

*Economic Community
Of West African States*



*Communauté Economique
Des Etats de l'Afrique de l'Ouest*

WEST AFRICAN POWER POOL
SYSTEME D'ECHANGES D'ENERGIE ELECTRIQUE OUEST AFRICAIN
General Secretariat / Secrétariat Général

Client: West African Power Pool (WAPP)
Country: Liberia

**WAPP/CLSG TA – ENERGY SUPPLY ALTERNATIVES
STUDIES & PROJECT PREPARATION IN LIBERIA**

**Terms of Reference
for an
Optimization Study for the Development of
Power Generation in Liberia**

FINAL

(24 August 2018)

LIST OF ACRONYMS AND ABBREVIATIONS

CLSG	Côte d’Ivoire-Liberia-Sierra Leone-Guinea Link
ESIA	Environmental and Socio-Economic Impact Assessment
ESMP	Environmental and Socio-Economic Mitigation Plan
FDA	Forest Department Agency
GBR	Geological Baseline Report
GoL	Government of Liberia
HPP	Hydro Power Plant
IDA	International Development Agency
IR	Inception Report
LEC	Liberia Electricity Corporation
LFT	Liberia (Local) Focal Team
LHS	Liberia Hydrological Services
LISGIS	Liberia Institute of Statistics and Geo-Information Services
LTDP	Long Term Development Plan
MME	Ministry of Mines and Energy (Liberia)
NEP	National Electricity Plan
OS	Optimization Study
PIP	Priority Investment Project
PIPES	Planning, Investment Programming and Environmental Safeguard Department (of the WAPP)
PDU	Presidents Delivery Unit
RAP	Resettlement Action Plan
SC	Steering Committee

LIST OF ACRONYMS AND ABBREVIATIONS (cont'd)

STA Strategic Transaction Advisor

TA Technical Assistance

ToR Terms of Reference

WAPP West African Power Pool

WB World Bank

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1. BACKGROUND

1.1 Context

In support to the WAPP Secretariat's program to establish an interconnected and coordinated network for fourteen countries in West Africa, the World Bank provided a grant for Phase I of the Cote d'Ivoire–Liberia–Sierra Leone–Guinea (CLSG) Interconnection Project in order to mobilize Technical Assistance aiming at:

- (i) enhanced WAPP integration,
- (ii) synchronizing WAPP transmission networks and
- (iii) capacity building of the WAPP.

Component 2A of this Technical Assistance (*Supply Alternatives Studies & Project Preparation Support*) aims at ensuring that generation capacity will be developed along the CLSG line in a timely and least cost manner. Key supply alternatives have been identified through the WAPP masterplan in 2011, including the rehabilitation of the Mount Coffee Hydropower Plant (HPP) on the Saint Paul River in Liberia.

As the rehabilitation of Mount Coffee HPP is now completed with all four 22MW units commissioned, the WAPP is exploring ways to further support future regional & national development through securing production of sustainable electricity generation over time.

Activities to be carried out under Subcomponent 2A.3 (*Supply Alternatives Studies & Project Preparation for Hydropower Development on St. Paul River*) of the Technical Assistance (TA) aims at addressing this issue through the assessment of the potential contribution of the St. Paul River's hydropower resources to electricity supply at Liberian and regional levels in the medium to long term. Planned activities under Subcomponent 2A.3 include:

- an **Optimization Study** to prepare a Long-Term Development Plan (LTDP) for new generation & storage projects in Liberia, from which a Priority Investment Project (PIP) will be recommended together with transmission;
- a **Feasibility Study** of the PIP selected by the Liberian authorities, including complementary geotechnical investigations;
- a detailed **Environmental & Social Impact Assessment (ESIA)** of the PIP, including an Environmental and Social Management Plan (ESMP) and a Resettlement Action Plan (RAP). The ESIA will also include a comprehensive analysis of alternatives and a cumulative impact assessment, which will take into account the part of the St. Paul River Basin in Guinea;
- the support from a **Strategic Transaction Adviser (STA)** to identify adequate options for structuring and financing the PIP.

These Terms of Reference define the scope under which an International Consultant will be procured to carry out the Optimization Study.

1.2 Previous Studies and Available Information

The St. Paul River has a technical hydropower potential of over 600 MW. As shown on Figure 1.1 below, this potential could be exploited by means of one or two upstream regulating reservoirs (Via Reservoir and the Diversion Reservoir, also called SP4) and a downstream cascade of three to four main HPPs as follows: one plant at the foot of Via Reservoir (around 130 MW), one at St. Paul 2 Dam (200 MW), one at St. Paul 1B Dam (120 MW) and the Mount Coffee HPP.

