Feasibility Study for the Nigeria: Kiri Dam Hydroelectric Power Plant

Task J Report: Final Report

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REPORT SUMMARY

The study of hydroelectric installation was initiated by a **Task A** site visit in December 2009 to discuss options and collect initial information for evaluation. The Upper Benue River Basin Development Authority has provided the data, drawings and information necessary to conduct this study. PHCN and NERC of the Government of Nigeria also provided information along with other government agencies.

The objective of the **Task B** study was to define and conceptualize the best option and size for installation of hydropower at the Kiri Dam. Originally, the preferred option for installation was the use of one or more scour gates at the dam, adjacent to the irrigation intake works. Other options included use of one of the spillway radial gate bays or installing an intake and penstock on the long earthen embankment section.

The report provides a description of the existing plant, hydrology evaluation and physical parameters to consider in implementing hydropower. The report provides an evaluation of the available head and flow for potential power production as well as an evaluation of each of the main alternatives. The hydrology for any future power project will be dependent on releases from the upstream Dadin Kowa Project. That project is to have hydropower installed, which will change its release schedule to benefit dry season generation at both Dadin Kowa and Kiri Dams according to information provided by the Upper Benue River Basin Development Authority.

In early information from The Upper Benue River Basin Development Authority (The Authority) there was a current requirement of 180Mm^3/month of irrigation water from the Dadin Kowa Dam, above the Kiri Dam on the Gongola River, to service local irrigation and thus not available for Hydro Electric Power (H.E.P) from Kiri Dam. Additionally, another 180 Mm^3/month,, as a worst case scenario, would be diverted from the upper reaches of the Gongola to irrigation from Dadin Kowa and thus not available for Kiri Generation. Since that time, PERI/IESG has been told that neither of these quantities of irrigation water will be withdrawn from the Gongola above Kiri. Power generation is the higher priority for the water out of Dadin Kowa Dam and into the Kiri reservoir. This will allow additional generation for Kiri Dam, especially into the dry season months. Independent of this consideration, the report includes, as a late addition, the prospect of additional turbine or turbines in the power house to generate additional power, though most likely in the rainy season only. The original restriction to 20 MW for the report was a result of the Nigerian Electric Regulatory Commission's (NERC) requirements that generation up to 20 MW does not have to enter the Nigerian grid, therefore allowing Adamawa state to keep the power generated by Kiri Dam as a captive resource. There has been some indication from NERC through the TDA in Abuja, that this may be modified to allow additional generation at Kiri Dam

The water coming from Dadin Kowa in the rainy season will allow an additional one or two 10 MW units to be installed, each of which will operate for only a comparatively short portion of the year. The financial analysis in Task D provides a definitive analysis as to whether this

marginal output is competitive with cost and availability of energy from the Nigerian state utility during the rainy season. Section 8.7 of the Task B report addresses the prospect of additional turbines.
The last section of the Task B report is a presentation of the elements of the selected plan, including costs, schedule, impacts and output of the proposed project.

The Task C report is written to follow up on the information developed in Task B, where the conceptual engineering design of the Kiri Dam project was developed. This report was researched and prepared for the Governor of Adamawa State, by Princeton Energy Resources International (PERI) and International Energy Services Group Ltd. (IESG). Kiri Dam is located on the Gongola River in Adamawa State in eastern Nigeria, about midway between north and south. The Task B conceptual engineering design was based on an examination of the dam and environs, the transmission requirements to the Yola substation and certain assumptions listed in the Task B report, including the assumptions of the drawdown of the upstream Dadin Kowa dam and reservoir.

Dadin Kowa is intended to generate power in amounts greater than that planned for Kiri Dam and thus will provide the flow required for generation of the anticipated 20-30 MW to be available from Kiri Dam. Dadin Kowa is able to do this, as stated in Task B because it has a much greater reservoir behind the dam and can store substantial amounts of water to be drawn down during the dry season. The greater part of this water will pass downstream to supply water for generation by Kiri Dam. Any failure of Dadin Kowa Dam and reservoir to supply this water, especially during the dry season, will severely affect the output of the Kiri Dam and invalidate the financial and economic analyses of this report.

