assessment of geohazards that potentially affect hydroelectric projects in tectonically active, unstable mountainous terrain. This experience should include probabilistic and

deterministic seismic hazard assessment, evaluation of glacial lake outburst floods, landslide induced tsunamis and similar natural hazards.

5.4.6 Hydrologist / Sediment Engineer

The Hydrologist shall be a professional scientist or engineer with a minimum of a Bachelor degree in a related discipline. A post-graduate qualification will be considered an advantage.

The Hydrologist shall have at least 10 years of relevant experience which should experience of analysing river flows for hydroelectric yield and flood flows for sizing of spillways and construction for major dams on rivers with mean annual runoff greater than 150 m^3/s. This experience should include analysis of flood return period and of estimation of probable maximum floods throughout the project lifetime.

The hydrologist shall also have experience of investigation, analysis and management of reservoir sedimentation, preferably in physical environments similar to the project area.

5.4.7 Hydraulics Engineer

The Hydraulics Engineer shall be a professional civil engineer with a minimum of a Bachelor degree in Civil Engineering or a related discipline. A post-graduate qualification will be considered an advantage.

The Hydraulics Engineer shall have at least 10 years of relevant experience which should include the study and design of major hydraulic structures including spillways with design discharge of at least 2500 m^3/s capacity. The Hydraulics Engineer shall have experience of using computational fluid dynamics and other numerical modelling in the design of hydraulic structures, and of analysing options for water passages for the power conduits and spillways.

5.4.8 Hydraulic Transient Engineer

The Hydraulic Transient Engineer shall be a professional civil engineer with a minimum of a Bachelor degree in Civil Engineering or a related discipline. A post-graduate qualification will be considered an advantage.

The Hydraulic Transient Engineer shall have at least 10 years of relevant experience which should include the study and design of waterways and surge management facilities for major hydroelectric schemes with turbine flows exceeding 400 m^3/s. This experience should include calculations for cavitation and water hammer, the requirements for surge chambers, and estimating the response time of valves and gates in contingency / emergency conditions.

5.4.9 Structural Engineer

The Structural Engineer shall be a professional civil engineer with a minimum of a Bachelor degree in Civil Engineering or a related discipline. A post-graduate qualification will be considered an advantage.

The Structural Engineer shall have at least 10 years of relevant experience which should include the design of structural components for major hydroelectric projects in regions of high seismic activity.

5.4.10 Electro-mechanical Expert

The Electro-mechanical Expert shall be a professional electrical or mechanical engineer specialising in in hydroelectric plant, with a minimum of a Bachelor degree in Electrical or Mechanical Engineering or a related discipline. A post-graduate qualification will be considered an advantage.

The Electro-mechanical Expert shall have at least 15 years of relevant experience which should include the study, design and specification of the electrical and mechanical components of major hydroelectric power stations with unit size of at least 250 MW (this role may be split between two staff specialising in electrical and mechanical engineering respectively).

5.4.11 Hydromechanical Engineer

The Hydromechanical Engineer shall be a professional engineer with a minimum of a Bachelor degree in relevant engineering discipline. A post-graduate qualification will be considered an advantage.

The Hydromechanical Engineer shall have at least 10 years of relevant experience which should include the study, design and specification of hydromechanical equipment for major water resource projects including hydraulic gates, valves, hoists, cranes, trash screens and trash racks, including options for the main inlet valve

5.4.12 Survey Engineer

The Survey Engineer shall be a qualified civil engineer or surveyor with 10 years of relevant experience which should the design, specification and supervision of survey contracts for major hydroelectric projects in a physical environment similar to that of the project. This experience shall include topographic survey and mapping and remote sensing using aerial photography, LIDAR and satellite imagery.

5.4.13 Cost Engineer / Construction Planner

The Cost Estimator / Construction Planner shall be a professional civil engineer with a minimum of a Bachelor degree in Civil Engineering or a related discipline. A post-graduate qualification will be considered an advantage.