Today only the Mount Coffee rehabilitated HPP exists, with an installed capacity of 88 MW. Two additional units of similar size (22 MW) could also be added to Mount Coffee HPP as two additional intake bays (from which two new penstocks could be installed downstream), were originally built into the intake structure to accommodate such an expansion.

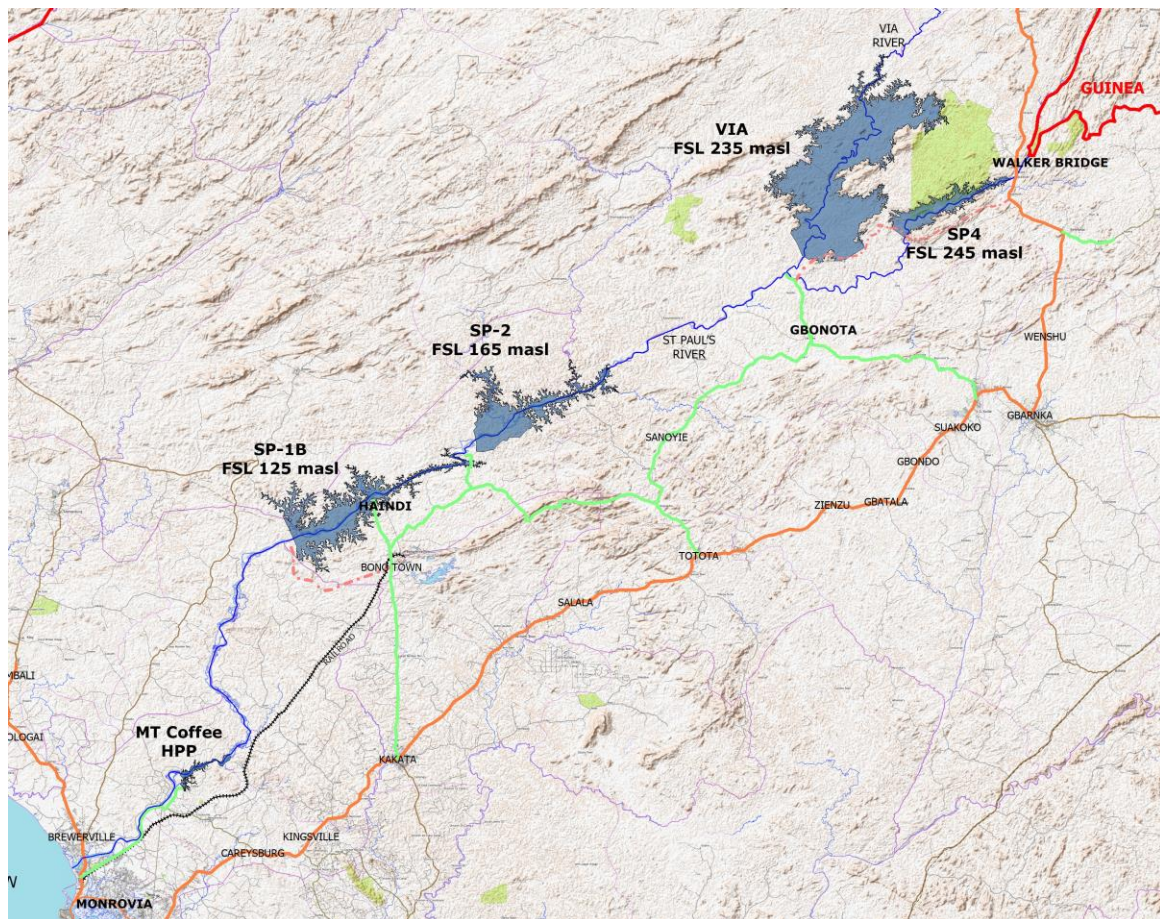


Figure 1.1 St. Paul River Hydropower Cascade as Studied by Chas. T. Main Int'l in 1982, and updated by Hydrotec in 2018 using LiDAR

As a run-of-river scheme, Mount Coffee HPP has, up until the end of June 2018, generated over 200 GWh since unit one came on line mid-December 2016. Previous studies have demonstrated that the scheme would benefit significantly from upstream storage development (& potentially additional installed hydropower capacity) that would

reduce its exposure to low river flows in the dry seasons and therefore increase its firm annual energy output.

Several reports have been written that have identified how the St Paul River catchment's hydropower potential could be developed in order to sustain Liberia's increasing need for additional generation to meet on-grid and off-grid demand.

