EXECUTIVE SUMMARY

BACKGROUND

Ghorband and Nandihar Hydropower Projects were identified by Pakhtunkhwa Hydel Development Organisation (PHYDO) [the then SHYDO], Peshawar, Pakistan and Deutsche GesellschaftfuerTechnischeZusammenarbeit GmbH (GTZ), Eschborn, Germany through a report titled "Hydropower Development in Mountainous areas of NWFP: 1992". The details for these Projects are given in "Vol. III Chapter–5 of 'Regional Development Study Indus Swat / Mansehra West" through an inventory of hydropower potential for Indus Swat and Mansehra area. Only small portion of hydropower potential (about 15%) has since been developed. A large portion of the same is yet to be harnessed.

Afterwards PHYDO had planned to develop step–wise several of these identified schemes with selective alternatives. Out of these Ghorband Hydropower Project was identified as SCHEME No. 2 / Alternative 1 – SeraiKarora – on Ghorband / Shin River (18 MW) now called as Ghorband Hydropower Project [GHPP] and Scheme No. 7/ Alternative 1 – Thakot – on Nandihar River (10.3 MW) now called as Nandihar Hydropower Project [NHPP] and are entrusted to Ghorband Nandihar Hydropower Consultants [GNHPC] for present Feasibility Stage Study.

Accordingly, Consultancy Agreement for Feasibility Studies of both Ghorband and Nandihar Hydropower Projects was signed on 22 June, 2012 between Joint Venture of Consultants comprising of **NDC, BAK** and **Hydro-Tech**in association with **LI and KEC**(GNHPC)by **Pakhtunkhwa HYDEL Development Organization** (PHYDO) Peshawar (Client) at a total cost of Rs. 65,864,464/- breakup of which is tabulated below:

Sr. No.	Description	Amount (Rs.)
1	Salary Cost/Remunerations	34,058,067
2	Direct (Non Salary) Cost Projection Office	14,362,589
3	Direct Cost Field Office	3,103,808
4	Field Survey and Investigations Cost	14,340,000
	Grand Total:	**65,864,464**

(Rupees Sixty Five Million Eight Hundred&Sixty Four Thousand Four Hundred and Sixty Four only)

Note: *Later, on the request of the Consultants an Addendum No. 01 was issued in Nov 2012 wherein Consultants were allowed to adjust/reallocate funds within various Direct Costs Heads and for new items of Costs as warranted for completion of services. Consultants were also allowed to adjust Salary Costs within the provisions earlier made.*

As a part of Services, the Consultants prepared a combined **Inception Report**for both the Hydropower Projects which was submitted to the Client in Oct 2012, whereas, combined **Mid Term Report** was submitted in Jul 2013.

In this Report only Nandihar Hydropower Project is discussed.

INTRODUCTION

Nandihar Hydropower Project (GHPP) was proposed as runoff the river (Diurnal peaking Project) on NandiharKhwar River in Battagram District of KPK. After thorough deliberations in different meetings and discussions with the Client, finally it was decided that a **Power Tunnel (**from Batle to the site of the Powerhouse inbetween **Bar Goriar and KuzGoriar** Villages) is to be constructed. This option was approved by PHYDO and the Consultants were allowed to carry out additional topographic surveys, Geotechnical studies etc for conducting the Feasibility Studies of this option.The proposed Hydropower Station, as per TOR, will have no huge reservoir. However, it would include Weir, Tunnel, Penstock and Powerhouse etc. These components may have some impact on the environments, temporary or permanent.

GENERAL DESCRIPTION OF THE PROJECT

The Project is based on the concept of divertinga partial flow of Nandihar River by means of a diversion weir and further through a 5.9 Km power tunnel to the Power House where water discharges to the Indus River some 12 Km further downstream.