The Cost Estimator / Construction Planner shall have at least 10 years of relevant experience which should include preparation of construction schedules and capital cost estimates for major water resources projects in a similar environment to the project. Ideally this experience will include development of unit rates from scratch, based on labour, plant, materials and fuel, and familiarity with contractor’s approach to estimating productivity, overheads and profit.

5.4.14 Economist / Financial Analyst

The Economist / Financial Analyst shall be a professional economist or financial modeller with a minimum of a Bachelor degree in a relevant discipline. A post-graduate qualification will be considered an advantage.

The Economist / Financial Analyst shall have at least 10 years of relevant experience which should include the economic analysis and financial modelling of major hydropower projects in an economic environment similar to that of the project. This experience should include cost-benefit analysis of projects in terms of national economic benefit and project viability, taking into account shadow pricing and carbon benefits. The financial modelling experience should cover a range of public, private and PPP arrangements, including support mechanisms, concessionary finance and risk insurance.

The consultant is encouraged to employ qualified local experts for key and non-key positions who could add expertise and lower cost.

6 Reporting Requirements

6.1 Phase A

The initial deliverable for Phase A is the Dam Options Report prepared under Task A.3. This will be submitted in final form in preparation for the workshop.

The final deliverable of Phase A is the Gap Analysis and Scoping Report, including a summary of the dam options assessment, the workshop and its conclusions, as described in Task A.5. This report will initially be submitted in draft form for consideration and comment by the Client.

As discussed in section 4.1 above, this report will be used by the Client as the basis for agreement of the scope and any budget adjustment for the services to be undertaken in Phase B.

The Phase A Report will be updated to reflect the outcome of the discussions with the Client, and the scope of services will be incorporated into an amendment of the Consultant’s contract for Phase B.

6.2 Phase B

Reports will be prepared for each subtask under Phase B as each task is completed. Where appropriate a single report may cover multiple subtasks. The reports shall be submitted in draft form, and the Client will aim to provide comments and feedback within 15 days of receiving the reports. The final subtask reports should be appended to the Feasibility Study Update Report to provide detailed analysis on each topic.

The final deliverable for Phase B will be the Feasibility Study Update Report. This will be submitted initially in draft form, and will be updated to reflect comments by the Client. The Client will aim to provide comments and feedback within 30 days of receiving the report.

Secondary deliverables will be defined along with the scope of the Phase B services, and may include specifications for procurement of surveys and site investigations and interim reports on aspects of the Project that require discussion or early agreement.

All deliverables will be in English with Russian translation.

7 Time Schedule and Duration of Services

The Consultant shall submit its detailed time schedule for the services, taking into account the following provisional milestone dates (all dates in months following the effective date of the contract):

- Dam Options Report 2½ months
- Dam Options Workshop 3 months
- Draft Gap Analysis and Scoping Report 4 months
- Commencement of Phase B 5 months
- Draft Feasibility Study Update Report 11 months

The Consultant's staff-month inputs are envisaged to be as follows:

- Phase A: 12 staff-months of which half are expected to be provided by senior discipline experts. 4 staff-months are envisaged to be in the country of the Client.

- Phase B: 50 staff-months of which half are expected to be provided by senior discipline experts and senior engineers and scientists. 12 staff-months are envisaged to be in the country of the Client.

The Consultant shall submit in his tender a staffing plan based on a reasonable expectation of the work involved in Phase B, considering the envisaged time inputs above, including the assumption that a geologist / geotechnical engineer will be based on site for four months to supervise the site investigation works.

In the Gap Analysis and Scoping Report, the Consultant shall present his detailed work plan and staff inputs for Phase B, reallocating the budget as appropriate to suit the work required. This reallocation will be subject to agreement by the Client prior to commencement of Phase B. Adjustment of the overall budget may be agreed at this stage in the event of unexpected work, such as including two dam types in the Phase B study, but any increase must be substantiated by the Consultant.

