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PREPARATION, REVIEW AND AUTHORIZATION

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EXECUTIVE SUMMARY

1 INTRODUCTION

Batakundi Hydropower Project (HPP) is one of the series of hydropower development projects launched by Pakhtunkhwa Energy Development Organization (PEDO), Government of Khyber Pakhtunkhwa (KP). The objective of the proposed hydropower scheme is to generate and add cheap energy to the system in order to meet the current shortfall and increasing demand of electricity in the region through economical and sustainable means.

Batakundi HPP was originally identified under the study "Identification of Hydropower Potential in Kaghan Valley" by the then Sarhad Hydel Development Organization (SHYDO) (now called PEDO) with the technical collaboration of the German Agency for Technical Cooperation (GTZ).The project envisaged a 60 m high dam with a 4.5 km long headrace tunnel and an underground powerhouse on the right bank of Kunhar River. The dam axis was, identified 8 km upstream of Batakundi Village, headrace tunnel on the right bank and the powerhouse near Dhadar nullah confluence with Kunhar River.

PEDO carried out ICB in 2011 for the selection of Consultant to carry out detailed Feasibility Study of the Project. As a result of the competitive bidding, the Consortium of Consultants led by Mirza Associates Engineering Services (Pvt.) Ltd. (MAES) was selected for implementation of the Feasibility Study of Batakundi HPP. The letter of commencement was issued on June 13, 2012 for pre-feasibilty study,which was later converted to the feasibility study. The Consultants carried out the services for two years i.e. June 2012 to October 2014 and have completed a bankable Feasibility Study of the project.

The study has resulted in a project size of 96 MW with an excellent economic rate of return. **Table - 1** presents the salient features of the project. The Batakundi HPP is proposed to be located on Kunhar River, with its powerhouse located about 1 (One) km downstream of Batakundi Village, which falls in District Mansehra of KP Province. The project area is accessible by road from Rawalpindi / Islamabad through Abbotabad, Mansehra and Balakot **(Figure 1)**

Table - 1: Salient Features of the Project

HYDROLOGY (DESIGN FLOWS)	
Catchment area at dam site	720 km^2
Mean annual flow	32 cumecs
Design discharge	52.0 cumecs
Design flood (10,000 Year Flood)	2244 cumecs
RESERVOIR	
Reservoir length	2080 m
Reservoir area	0.235 km^2
Maximum flood level	2790 m.a.s.l
Max. reservoir operating level	2787 m.a.s.l
Min. reservoir operating level	2782 m.a.s.l

Reservoir capacity at 2787 m.a.s.l	3.50 MCM
Reservoir capacity at 2782 m.a.s.l	2.45 MCM
Live storage	1.05 MCM
DAM STRUCTURE	
Dam height above riverbed	58 m
Length of crest	120 m
Dam crest level	2793 m.a.s.l
River bed level	2735 m.a.s.l
Dam foundation level	2726 m.a.s.l
Dam type	Composite Dam (Rockfill/Concrete Gravity)
DIVERSION TUNNEL	
Flood during construction	509 cumecs
Length of diversion tunnel	370 m
Size of tunnel (D-shaped)	W x H = 7 m x 5.5 m, Top Radius = 3.5m
GATED SPILLWAY	
Number of gates	2 (Two)
Gate type	Radial
Width of gate	8 m
Height of gate	12 m
Discharge capacity	1626 cumecs
Spillway sill level	2775 m
LOW LEVEL FLUSHING OUTLETS	
Number of gates	2 (Two)
Gate type	Vertical
Width of gate	5.0 m
Height of gate	5.0 m
Discharge capacity (at maximum flood level)	1282 cumecs
Sill level	2737.0 m
POWER WATERWAY/ POWER INTAKE	
Type	Lateral Intake
No. of racks	2 (Two)
Rack size (W x H)	5 m x 6 m
Deck elevation	2793 m.a.s.l
Sill level of intake racks	2772 m.a.s.l
No. of gates	1 (one)
Gate size	5.2 m x 5.2 m
Sill level of gate	2770.50 m.a.s.l