By this concept some 215m head can be obtained for Power Generation which permits a maximum available capacity ex-generator of 12.3 MW and a mean annual energy generation of 69.84GWh at a base cost of US $ 40.078 million. Salient features of the project are as follows;

Salient features of Nandihar Hydropower Project

Description	**Symbol**	**Value**	**Unit**
Design Discharge	Qd	6.5	m^3/sec
Environmental Flows	Qe	0.2	m^3/sec
No. & Type of Units		2	Pelton
Design Discharge (single unit)	Qunit	3.25	m^3/sec
Net Head	Hn	214.37	m
Turbine Efficiency at QD	η_T	92	
Generator Efficiency	η_G	98%	
Transformer Efficiency	η_{Tr}	99.5%	
Annual Shutdown	T_{AS}	20	days
Results			
Gross Power	P_G	12.3	MW
Annual Energy	EA	69.84	GWh
Plant Factor	PF	64.7	%

General Information

Total Cost of the Project	PKR.5039.41 M (US $ 47.097 M)
Unit Cost of Generation	Rs. 3.935/-
EIRR (compared to CCGT)	13.46%
Period of Construction	36 Months
Project Layout	Left Bank of NandiharKhwar
Weir Location	KuzGandur Village
Catchment Area	463 km^2
Powerhouse location	Goriar Village
Weir & reservoir	
Weir Height	12.8 m
Free board	1.8 m
Normal Reservoir level	743 m a.s.l
Minimum reservoir level	738 m a.s.l
Reservoir Capacity @743	0.1 MCM
Weir Top Level	744.8 m a.s.l
Tail water level	512 m a.s.l
Length of the Weir crest	92 m
Desander	
TYPE	Surface
No. of Chambers	2 No.
Total Length	76.5 m
Total Width of 2. Chambers	9.73 m
Gross Head	224.5
Total Head loss	10.2
Net Head	214.37
Power & energy	
Design Discharge	6.5 Cumecs
Intake (Lateral Intake) at Left	Single Intake with Trashrack
Headrace tunnel (HRT) Length	5968.0 m
HRT Diameter (Horse Shoe)	2.3 m

Penstock length	400.0 m
Penstock Dia (Steel Penstock)	1.3 m
No. of Turbine	2 Pelton Units
Rated Power	12.3 MW
Annual Estimated Energy	69.84 GWh
Annual Shutdown	20 Days
Plant Factor	64.7%
Spillways details	
Main Upper Spillway	
Gated/Ungated	Radial Gated
Height of the Spillway	2.5 m
Width of the Spillway	3.5 m
No. of Bays	4 No.
Discharge capacity at Max. RWL	261 Cumecs
Bottom Outlets	
Gated/Ungated	Vertical Lift Gate
Height of the Spillway	1.5 m
Width of the Spillway	1.5 m
No. of Bays	3 No.
Discharge capacity at Max. RWL	73 Cumecs
Total Discharge Capacity	334.0 Cumecs
Surge shaft	
Surge Shaft Dia	4.0 m
Surge Shaft Height	22.0 m
Power house	
Type	Surface Power House
Main Dimensions (W x L x H)	43.5 x 14 x 17
Tailrace Channel	
Type	Trapezoidal
Total length	18 m

SCOPE OF SERVICES

Scope of services of the Consultants was elaborated in the Terms of Reference (TOR) issued by the PHYDO, which comprises the following tasks:

- **TOPOGRAPHIC SURVEY**
- **HYDROLOGY AND SEDIMENTATION**
- **ENGINEERING GEOLOGY & EVALUATION OF SEISMICITY**
- **ASSESMENT OF ENVIRONMENTAL AND SOCIAL IMPACTS**
- **DESIGN AND LAY OUT OF STRUCTURES**
- **DEVELOPMENT OF CONSTRUCTIN PLAN**
- **TRANSMISSION OF POWER**
- **UNIT PRICE**
- **BENEFITS OF THE PROJECT**
- **ECONOMIC PARAMETERS**
- **SENSITIVITY ANALYSES**
- **OPERATONATIONAL COST ESTIMATE**
- **SERVICES AND REPORTING BY THE CONSULTANTS**
- **PC-I**

All the aforementioned tasks are described in detail in the succeeding chapters, however, the status of each task is briefly given here under:

Topographic Survey

Topographic Survey of Nandihar HPP Area was commenced during the month of Jan 2013. The delay in commencement of this very important task can be attributed to the absence of Project Manager for about three months and late fielding of Survey Parties. In order to achieve a much suitable result, the Topographic Survey was repeated time and again with the help of TOS and Satellite Images etc. The survey was finally completedto the satisfaction of all concerned in the month of July 2013.