8 Client's Inputs and Counterpart Staff

8.1 Services and Facilities

- The Client will assist to expedite the receipt of data from government agencies and industry institutions
- The Client will constantly monitor the progress of the tasks
- The Client will provide assistance with obtaining visas, work permits and authorisations, including for access to the project site

1. The MoE/EPP will set up a team, which will manage the Study and support provide support to the consultants. MoE will administer the contract, including formal approval of Study progress milestone deliverables, the Study final reports, and payment of invoices.

2. The Consultant will report in day-to-day work on technical matters to the MoE/EPP team. All written communications, Deliverables and reports should be sent to

3. The MoE will be responsible for ensuring full cooperation of the clients and availability of counterpart experts, data, relevant background studies and other information, and coordination with other relevant studies that may be conducted simultaneously. The clients may set up study facilitation teams, staffed with the counterpart's experts, if needed. The MoE will also be responsible for ensuring access to the sites relevant for conducting the Study and availability of the various stakeholders as required to carry out the Study.

4. The Client will assist the consultant to obtain available information, data, reports, maps and any other relevant information and materials from Governmental Institutions and State Authorities as far as possible. However, it is the duty of the Consultant to check reliability, quality and suitability of this information and where gaps exist, the consultant, at its cost, shall collect and analyze additional data and information from other sources, as required to complete the assignment in a satisfactory fashion. The key available reports include:

1. The list of documents and archival materials to be transferred by the Client

FEASIBILITY STUDY (FS) OF INVESTMENT IN KAMBARATA HPP-1 ON THE NARYN RIVER KYRGYZ REPUBLIC, Volume 1 (English)
FEASIBILITY STUDY (FS) OF INVESTMENT IN KAMBARATA HPP-1 ON THE NARYN RIVER KYRGYZ REPUBLIC, Volume 2.1 (English)
FEASIBILITY STUDY (FS) OF INVESTMENT IN KAMBARATA HPP-1 ON THE NARYN RIVER KYRGYZ REPUBLIC, Volume 2.2 (English)
FEASIBILITY STUDY (FS) OF INVESTMENT IN KAMBARATA HPP-1 ON THE NARYN RIVER KYRGYZ REPUBLIC, Volume 2.3 (English)
FEASIBILITY STUDY (FS) OF INVESTMENT IN KAMBARATA HPP-1 ON THE NARYN RIVER KYRGYZ REPUBLIC, Volume 2.4 (English)
FEASIBILITY STUDY (FS) OF INVESTMENT IN KAMBARATA HPP-1 ON THE NARYN RIVER KYRGYZ REPUBLIC, Volume 3 (English)

FEASIBILITY STUDY (FS) OF INVESTMENT IN KAMBARATA HPP-1 ON THE NARYN RIVER KYRGYZ REPUBLIC, Volume 4 (Russian)
FEASIBILITY STUDY (FS) OF INVESTMENT IN KAMBARATA HPP-1 ON THE NARYN RIVER KYRGYZ REPUBLIC, Volume 5.1 (English)
FEASIBILITY STUDY (FS) OF INVESTMENT IN KAMBARATA HPP-1 ON THE NARYN RIVER KYRGYZ REPUBLIC, Volume 5.2 (English)

List of additional information provided by the Client

#	Document Title	Document Type/ Form	Number of Copies
1.	Interim report on development of justification of investments (FS) in Kambarata HPP-1 on the Naryn River, Kyrgyz Republic	Hardcopy	1
2.	Land allocation plan for the reservoir areas of Kambarata HPP-1 and HPP-2 to be withdrawn from the land of Toktogul district, Osh region, and Toguz-Toro district, Naryn region of Kirghiz SSR. Technical Documentation Archive of Kirghizgiprozem. Registration No. 9755. Drawing: Land allocation plan.	Hardcopy	1
3.	Priority actions for pre-construction stage of Kambarata HPP-1 #1195-15-1ПЗ, GIRDOPROJECT PII (design institute). License КРЖ-1 №02728 issued on May 11, 2009	Hardcopy	1
4.	Feasibility studies on determination of unexpended costs and compensation for damage to agriculture caused by land allocation for the Kambarata HPP-2 reservoir area and construction site, as well as for the reservoir area No. 1	Hardcopy	1
4.1.	Land plan for areas intended for allocation to be used for the utilities during construction of Kambarata HPP-1 and HPP-2 to be withdrawn from the land of Shopokova government-run cooperative in Toktogul district.	Hardcopy	1