LOW PRESSURE HEADRACE TUNNEL (Concrete Lined)	
Diameter	5.2 m
Length	4,410 m
SURGE SHAFT	
Diameter	8 m
Height	57 m
HIGH PRESSURE TUNNEL (inclined)	
Diameter **(steel lined)**	3.5 m
Length	550 m
PENSTOCKS	
No. of penstocks	4 (Four)
Diameter	1.7 m
Length of penstocks	100 m
POWER GENERATION	
Gross head	221.0 m
Max. net head	218.0 m
Min. net head	211.5 m
Rated net head	215.0 m
Plant design discharge	52.0 cumecs
Installed plant capacity	96 MW
Mean annual energy (average 53 years.)	368.7GWh
Plant factor	43.8% (Average year)
Firm power	49.6 MW
Turbine type	Francis, 375 rpm
No. of units	4 (Four)
Turbine setting	- 3.3 m
Turbine centreline level	2561 m.a.s.l.
Generators	4 (Four)
Powerhouse type	Underground Cavern
Powerhouse cavern (L x W x H)	80 m x 12 m x 26 m
Transformer cavern (L x W x H)	64 x 9 x 9 m
Busduct length	5 m
No. of busducts	4
Substation type	Indoor GIS
Transmission line	132 kV
TAILRACE TUNNEL (CONCRETE LINED)	
Normal tailwater level	2566 m.a.s.l
Minimum tailwater level	2564 m.a.s.l
Maximum tailwater level	2568 m.a.s.l

Width of tunnel	5.0 m
Length of tailrace tunnel	110 m
Outlet sill level	2564 m.a.s.l
Stoplog operation platform level	2574 m.a.s.l

This Feasibility Study Report consists of a Main Report (Volume-1) and nine (9) supporting volumes. The Main Report consists of eighteen (18) sections completely covering all aspects of the project at feasibility study level, whereas the nine(9) volumes present details of the studies, field data, drawings and other required information related to different sections of the Main Report.

2 DESIGN CRITERIA (CIVIL, ELECTRICAL AND MECHANICAL)

A design criteria is necessary for setting out the guidelines / basis of all the designs and field operations necessary for preparing the Feasibility Report. The design criteria document for Civil, Electrical and Mechanical works has been prepared, which covers all aspects of the design and field operations.

3 TOPOGRAPHIC AND HYDROGRAPHIC SURVEYS

The topographic survey and mapping have been carried out for all the components of the project. The tasks include establishment of datum and ground control points (GCPs), detailed topographic ground survey at the sites for dam, reservoir area, tunnels, powerhouse, tailrace outlet; and the river valley cross sections at the dam and powerhouse areas. The work has been done mainly by conventional survey aided by SPOT-5 satellite imagery.

Topographic surveys for the project features have been carried out at the following scales:

a.	Reservoir area, Headrace Tunnel / Channels, Access Roads	1:2000
b.	Dam Site and Intake Area	1:500
c.	Surge Tank, Pressure Tunnel / Penstock, Powerhouse and Tailrace	1:1000
d.	Project Layout	1:25,000

The survey has been carried out in local grid system of Survey of Pakistan (SOP) using the benchmark at Batrasi as datum. All survey work has been duly verified with dual frequency GPS survey instruments and found to be correct.

The terrestrial survey has been carried-out for the two (2) alternative project layouts conceived and selected for the field work at the Inception Stage and covers all the above mentioned project components.

For the inaccessible areas of the tunnel alignments, topographic maps have been developed with the help of high resolution Digital Elevation Models (DEMs), ortho-rectified with ground survey.

Hydrographic survey was carried out and longitudinal profiles of the relevant stretch of Kunhar River were prepared.

4 HYDROLOGY AND SEDIMENTATION STUDIES

The project has a catchment area of 720 km^2 up to the dam site. The flow estimation at the dam site has been made from the long term gauging station on Kunhar River at Naran / Kaghan. Ten (10) daily, monthly and annual flows have been estimated from daily discharge data for the period 1960 to 2012. The mean monthly flow estimated at the dam site varies from 7.0 cumecs to 101.9 cumecs with average annual flow as 32.0 cumecs. The mean annual flow at the dam site varies from 20.8 to 43.4 cumecs with average value as 32 m^3/s.

The flood has been estimated from the long term record of instantaneous discharge at Naran / Kaghan gauging stations. By applying statistical formulae, floods for various return period have been estimated at the dam and powerhouse sites. The recommended flood magnitudes for the dam and powerhouse sites corresponding to 10,000 year return period are 2244 and 2298 cumecs, respectively.

Mean annual total sediment inflow to the dam site is about 0.206 MCM (167.1 AF). The life of Batakundi reservoir without considering any flushing option is estimated as about 33 years. Sands will start entering the power tunnel when flow through the reservoir exceeds 185 cumecs, however, a sediment particle of 0.1 mm diameter is expected to enter the power tunnel when flow exceeds 480 cumecs. On an average basis, the annual sediment load entering the power tunnel would be 0.096 M Tons.