The Task C Economic Analysis is intended to use conventional power project finance economic analysis to model certain stated conditions and assumptions in order to determine the economic feasibility of construction a hydro power addition to the Kiri Dam. The estimates for size and performance of the plant are based on information developed in Task B. The estimates for up-front capital costs and for ongoing, annual operating expenses are based on the information developed in Task B for capital costs and operating costs.

External to Task B information, PERI and IESG have investigated the current power situation in Yola and have developed current costs of power to the consumers in the area. Power Holding Company of Nigeria (PHCN) has a 142 kV line currently running into the Yola substation by which power is available to the city and surrounding areas when there is adequate capacity to serve the area. There is often no adequate capacity, as Yola is at the end of a radial line from the north and west. While the comparatively poor transmission is certainly a consideration, the basic problem is lack of adequate generation capacity in the PHCN system.

According to the manager of the Yola substation, with whom PERI and IESG met during the site visit of December 2000, the substation has transferred as much as 35 MW to the local distribution system through the Yola substation.

The **Task D** Financial Analysis is organized as:

- Introduction
- Preliminary Discussions with Banks and Other Sources of Financing
- Sensitivity Analysis of Results from Testing the Discounted Cash Flow Financing Model
- Three Potential Ownership/Financing Structures
- Final Written Report, and
- Appendices.

In this report, PERI and IESG present results from having talked to banks and other financing institutions. We set forth results of sensitivity analyses, showing which variables have greater effect on project results, including especially the tariff to be charged for power. We describe three attractive ownership/financing structures for the hydroelectric project. We present a final, written Task D report with appendices.

Specifically, PERI and ISEG have:

1) Presented results of having consulted with debt and equity financing sources, including private commercial banks, public bilateral development banks, other institutions offering debt financing, and possible private developers or sponsors, who would contribute at least some equity investment. Institutions contacted include Citibank, Standard Bank, and Macquarie Capital. They also include the Export-Import Bank of the United States (USEXIM), the U.S. Overseas Private Investment Corporation (OPIC), and the World Bank's International Finance Corporation (IFC), which provides investment and advisory services to the private sector in developing countries. They include General Electric, Islamic Development Bank, African Development Bank Group, and Africa Finance Corp. of Nigeria, and potential developers, including Contour Global, Sithe Global Power, and AES. For each bank or other institution, the type of financial assistance offered will be discussed, such as debt, risk insurance, other, and the terms of that assistance. Investment interest in the Kiri Dam hydro project will be described, as well as useful actions that project participants might undertake to structure a sound project that will attract financing.

2) Present results of cash flow financing model sensitivity analysis. We have presented results for changes to: 1) term of Power Purchase Contract, looking at 10-, 20-, and 30-year contracts; 2) water flow to the power plant, which determines the net capacity factor and power produced; 3) capital cost; and 4) debt term and the debt interest rate.

Changes to model results are measured in two ways: a) by holding the tariff (project revenues) constant and examining how IRR and debt coverage change and b) by changing the tariff pattern to hold IRR and debt coverage to attractive levels and examining how the Cost Of Energy tariff (COE) changes. For the latter, the pattern of the tariff charged (year one and year after debt is repaid) will be raised or lowered after adjusting term of contract, capacity factor, capital cost or other variable, to the lowest level where debt coverage for lenders or other debt investors and/or IRR for equity investors remain attractive.

3) Develop and present three potential ownership/financing structures for Kiri Dam Hydroelectric Project. Task C, presented a preliminary description to the Advisory Committee and sought their input. The better options are:

a) 20 MW 20-year Public-Private-Partnership, where the public contribution is all equity (Cash Flow Appendix A in Task C);
b) 20 MW 30-year Public-Private-Partnership, where the public contribution is all equity (Cash Flow Appendix E in Task C);
c) 20 MW 20-year Public-Private Partnership, where the public contribution is about two thirds subordinated debt and one third equity (Cash Flow Appendix G in Task C); and
d) 20 MW 20-year Independent Power Producer using limited recourse Project Finance (Cash Flow Appendix F in Task C).