Hydrology and Sedimentation

The hydrological studies for Nandihar HPP were required to determine probable runoff of the project catchment and the discharges available for power generation in its magnitude and seasonal variations as well as quantum of sediments flow. These studies included Installation of Gauge Station and fielding of suitable Hydrographer, Gauge/Sediments observers etc. All the Hydrological and Sedimentation studies were carried out according to TOR provided by the Client and completed in Oct 2013, however, gauge observation/sediment measurement continued till end Dec 2013.

Engineering Geology & Evaluation of Seismicity

Geological and Geotechnical Engineering was conducted satisfactory, however, it was a little bit delayed because of late fielding of Chief Geologist. Simultaneously, construction material survey was carried out as a parallel activity. Similarly, Seismic Hazard Evaluation was also carried out by a relevant expert. All these activities were successfully completed by Oct 2013 and reports by concerned experts were submitted in Nov 2013.

Project Layout and Hydraulic Design

The information provided in PHYDO/GTZ report is of very basic level. The revised estimated power is 10.3 MW. Several layouts were studied for this project. In planning,these layouts and recommendations of the GTZ report were kept in view. However, several significant changes were found necessary in the light of latest available topographic, hydrological and environmental data.

The hydraulic design studies of Nandihar Hydropower Project include design of weir, intake, sand trap, power tunnel, surge shaft, penstock, powerhouse and tailrace.

Seismic Hazards

Seismic Hazard Evaluation for the Nandihar Hydropower Project has been carried out using both Deterministic as well as Probabilistic Approaches. In this regard all the earthquakes recorded/ reported from 1973 till April 2013 were studied and all the tectonic features that can pose seismic hazard for the project were taken care of. Acceleration attenuation relationships used in this risk assessment were also tested against the Strong Motion data recorded at Abbottabad and Tarbela Observatories. Project volume and electric-power generation as well as water storage capacity along with possible human-life/ property hazard, in case of its failure, were also kept in mind while suggesting design parameters related to the Peak Ground Accelerations, both for a Maximum Credible Earthquake and an Operating Basis Earthquake

Structural Design Studies

Structure design of the project has been done ensuring the stability and safety of structures against encountered forces/loads including hydrostatic pressure, earth pressure, imposed live, uplift, seismic and other design loads etc using guidelines of established manuals and code of practices. Reinforcement Design is based on ACI Ultimate Strength Design (USD) method. Grade 60 bars are used. Load factors for components other than power tunnel, are based on ACI 318-01. Factors for power tunnel are adopted from US Army Corps of Engineers EM 1110-2-2901 – Tunnels and Shaft in Rock. Design strength of structural members has been taken as a product of nominal strength and strength reduction factor. Allowable stresses are according to ACI 318. Design considerations for all individual Project Components are elaborated in the relevant Sections of the report.

Mechanical Equipment

Mechanical equipment includes turbines, governors, inlet valves, gates, stop-logs, trash-racks and cranes etc. For the operating net head range of 210.57m to 214.37m a Francis type of turbine could be considered for Nandihar power plant. However for the range of discharges available, from 27.54 m^3/s (maximum) to 0.94 m^3/s (minimum), a Pelton turbine is considered more appropriate, as it has a better efficiency over the whole range of discharges. From the comparative study of various turbine sizes and combinations, two turbines each with 4.25 m^3/sec flow have been selected. Considering turbine efficiency of 92% and the head range of 210.57m to 214.37m and design flow of 4.25m^3/s, the power will be 6.15 MW for each unit considering generator efficiency as 98%. For determining appropriate unit capacity, both technical as well as economic aspects have been examined in a comparative study taking into account equipment dimensions, transport limitations,

power and energy benefits, manufacturing experience, power system regulation, and cost estimates etc.