The pivot point of delta deposits will reach a distance of 1600 m from the dam face as a result of one year sediment deposition.

Optimum flushing discharge to carry out efficient flushing of the reservoir is computed as 64 to 120 cumecs, with flushing duration of one to two weeks depending on the flow available for the purpose and the amount of deposited sediments. The life of the reservoir can be enhanced to 65 years with appropriate flushing operations at the rate of one flushing per year in the month of July.

5 NEOTECTONICS AND SEISMIC HAZARD STUDIES

The region encompassing the Batakundi HPP is highly complex in terms of its tectonic set up. The estimated seismic hazards in terms of peak ground acceleration (PGA) with 10% probability of exceedance in 50 years i.e., 475 year return period as computed by different workers for Naran – Batakundi area, range between 0.09 and 0.70.

5.1 Seismic Design Parameters Based on Deterministic Seismic Hazard Assessment (DSHA) Approach

According to ICOLD (2010), DSHA is used for assessment of Maximum Credible Earthquake (MCE), and PGA values for both 50-percentile (median) and 84-percentile (mean plus one standard deviation) are listed.

For the dam and powerhouse sites, at GMPE with 84-percentile value, four of 7 identified faults are capable of generating PGA >0.5g. The maximum PGA is expected from MMT Fault that passes close to the dam site with a value of 0.68g.

5.2 Seismic Design Parameters Based on Probabilistic Seismic Hazard Assessment (PSHA) Approach

Ground motion parameters for return periods from 150 to 10,000 years for appropriate selection as the MDE parameters corresponding to PGAs of 0.33 to 0.68g for the dam and the powerhouse sites have been included. However, considering the seismic history of the Naran-Batakundi area, it is recommended that the ground-motion parameters for the MDE may be selected for 1000 year return period as a minimum and 10,000 year as the maximum.

The OBE is expected to occur during the lifetime of the structure. No damage or loss of service is allowed. It has a probability of occurrence of about 50% during the service life of 100 years. The return period is taken as 150 years (ICOLD 2010). The OBE ground motion parameters are estimated based on PSHA. For the project, 150 year return period has been recommended for selection of the OBE ground-motion parameters, which corresponds to 0.15g for the dam site and the powerhouse sites.

6 GEOLOGICAL AND GEOTECHNICAL STUDIES

The field work for the project comprised surface geological mapping including scan line surveys, geophysical survey using seismic refraction method, drilling of boreholes, coring and logging, performance of permeability and water pressure tests, and excavation of test pits at potential construction material sources.

Sedimentary and metamorphic rocks are exposed in the project area. The following two formations / rock units are encountered along the dam site, headrace tunnel and powerhouse area of the Batakundi HPP, which belong to Sharda Group.

Burawai Gneisses (Bans Pelite)

Dadar Migmatites

A total of 08 scan line surveys and 06 profiles of seismic refraction survey, were carried out at the dam / intake area, headrace tunnel, powerhouse etc.

For collection of the soil / rock samples and to perform in-situ tests, 21 boreholes were drilled at the proposed structure locations, with total drilling depth of 1414 m.

Test pits were also excavated at various structure locations for investigation and verification of the extent of overburden and physical inspection of its nature at the site. Some other pits were excavated in prospective borrow areas for evaluation of the construction materials i.e. coarse as well as fine aggregate, rockfill and cohesive material.

Suitability of the potential construction material sources has been examined through laboratory testing of representative samples.

On the basis of observed RQD values, the bedrock can be classified as “Very Poor to Excellent” with a very wide range of core recovery.

In the light of data collected and analyses carried out, the rock mass design parameters were determined for various components of the project, and used for evaluating the stability as well as foundation design parameters for the various structures. For the underground structures i.e. headrace tunnel, surge shaft, powerhouse caverns and tailrace tunnel, stability analyses and design of support systems have been carried out.

7 PROJECT LAYOUT STUDIES

The Consultants identified alternative dam and powerhouse sites in addition to the previously identified sites by GTZ-SHYDO (now PEDO) **(Figure 2).** The selected project layout is on the right bank of Kunhar River with the geodetic co-ordinates of the dam and powerhouse sites as follows:

Site	Latitude	Longitude
Dam	34^0 – 55' – 07"	73^0 – 48' – 23"
Powerhouse	34^0 – 56' – 20"	73^0 – 46' – 24"

Based on the parameters for screening viz: good topographical, hydrological and geological conditions, minimal environmental issue etc, the dam site selected is located 4.5 km upstream of Batakundi Village. At the selected dam site, the valley sections are narrow at the upstream cofferdam, downstream cofferdam, diversion tunnel, main dam, plunge pool and power intake area.