These reports were reviewed and synthesized by Hydrotec Pty Ltd between December 2017 and July 2018, with a view to timely supporting Liberia by collecting technical data and preparing & supervising studies for the development of the St Paul River (Project P113266: "Technical Assistance for Optimizing Mt Coffee and Hydropower in Liberia"). In summary, the objectives of this TA's assignment were to provide:

- (i) technical and socio-environmental inputs towards identification and preparation of key studies aiming at improving the sustainability of Mt Coffee and increasing hydropower production; and
- (ii) support to the WAPP and to the Government of Liberia (GoL) in coordinating activities with local authorities and stakeholders through mobilization of a Liberia Focal Team (LFT).

Key deliverables of the Technical Assistance (TA) study were:

1. Consolidated database of available studies
2. Synthetic comparison of hydropower candidates in Liberia
3. Update Demand forecast report
4. Hydrological review of the St Paul River report.
5. Simplified Review of socio-environmental stakes of projects report and estimate of population potentially affected
6. St. Paul river hydropower simulation model & strategic outline for development of renewable energy projects (incl. potential solar), and identification of key features of complementary studies
7. Preliminary Geological Baseline Report
8. Review and finalization of the terms of reference (ToR) for an Optimization study.

As part of this TA, two key outcomes are of particular importance for the next phase of the studies:

1. A database of background documents was compiled and added to a "cloud" based document storage and sharing platform called ShareFile. The Sharefile platform set up (on an annual subscription model) now has over 70 documents stored on it (some of which date back to the mid 1970's) for reference purposes. To assist in future studies, all data reviewed, model inputs and outputs, work files and Hydrotec's reports available will also be provided on the Sharefile, and a summary excel file has been created to catalogue the database and summarize key content in the documents (e.g. year published, author, relevant topics etc).

2. LiDAR survey was carried out for the whole stretch of the St Paul River upstream of Mount Coffee, where new hydro developments are considered. This new data together with Digital Terrain Model (DTM), geo-referenced orthophotography and LiDAR information already available downstream of Mount Coffee shall be made available to Consultants involved in the development of the Priority Investment Program.

It is expected that the Consultant retained for the Optimization Study will draw on the information provided in the Sharefile and take full advantage of the work carried out in the TA for its assessment of the technical, economic and socio-environmental aspects of all the potential schemes identified in the St Paul River catchment and any others with significant potential.

2. SCOPE OF WORK

2.1 Study Objective

The overall objective of the Optimization Study is to identify the Priority Investment Project (PIP) including priority hydropower Projects on the St. Paul River and including production, storage, and transmission.

In order to do so, the optimization study will identify a long-term development plan that will optimize the development of the St. Paul River cascade in the long run, considering market opportunities and developments in the basin since previous studies were undertaken. It will rank potential projects in order of merit in the short, medium and long term and propose a Priority Investment Project (PIP) to be developed within next 5-10 years that will then move into a bankable Feasibility Study (FS) stage.

2.2 Scope of Services

In specific terms, the Consultant will be requested to mobilize skilled expertise and resources in order to execute all tasks in the following three types of activities:

- A) Market Review
- B) Preliminary Assessment of Future Supply Options
- C) Definition of Long Term Development Plan (LTDP) and the Priority Investment Project (PIP)

The tasks to be performed under each group of activities are detailed below.

2.3 Tasks

A) Market Review

The first step of the optimization study will be a market study for electricity from the next generation projects in Liberia. This market analysis will explore national needs and the regional export/import opportunities over time and will assess the needs for base and peak loads as well as ancillary services expected from the future developments.

Tasks to be performed include:

- (a) Reviewing regional and Liberian on-grid and off-grid electricity load under different assumptions including mining projects, to consolidate information on:
 - Grid-coverage forecast (based on analysis on locations to which it would make economically sense to interconnect to grid);
 - Historic and 20-year forecast demand in capacity (MW) and energy (GWh) (from 2020 to 2040);
 - Technical and non-technical losses;
 - Daily and annual load shape.
- (b) Reviewing characteristics of on-grid and off-grid existing generation assets as well as short-term (committed) projects, to consolidate information on their actual capability (firm MW and GWh and average GWh), as well as other relevant planning characteristics such as their reliability, O&M costs, fuel availability, etc.;
- (c) Reviewing the characteristics of the existing transmission grid and committed expansion projects, including the on-going CLSG interconnection project; possible limitations to Liberia importation and/or exportation of electricity shall also be identified at this point;
- (d) Reviewing the load-supply balance under present conditions to assess the timing & sizing of supply requirements to close the gap;
- (e) Establishing planning criteria that will be used for the development of the long-term development plan (for at least a 20-year period), including target reliability levels for peak load (MW) and energy (GWh) and definition of firm capacity/energy;
- (f) Opportunity tariffs for exports and imports will also be assessed in order to support further modeling and optimization.