Two additional ownership/financing structures for a 30 MW plant, instead of 20 MW, were developed with Task C. These are:

e) 30 MW 20-year Public-Private Partnership, where the public contribution is all equity (Cash Flow Appendix I in Task C); and
f) 30 MW 20-year Public-Private Partnership, where the public contribution is about two thirds subordinated debt and one third equity (Cash Flow Appendix J in Task C).

These represent six cases, excluding only that of the 20 MW 10-year Public-Private Partnership where the public contribution is all equity, but where the short 10-year contract life raised COE.

With the sensitivity analysis to come, PERI and IESG found that the Kiri Dam hydroelectric project is fairly robust to reductions in water supply. If a drought occurs or if Dadin Kowa does not release water as projected, within reasonable levels, the Kiri Dam 20 and 30 MW plants both could pay O&M, pay debt, and turn a modest return on equity. PERI and IESG were surprised at these results and they caused us to cite four additional attractive ownership/financing structures. These are:

g) 30 MW 30-year Public-Private Partnership, where the public contribution is all equity (with debt repaid as 22 years at 9.5%);
h) 20 MW 30-year Public-Private Partnership, where the public contribution is all equity and where debt is repaid faster (as 15 years at 8.0%, not 22 years at 9.5%);

i) 30 MW 30-year Public-Private Partnership, where the public contribution is all equity and where debt is repaid faster (as 15 years at 8.0%, not 22 years at 9.5%); and
j) 30 MW 30-year Public-Private Partnership, where the public contribution is about two thirds subordinated debt and one third equity and where debt is repaid faster, as 15 years at 8.0%.

From these cases, Adamawa performed a review and selected three cases. These are: case (e) the 30 MW, 20-year PPP plant, case (g), the 30 MW, 30-year PPP plant where debt is 9.50% for 22 years, and case (j), the 30 MW, 30-year plant, where the public contribution is about two thirds subordinated debt and one third equity, and where all debt is 15 years. PERI and IESG agree with this selection.

4) Present this finalized Task D written report to the Advisory Committee. This report sets forth the analytical work performed and presents results. It summarizes findings and presents conclusions. A copy of the Excel discounted cash flow model developed under Task C was sent with the Task C report, but it is included again, here. See the Cash Flow Sensitivity Appendices Index at the back of this report. The cash flows are grouped by variable tested for sensitivity (e.g., contract term, net capacity factor, capital cost). The three optimal financing structures were developed from the sensitivity analysis.

In the Cash Flow Sensitivity Appendices Index, note that files are presented as both pdf files (to show printed results) and Excel files (to show calculations). Because their number was very large, those files that show less important information or that show only small iterations, are included as electronic copies only. Those files that are more relevant are included as both paper and electronic copies. The computer files will be sent by CD-ROM. Another copy of the report and model will be sent electronically by email.

In **Task E** PERI/IESG has performed a preliminary review of the Project's anticipated social and environmental impacts with reference to the Host Country requirements (i.e., municipal, state, Federal levels) and in line with the guidelines of the multilateral lending agencies such as the World Bank Organization and the African Development Bank. The review has identified some potentially negative impacts. The extents to which they can be mitigated are described in this section. In addition the requirements for a more detailed environmental and social impact assessment prior to the start-up of the construction operations are provided.

Dams vary considerably in their adverse environmental and related social impacts. From an environmental standpoint, there are relatively good dams and bad dams. While some dams are benign, others have caused environmental damages. The severity of environmental impacts from a hydroelectric project is largely determined by the dam site. While dams at good sites can be very defensible from an environmental standpoint, those proposed at questionable sites will inherently be problematic, even if all feasible mitigation measures are properly implemented.

The most effective environmental mitigation measure is good site selection, to ensure that the proposed dam will cause relatively little damage in the first place. The World Bank Organization provides quantitative indicators for rating and ranking proposed new hydroelectric projects in terms of their likely adverse environmental impacts. These were applied in the preliminary assessment and for the purpose of developing guidelines for a formal environmental impact assessment.