Electrical Equipment

Theelectricalequipmentforpowerproductionandtransmission,comprisingallnecessaryauxiliary suppliesandservices,willbeconstructedtoprovideamaximum power outputwiththehighestreliabilityand availability.Theequipmentmainlyconsists of:

- Twoverticalshaft generators of 6.15 MW each feeding two 11 kV outgoing feeders, 11kV Switchyard consisting of circuit breakers, Isolators C.Ts, P.Ts, earthing switches, measuring devices etc.each connected via 11 kV single core cables to the respective generator circuit breaker.
- Two 11KV outgoing feedersforinterconnectionofthepowerplantwithtwooutgoing transmissionlinecircuit either feeding radial load or synchronized with local 11 kV distribution line(132 kV Grid is available at Thakotabout 3km away).
- AuxiliarysupplyforallelectricalpowerneedsoftheNANDIHARbuildingsandtheintake area.
- Measuring, controlandprotectiondevicesforallfunctionsoftheplantincluding the control Room.

Environmental and Social Assessment (IEE & SIA)

A series of meetings were held by the GNHPC Environmentalist/Social Expert with local population, elites of the area, public representatives, district administration, revenue, forest, agriculture, irrigation & other departments for consultation, information sharing and obtaining their views about the proposed project**.** Lands in Nandihar Project area comprise cultivated, waste lands and settlements. Fruits and thick forest lies in the Project area, which will have to be removed during construction stage of this Project.

It is concluded that the Project activities will have some adverse environmental impacts of medium to high level in some (identified) areas. The overall environmental impact will be from “low to medium”. There should be trained staff at the project site for environmental management and monitoring.

Cost Estimates

The total project construction cost of civil works has been estimated on the basis of current market. Appropriate escalation factor has also been applied to meet with current market prices. In case of cost of E&M Equipment, due consideration has been given to the current recession in the market. Equipment which can be manufactured locally has also been appropriately utilized. The estimate is based on current price level and in converting US dollars to Pak Rupees, the prevailing exchange rate as in January -2014 has been adopted viz US$ 1 = Rs. 107.00.

Base cost of the project has been estimated as PKR 4288 million (40.078 million $) and the investment cost as PKR 5039 million including price escalation, custom duties and interest during construction.

Based on these cost estimates for the project, economic and financial analyses of the project have been carried-out.

Economic Analysis

To demonstrate economic feasibility of Nandihar Hydropower Project, equivalent thermal power cost approach has been used. The life cycle cost of Nandihar HPP has been compared with the life cycle of cost of alternative equivalent thermal plant i.e. Steam Generation Plant using Furnace Oil (FO Plant) and a Combined Cycle Gas Turbine (CCGT).

Above analysis reveal that;

- Nandihar Hydropower Project (NHPP) is an economical and feasible Project on River Nandihar. Its installed capacity, as estimated through different studies, comes to 12.3MW. The Project will generate 69.84GWh of annual energy when fully commissioned, which is anticipated to take 36 months after fulfillment of requisite formalities like detailed Engineering Design, Tendering and Letter of Commencement to the Contractor.

- Environmental Impact Assessment (EIA) Studies have determined the overall impact rating of the Project activities as “low to medium”.
- It is concluded that the IEE is adequate to justify environmental and social clearance of the Project. There is no need for further analysis and the environmental and social assessment of the Project.
- Project Economic analysis of the project reveals that the project is economically viable as the Economic Internal Rate of Return (EIRR) is greater than the opportunity cost of capital.
- EIRRs calculated for the CCGT & Furnace oil Thermal alternatives come to 14.22% & 24.25% with CDM benefits and 13.46% & 23.87% without CDM Benefits respectively.
- FIRR comes to 11.56% whereas cost of Generation is PKR 3.935 per unit.

- The Economic comparison FO plant and CCGT with Hydropower plant indicates CB ration without CDM as 1.12 & 1.81 and with CDM as 1.15% & 1.84% respectively.
- Revenue has been estimated on the basis of system sale price of 10.35 PKR/Kwh. 2% auxiliary consumption has been assumed.

Conclusions

From the Study it has been concluded that the project is viable and recommended for detailed engineering design and execution.