In order to complete these tasks, the Consultant shall draw on previous work accomplished by other Consultants in the sector. To this end, it is expected that most of the data relevant to the Optimization Study (OS) will be extracted from the database (and Final Report) prepared by Hydrotec in 2018 in support to the OS, which includes a demand forecast, a quick overview of the available resources, and key basic information on St Paul's River watershed as follows:

- a rainfall-runoff model and the related input data and 63 years monthly flow series
- topographical information from LiDAR surveys including the DTM and geo-referenced orthophotography.
- socio-environmental data collected in the upstream watershed
- a Geological Baseline Report (based on bibliographic work)
- generation estimates based on HEC-ResSim simulations
- a high-level review of hydropower candidates.

The Consultant is also expected to benefit from an updated baseline concept design with cost estimates for Via and SP4 dams (to be confirmed).

Since key data in the database is expected to be in ready-to-use format, the work shall be limited to reviewing and confirming the adequacy of the input data derived, and providing complementary data whenever appropriate.

The following documents, which will be included in the Sharefile, shall also be critically reviewed:

- *The Rural Energy Strategy and Master Plan for Liberia* developed by Gesto Energy between July 2015 and April 2016;
- *Liberia's Least Cost Power Development Plan (LCPDP)* developed by Fichtner, which Final Report was issued in August 2014;
- *WAPP Master Plan for Generation and Transmission of Electrical Energy*, which latest version by Tractebel / EDF dated 2011 is currently being updated, with a first draft expected by mid-September 2018.

When reviewing these documents, any missing data shall be identified and supplemented as required to ensure that the best information is used to derive the inputs on which the OS will be based.

B) Preliminary Assessment of Future Supply Options

In parallel with the market review, the Consultant shall look into supply alternatives available to fill the gap over the short-, medium-, and long-term horizons. In doing so, hydro developments on the St. Paul River shall be considered as the only ones available over the planning horizon, and no consideration shall be given to other potential cascade developments in the OS.

The assessment of future supply options includes the following tasks:

1. Defining St. Paul River Hydro Baseline Candidates
 - a) Confirm location and possible layout for potential candidates based on:
 - Topographical data (LiDAR) available
 - Hydrological Data (Series of inflows) previously established
 - Geological / Geotechnical Data extracted from previous work (GBR); where necessary, simple geotechnical investigations such as seismic lines may be required to confirm the absence of fatal flaws that would precluded the development of a dam
 - Key socio-environmental features identified in the reach upstream of Mount Coffee

- A field reconnaissance visit to candidate locations to be organized jointly with local experts
- A review of other water uses in the basin and the recommended ecological flows
- Estimated plant capability (firm and average capacity and energy).

The Consultant may explore potential reservoir/dam/generation candidates beyond those described in previous studies (taking the opportunity of Lidar data newly made available). New potential candidates (different from Via, SP4, SP2 and SP1B) with large reservoir capacity versus limited dam crest will in particular be explored (3 new potential candidates will at least be proposed/analyzed within this screening process).

Based on above criteria and analysis of potential fatal flaws, potential candidates will be screened in order to eliminate schemes which are clearly less attractive, with the objective of establishing a list of baseline candidates to be considered in the development of the optimal generation expansion plan that will lead to the identification of the PIP.

- b) Develop layouts and conceptual designs for each baseline candidate identified using the consolidated information available.

Due consideration shall be given to developing such layouts for a range of dam heights whenever appropriate so that optimal cascade development can be derived in the next step of the OS.

- c) Prepare preliminary cost estimates (with $\pm 30\%$ accuracy) incl. cashflows, socio-environmental costs, and O & M using unit rates provided in the database.
- d) Review plant capability (firm and average capacity and energy) for various installed capacities (rated flow) and dam heights.
- e) For each baseline candidate, carry out a preliminary optimization of the conceptual design based on multi-criteria approach that takes into account technical &, economic parameters and potential environmental and social impacts. Key parameters to be defined are dam heights (and reservoir sizing for the Via and SP4 Reservoirs), and installed capacity (rated discharge) for all hydro projects.

This optimization has to be carried out with a long-term view to capture all benefits from hydro generation so that the optimum cascade development can be identified.