	Land schedule, Technical Documentation Archive of Kirghizgiprozem. Registration No. 9755		
4.2.	Land allocation plan for the flooding area of Kambarata HPP-2 at the full reservoir level of 959 m and construction site of hydraulic structures to be withdrawn from the low-yield land of Shopokova government-run cooperative in Toktogul district, Osh region. Technical Documentation Archive of Kirghizgiprozem. Registration No. 9755	Hardcopy	1
4.3.	Drawing of the selected location of a construction camp and industrial area of Kambarata HPP to be withdrawn from the land of Shopokova government-run cooperative in Toktogul district, Osh region. Technical Documentation Archive of Kirghizgiprozem. Registration No. 9755	Hardcopy	1
4.4.	Land allocation plan for the reservoir areas of Kambarata HPP-1 and HPP-2 to be withdrawn from the land of Toktogul district, Osh region, and Toguz-Toro district of Naryn region of Kirghiz SSR. Technical Documentation Archive of Kirghizgiprozem. Registration No. 9755.	Hardcopy	1
5.	Allocation of land to the Construction management unit “Narynhydroenertostroi” for construction of facilities of Kambarata HPP-1 and HPP-2 and water reservoir of HPP-2 to be withdrawn from the farmlands of Toktogul district. Technical Documentation Archive of Kirghizgiprozem. Registration No. 13872	Hardcopy	1
5.1.	Land allocation plan for construction sites No. 2, 3 and 4 and hydraulic	Hardcopy	1

	structure of Kambarata HPP-1 to be withdrawn from the farmlands of Toktogul district, Osh region, the Kirghiz SSR. Technical Documentation Archive of Kirghizgiprozem. Registration No. 9755		
5.2.	General land allocation plan for phase one facilities of Kambarata HPP to be withdrawn from the farmlands of Toktogul district. Technical Documentation Archive of Kirghizgiprozem. Registration No. 11143	Hardcopy	1
5.3.	Land allocation plan for the facilities of Kambarata HPP-1 and HPP-2 to be withdrawn from the farmlands of Toktogul district. Technical Documentation Archive of Kirghizgiprozem. Registration No. 138712.	Hardcopy	1
5.4.	Additional drawing of directions of drainage system, penstock and transmission line.	Hardcopy	1
5.5.	Construction arrangement. Construction layout plan in the area of HPP-1. Sheets 1,2.	Hardcopy	2
6.	Justification of investments in construction of Kambarata HPP-1 and HPP-2. Report on the front-end engineering design	Electronic	1
7.	Statement of state expert review of justification of investments in construction of Kambarata HPP-1 on Naryn River, Kyrgyz Republic (FS) (estimates)	Electronic	1
8.	Statement of the state environmental expert review	Electronic	1
9.	Terms of reference for “Drafting feasibility study for investments (FS) in Kambarata HPP-1 on the Naryn River, Kyrgyz Republic”.	Electronic	1
10	Additional materials: - Water-power study; - Hydrology data for Kambarata HPP-1;	Electronic	1

	- For InterRAO (drawing К1 AutoCAD); - Kambarata HPPs – materials dated back to the 90ies; - Initial report on Kambarata HPP-1; - Normative and legal acts and standards and technical documentation - Area of 543.1 ha for construction of facilities; - Pre-FS drafted by EDF, France; - Annex to FS – Cost estimates; - Power output diagram - Drawings of HPP-1; - Economics of Kambarata HPP-1; - Expert’s review of FS and ToR.		