Projects with a small reservoir surface area (relative to power generation) tend to be most desirable from both an environmental and social standpoint. The reason for this is that such factors minimize natural habitat losses as well as resettlement needs. In general, the most environmentally benign hydroelectric dam sites are on upper tributaries, while the most problematic ones are on the large main stems of rivers. In this regard the Kiri dam does not appear to have significant negative impacts to either natural habitat losses or resettlements; however these will need to be more clearly defined in a formal impact assessment that is beyond the scope of the present study.

Table 1 of the TaskE report provides a summary of the key areas of concern for the environmental impacts of the project. Mitigation options for each area are defined in the table along with recommended steps to be included in the formal environmental impact assessment.

Task F reviews the requirements of the Nigerian Electricity Regulatory Commission as it pertains to electrical generation. Every applicant must satisfy three broad eligibility requirements for a license, legal, technical and commercial. The various licenses issued are: generation, transmission, system operations, distribution and trading. The Kiri Dam project will be required to get a generation license for off grid generation. A license application, with proper documentation, should be approved or denied within six months of submission.

Task G reviews the anticipated impact of the Kiri Dam hydroelectric project in the area of the dam.

The current infrastructure to accept the power from the Kiri Dam is discussed and is found to be adequate. There is evidence of the Yola substation accepting 35 MW in the past and distributing it to the area loads. As stated in Tasks D of the report, the cost of power at the Yola substation bus is expected to be approximately US$0.12 per kWh as opposed to approximately US$0,27 for the common self generation using high speed Diesel generators.
Market oriented reform is discussed, especially the results of the Electric Power Sector Reform Act of 2005 and its implementation since that time. There is some interest in the Kiri Dam project's being a catalyst for accelerating private power in Nigeria, but the size of the project will likely have little effect in that respect.
Likewise, human capacity building will accelerate little with the installation of the dam. The project will involve approximately 300 craft during the approximately 2 year construction period, with most of the skilled craft coming from other more industrialized areas. The common mode for this development is for a local labor helper to one of the skilled trades to be accepted as

a helper for fallow on work with the skilled trades and move on with the craftsman to the next job. In some cases this will continue and build until the helper learns the skills required to move up.
Technology transfer will likewise be limited because of the size of the plant and the comparatively simple technology used. The most likely training to be done is for the operations and maintenance personnel working on the project. It is likely the project will be unmanned except for dispatch in Yola and the plant will require little in the way of full time personnel. It is expected that any maintenance will be performed by those in Yola who are dispatched as needed.

Task H asks for a listing of prospective US suppliers to the Kiri Dam project. Hydro turbine suppliers in the US are limited, with two suppliers that are European with assembly facilities in the US and one company that designs and builds turbines in the US. General Electric sold their hydro power group to Andritz and the remnants of the Aliss Chalmers hydro works remains in York, PA under the ownership of Voith. Equipment that is common to all power work, such as switchgear, controls, electric protection and relays are manufactured by a number of companies in the US. There are a number of engineering firm in the US capable of doing the design for the project. Few, if any, US EPC contractors have been seen doing work of this size and nature in the developing world in the past 15 years.

Task I suggests a path forward for developing the Kiri Dam Hydropower project. It will likely be necessary to obtain revisions to the NERC requirements that the term of any PPA be limited to ten years. A ten year term runs the cost of energy too high and leaves the project company with too little margin for error for the prospect of a few drought years. A 20 year term, or even a 30 year term for a hydro project would be more appropriate. Or perhaps no limit; let the project company and the off taker work that out. The requirement to put all output of any plant over 20MW into the national grid will be a problem for the 30 MW plant, though this is generally handled administratively in other parts of the world. The next step, as proposed in Task H is to interest commercial banks in the project followed by solicitations of interest from the development banks, such as the African development Bank, the Islamic Development Bank, the African Finance Corporation, the International Finance Corporation, a part of the World Bank Group. or for certain conditions of US content, the US EXIM bank and the US OPIC are valuable participants.

In **Task J** the final report copies are specified and a MS Power Point presentation is prescribed to be used in presenting the results of the study to interested parties.