- f) Establish plant availability: earliest in-service date, reliability, maintenance outages etc.

- g) Provide a preliminary assessment of the baseline candidates using simplified criteria such as a levelized cost per kWh to provide a relative value and ranking of future hydro projects for planning purposes.

2. Alternative Supply & Storage Options

Alternative options to supply the electricity demands shall be identified and defined in accordance with the findings of the market review. Generation and storage options to be considered shall include solar generation, thermal plants, batteries and/or the development of any other potential resource identified as part of the market review, and considered to be a viable option.

For each supply options, planning characteristics shall be defined, including:

- The proposed size for the units (Installed capacity)
- Plant efficiency (heat rate)
- Availability (earliest in-service date, reliability and maintenance)
- Investment and O&M costs.

For thermal alternatives, the Consultant shall also look into existing and planning fuel supply arrangements and facilities to assess the availability and cost of each type of fuel over the planning horizon.

The possibility to import electricity (especially via the CLSG interconnection) shall also be explored at this stage, and the characteristics, possible limitations, and cost of such imports defined using available information.

C) Definition of the Priority Investment Project (PIP)

The last step of the OS consists of conducting power system optimization and simulation studies to propose an optimal generation expansion plan from which the next Priority Investment Project (PIP) to be completed over the next five to ten years will be identified. Such a PIP from a hydropower perspective may include, for example, the development of a large storage reservoir or reservoirs (with or without installed capacity) and one or more hydropower schemes downstream with the associated transmission lines, sub stations and ancillary, access infrastructure.

In order to achieve this objective, the Consultant shall develop a load-supply model which will integrate hydrological variability (interannual and seasonal) as well as demand variability. Methodology and criteria driving the model should be made explicit and validated by the LFT and the WAPP.

On this basis the Consultant shall:

1. Develop the optimum Long-Term Development Plan (LTDP)

- (a) Compare several mixed development scenarios to meet the forecast demand with the required reliability level. These scenarios will be established to allow for a

comparison of the overall costs for various combinations of supply options including hydro candidates, thermal plants, batteries, solar energy and/or imports. Preliminary Environmental and Social costs for mitigation/resettlement plans shall also be estimated & integrated into the analysis. Phasing of the development of generation units over time in each specific site could also be considered.

- (b) Calculate, for each scenario, the levelized cost of energy (with and without exports) to confirm the optimal timing of generation investments that leads to the least cost development plan. As per WB guidelines, a discount rate of 6% will be applied, with sensitivity analysis at other rates.
 - (c) Assess the impact of import/export opportunities using the CLSG and other interconnections on the sequencing of projects over time and the economic (and financial) ratios.
 - (d) Carry out additional simulations (sensitivity analysis) to assess the robustness of the optimum scenario under adverse conditions such as inflows lower than anticipated, delays in exporting hydro surpluses, electricity demand higher or lower than forecast, series of days without sun etc.
2. Define the Priority Investment Project (PIP)
- a) Recommend, on the basis of the optimum development plan and sensitivity analysis carried out, the Priority Investment Project (PIP) on the St Paul River for the period 2020 - 2025.
 - b) Define how the PIP will be integrated within the national and regional grids and identify the needs for access roads, transmission lines and/or substations etc.
 - c) Identify risks that may hamper the development of the PIP and suggest mitigations measures
 - d) Identify the needs for early work that should be implemented as soon as possible for the timely development of the project. This may include construction of access roads, installation of rain gauges, river flow gauging stations, water quality and sediment sampling, etc.
 - e) Define the geotechnical and socio-environmental field investigation programs that will need to be executed at the next stage of the studies.
3. Propose an Implementation Framework / Road Map

The Consultant shall develop an implementation framework for the PIP that will highlight high-level activities that need to be carried out for the timely development of the project. In preparing this road map, due consideration shall be given to:

- Future Technical Work required (including in the Socio-environmental field) and the need (or not) for Prefeasibility Studies of priority investments¹
- Allowances for the necessary approvals between the various phases up to completion
- Institutional aspects, including the possible creation of a River Basin Authority for the St. Paul River, Guinea, and/or an inter-basin transfer authority (with the Republic of Guinea in which country the St Paul and Via Rivers originate)
- Expected participation of key stakeholders and proposed program for institutional strengthening, including capacity building of members of the LFT.

3. CAPACITY BUILDING

Capacity building of Liberian key stakeholders is considered of utmost importance for the success of the program and the Consultant shall take all required actions to facilitate technical training within its mandate.

Of particular relevance, the work plan of the Consultant shall give due consideration to:

- Integrating local counterparts in the Consultant's team during the site visit and, more generally, ensuring that they work with Consultant's staff whenever in Liberia;
- Organizing and delivering a one (1) week training session on the work carried out as part of the OS in the Consultant's Offices for five (5) to eight (8) Liberian counterparts;
- Providing draft copies of Technical Notes and/or Reports to key stakeholders at least two (2) weeks in advance of the validation workshop;
- Preparing presentations to be given at the validation workshop(s) and circulating in advance the material to be presented;
- Timely respond to comments received from key stakeholders, explaining how their concerns will be treated and/or integrated into the studies.

4. OUTPUTS AND DELIVERABLES

Deliverables to be produced as part of the OS are described below.

All reports and communications shall be in English.

4.1 Market Review Report

The Consultant shall submit to the WAPP and the LFT members a Draft Report on the Market Review in electronic form five (5) weeks from start of the project. The Report shall rely on a thorough review of available information and preliminary contacts with key stakeholders to present:

¹ The preparation of the Terms of Reference for the next stage of the pre-investment studies is explicitly excluded from the scope of work.

- The review of the available information and appreciation of the data provided;
- A description of the existing (and committed) generation and transmission systems;
- The base load forecast adopted for the study;
- The proposed planning criteria including reliability targets;
- Opportunity analyses of export and import tariffs at different time horizons;
- The load-supply balance with the existing supply system and the generation gap.

Comments from stakeholders on the Market Review received up to two (2) weeks after the issue of the Draft Report shall be consolidated in a validation virtual LFT workshop to be held at the end of the training session (or in the following week). These comments shall be taken into account in subsequent studies and integrated in the Market Review Final Report that will be issued two (2) weeks after the end of the training session at the latest.

4.2 One-week Training Session (at Consultant's Offices)

A one-week technical training session will be organized and delivered at the Consultant's premises, two (2) weeks following the submission of the Market Review Draft Report. The training session shall focus on key aspects of the OS work such as:

- Load forecasting
- System losses (technical and commercial)
- Existing Supply Capacity and Energy (firm, average)
- Planning characteristics of Supply Options (reliability, unit cost etc.)
- Load-supply Balance
- Imports & Exports Opportunities
- Generation planning approach and criteria
- Watershed resources development & management
- Hydropower planning & modeling
- Reliability and accuracy of key input (site specific) data
- Storage units
- Socio-environmental issues
- Etc.

It is expected that five (5) to eight (8) Liberian counterparts will participate in this training session, at the end of which they shall have gained a good understanding of the work to be accomplished in the OS, and enough technical background to appreciate the content of the OS deliverables and to comment them meaningfully.

An independent evaluation of the content and delivery of the training session will be requested from the Liberian Participants prior to their leaving the Consultant's offices at the end of their stay.

4.3 Supply Options Report

The Consultant shall submit to the WAPP and the LFT members a Draft Report on Supply Options in electronic form ten (10) weeks after the beginning of the study. This

Draft Report shall present all options considered viable for possible inclusion in the LTDP, with emphasis on:

- The supply options considered “committed” in the short term, which will be identical in all development scenarios to be compared;
- The characteristics of the proposed baseline candidates for the optimal cascade development of St. Paul’s River, including the conceptual design, reservoir curves, normal operating levels, plant installed capacity (rated flow) and estimated firm and average generation (capacity and energy), investment and O& M costs, availability, socio-environmental key features, and identified risks and possible mitigation measures;
- The description of all other potential supply options (solar, thermal plants, imports, geothermal, biomass etc.), and key planning characteristics of those considered viable (generation capacity, costs, availability etc.)

Comments from the stakeholders on the Supply Options shall be discussed in the validation workshop that will follow, taken into account into subsequent studies, and integrated in the final version of the Supply Option Report that will be issued no later than two (2) weeks after receiving comments.

4.4 Workshop on Supply Options and Planning Methodology

A two-day workshop shall be held two (2) weeks after issuing the Draft Report on the Supply Options, with the following objectives:

- To provide an overview of the hydro planning process that lead to the selection of the baseline candidates for the optimal development of the St Paul River cascade;
- To discuss and agree on key data, parameters, and assumptions adopted in the preliminary assessment of the supply options, including the hydro baseline candidates;
- To confirm revisions made to the Market Review Report including the adoption of planning criteria;
- To discuss and agree on modelling methodology that shall be applied to elaborate the LTDP;
- To collect comments on the Draft Report on Supply Options for their integration into next steps of the studies;
- To provide further capacity building to LFT members and key Ministerial and Utility interfaces on all aspects of the work done so far and the analysis that will be carried out for the elaboration of the LTDP.

The Consultant shall confirm the timing for the workshop at the start of the OS, in collaboration with the LFT and the WAPP who will form the basis of the audience at the workshop. The Consultant shall lead the presentations and submit its proposed agenda to the WAPP and the LFT at least ten (10) days prior to the workshop.

4.5 Optimization Study Report

The Consultant shall present the work undertaken and the results of this study in a complete draft report for comments. The report shall include maps and concept drawings of the baseline hydro candidates under consideration as well as the detailed results of the generation planning exercise and the economic analyses that justify the recommendation for the Priority Investment Program (PIP).

The draft OS report shall be submitted to the WAPP as eight (8) hard copies and in electronic form fifteen weeks (15) weeks from Start of the project for review and comments.

Its content shall be presented together with the implementation framework and roadmap, and discussed in a three-day validation workshop to be held in Liberia two (2) weeks later, and the comments integrated in the final version of the OS Report, which shall be submitted no later than two (2) weeks following reception of comments from all stakeholders at the workshop.

5. CONTRACT EXECUTION

5.1 Liaison with Stakeholders

During the execution of its assignment, the Consultant shall cooperate and liaise fully with the stakeholders and in particular (but not limited to):

- The WAPP Secretariat and its designated representatives as well as CLSG stakeholders;
- The Government of Liberia and in particular the Liberia Focal Team (LFT) that have been set up, together with the Ministry of Mines and Energy (MME) and the Ministry of Finance and Development Planning and the Presidents Delivery Unit energy team; Members of the LFT will stand as entry points for the Consultant in these institutions.
- The Liberia Electricity Corporation (LEC), the Liberia Energy Regulatory Commission (LERC) when formally ratified;
- Various agencies like the Liberia Hydrological Services (LHS), the Environmental Protection Agency (EPA), the Liberian Forestry Development Agency (FDA) the Liberia Institute of Statistics and Geo-Information Services (LISGIS), the Rural renewable Energy Agency (RREA) etc.; and

- Consulting firms and/or Consultants contracted under the TA program as well as all parties working in the sector, including funding agencies.

5.2 Reporting

The Consultant will be accountable to the WAPP Secretary General, and will work closely with the WAPP Secretariat's Planning, Investment Programming and Environmental Safeguard (PIPES) Department and the WAPP Coordinator for the World Bank Technical Assistance Program.

The WAPP considers communication of utmost importance. Liaison and coordination of all stakeholders must be duly taken into account for the successful completion of the mandate. To this effect, the Consultant shall hold regular updates/briefings/video conferences with the WAPP and other stakeholders on works in progress, problems encountered, and achievements.

5.3 WAPP Contribution and Consultant Expenses

The WAPP shall provide documents, where available, access to the Sharefile and the database of reference material for the performance of the services.

The Consultant shall provide his own office facilities for the execution of the services, as well as all vehicles, plant, equipment and tools needed to undertake the study.

Liberian Authorities shall provide assistance in obtaining work permits, and visas for the Consultant's staff. They shall also provide assistance in facilitating access to the sites, being understood that vehicles facilities shall be accounted for as an expense in the Consultant budget.

5.4 Schedule

A large part of the services are expected to be completed in a 5-month period, with the proposed following timeline for the submission of the deliverables:

Deliverables	Timeline
Kick-Off Meeting and Site Visit	S + 0
Market Review Draft Report	S + 5 weeks
Training Session in Consultant Offices (1 week)	S + 7 weeks
LFT virtual meeting to validate Market Review Report	S + 8 weeks
Market Review Final Report	S + 10 weeks
Supply Options Draft Report	S + 10 weeks
Workshop to validate Supply Options Report	S + 12 weeks
Supply Options Final Report	S + 14 weeks
Draft OS Report	S + 15 weeks
Workshop to present draft OS Report & Implementation framework and roadmap	S + 17 weeks
Final OS Report	S + 20 weeks

WAPP and Liberian representatives are aware that deadlines are ambitious but this is rationalized by the facts that:

- The Consultant is expected to benefit from all data collected and structured in the database as well as from previous studies. Most of the work is hence anticipated to be desk-based; and
- Work is expected to be implemented by a compact highly skilled and experienced team.

6. QUALIFICATION REQUIREMENTS

6.1 Criteria

The shortlisted Consultants will be selected based on their technical capacity, experience and qualifications in the fields related to this assignment. The shortlisting criteria are:

1. Knowledge of the Electricity Sector in West Africa and experience in hydropower developments. Familiarity with the WAPP organization, the CLSG interconnection project and the Electricity Sector in Liberia will be an advantage.
2. Relevant experience and competences in the development of electricity Master Plans involving mixed supply options including renewable energy (solar) and imports-export opportunities.
3. Strong expertise and experience in the preparation of hydropower generation projects with emphasis on optimization of cascade development using multi criteria approach, and proven record of successful studies at the preliminary (reconnaissance) and pre-feasibility levels. Previous experience in Sub-Saharan Africa will be considered favorably.
4. Availability of staff with strong technical expertise including socio-environmental specialists and staff with proven capabilities in economic evaluations, and capacity to mobilize relevant experts as needed over an estimated period of 5 months starting at end of year 2018.
5. Demonstrated interpersonal and communication skills, and fluency in English required (working knowledge of French an asset). The ability to work effectively in challenging environment where the various interests of several stakeholders need to be reconciled would be an asset.

Interested Consultants should provide all documents, statements and references related to these criteria.

6.2 Team Structure

The Consultant shall build up a team of international experts with extensive experience from similar studies for generation planning and hydropower developments and submit their curriculum vitae with the proposal.

Key positions to be filled include:

- i. Senior Generation Planner (for hydro resources and energy mix optimization)
- ii. Hydropower Expert
- iii. Environmental and Social Impact Assessment Expert
- iv. Cost Estimator
- v. Power Economist

The Consultant shall also complement his team with additional experts whose inputs are deemed necessary at various stages of the Optimization Study. These experts may include:

- vi. Hydrologist
- vii. Geologist / Geotechnical Engineer
- viii. Electro-mechanical Engineer
- ix. Civil Engineer (for Hydropower Layouts)
- x. Hydro generation modeler
- xi. Experts in other energy resources: Solar, thermal, biomass, etc.

6.3 Staff Qualifications

Proposed staff shall meet the qualifications and requirements described below. In addition, all staff must be fluent in English (written and oral), and well versed in the use of standard computer tools such as the Microsoft Office Suite.

The person who will be designated as Team Leader must also have excellent skills in Project Management as well as excellent oral and written communication skills. Knowledge of French is not compulsory but would be an asset.

- i. Senior Generation Planner

A Professional Engineer with at least fifteen (15) years' experience in the development of optimal long-term generation plan involving mixed energy sources and, ideally, interconnection exchanges.

As a generation planner, the candidate must have a strong background in simulating and optimizing hydro resources, including seasonal reservoirs and cascade developments, and a proven track record in the screening and evaluation of hydropower projects. He/she must have been involved in at least five (5) similar generation planning projects, preferably in Sub-Saharan Africa.

Knowledge of the Electricity Sector in Liberia and familiarity with WAPP organization will be an advantage, and hands-on knowledge of reservoir simulations model such as HEC-ResSim an asset.

ii. Hydropower Expert

Civil Engineer with at least fifteen (15) years' experience in preliminary and prefeasibility studies for major hydro projects including cascade developments with reservoirs. The candidate must have extensive experience in carrying out field reconnaissance for the development of new hydro projects, and in the preparation of general layouts and preliminary conceptual designs. He/she must have worked in at least four (4) projects of a similar nature where such skills were utilized, of which at least one (1) is in Sub-Saharan Africa.

iii. Environmental and Social Impact Assessment Expert

A professional with a Master's Degree in Environmental Management or equivalent qualifications and at least fifteen (15) years' experience in the assessment of socio-environmental issues related to cascade development on rivers with hydropower projects and reservoirs. The E&S the Expert shall have working knowledge of World Bank Safeguard Policies as well as local and international regulatory standards on environmental and resettlement issues, as well as proven international experience in at least three (3) projects of a similar nature, preferably in Sub-Saharan Africa.

iv. Cost Estimator

An Engineer or Qualified Technician with at least fifteen (15) years of experience in the preliminary costing of hydro generation assets for screening purposes and comparison with alternative generation sources. Demonstrated experience must include at least five (5) international projects of a similar nature, of which at least two preferably undertaken in Sub-Saharan Africa.

Competences in the preparation of cost estimates for alternative power generation assets such as thermal plants or solar schemes will be a significant advantage.

v. Power Economist

An Economist with not less than 10 years' experience in the Power Sector and the development of Long Term Generation Plan involving hydropower resources. The Power Economist should have experience on at least five (5) similar projects, with two (2) of them in Sub-Sahara Africa and be well versed in the preparation of demand forecasts and fuel cost projections, as well as the definition of interconnection exchange conditions (cost of imports/exports).