The selected powerhouse site is near Dhadar nullah confluence and Batakundi Village. The topographic and geological conditions at the powerhouse site favour an underground powerhouse. Necessary investigations have been carried out at the dam, powerhouse and headrace tunnel alignment to confirm the technical viability of project layout.

The previously identified project layout by GTZ-SHYDO (now PEDO) has been found technically un-feasible due to poor geological conditions at the proposed dam site D-1. The geological conditions at the dam site D-1 do not favour the placement of the main dam and allied structures for dam construction, as well as the power intake for the headrace tunnel.

The alternative Project layout has sound geological conditions at the dam site D-2, headrace tunnel, powerhouse and tailrace outlet areas. The sound geological conditions and promising topography for the project area and the availability of long historical record of flows at Batakundi give the confidence to improve the design discharge and installed capacity of Batakundi Hydropower Project.

The selected layout has relatively smaller dam, shorter low pressure tunnel, and a reservoir with adequate storage for daily peaking. The dam, reservoir and powerhouse sites have minimum environmental issues in terms of land acquisition, people's resettlement, road realignment etc **(Figure 2).**

8 PROJECT SIZING AND POWER POTENTIAL STUDIES

For the selected project layout, optimization of capacity, diameters of headrace tunnel and pressure shaft have been performed. For capacity optimization, long run marginal power and energy prices are used to estimate benefits for various design discharges. Considering the flows in the river at the dam site, a design discharge range from 24 to 76 cumecs with incremental intervals of 4 cumecs has been considered to determine the capacity, energy, benefits and costing. For each discharge, preliminary costs of the project have been estimated. Benefits have been estimated for each considered design discharge by computing power and energy on monthly basis. Corresponding net present value (NPV) calculations were also performed. The capacity with the highest NPV value has been selected as the installed capacity.

For optimization of the design of headrace tunnel and pressure tunnel, different diameters were assumed. The diameter having the lowest sum of incremental and energy loss costs was taken as the optimum. With sound and good geological conditions for the headrace tunnel, concrete lining is considered adequate and an optimized diameter of 5.2 m has been selected. Similarly, steel lining for the inclined pressure tunnel has been considered for which 3.5 m diameter is optimized for design discharge of 52 cumecs.

For optimization of plant capacity, run-of-the river and peaking options were evaluated and sensitivity analysis performed. It has been found that 4-hour peak with design discharge of 52 cumecs and plant capacity of 68 MW will be the optimum. The maximum and minimum reservoir levels were assumed as 2787.0 and 2782.0 m.a.s.l. respectively.

A residual flow of 0.70 cumecs in winter months and 1.5 cumecs in summer months has been assumed to estimate the power and energy on 10 daily basis. Efficiencies of 91.0%, 97.0% and 99% have been used for the turbines, generators and transformers respectively. The head loss has been estimated as 9.70 m for the design discharge of 52 cumecs.

During the low flow periods, the live storage is used to store water during off peak hours to improve the flows for power generation in the peak hours. It has been estimated that 1.05 MCM storage would provide additional flows in 4 peak hours.

The tailwater elevation varies from 2564 to 2568 m.a.s.l, and the net head varies between 211.5 to 218.0 m with an average value of 215.0 m. For the design discharge of 52 cumecs and net head of 215.0 m, the optimum installed capacity would be 96 MW with average mean annual energy of 368.7 GWh, at a plant factor of 43.8%. The calculated annual energy, for the years 2012 wet year, 1983 average year and 2006 dry year, is 505.56,364.06 and 288.9 GWh respectively.

9 CIVIL, DAM AND OTHER HYDRAULIC STRUCTURES

Hydraulic analysis and sizing of the project structures has been carried out to the feasibility design level for the following structures:

a. Main Dam
b. Power intake structure on the right bank of the river
c. Low pressure headrace tunnel
d. Surge tank
e. Steel lined high pressure tunnel
f. High pressure penstocks
g. Underground powerhouse with transformer cavern
h. Free-flow tailrace tunnel

9.1 Main Dam

At Batakundi dam axis, the right abutment has exposed rock while the geology at left abutment is weeker with a rock wedge avilable to an elevation of 2760 ma.s.l., and above this rock wedge the abutment contains glacial deposits.

Considering the geology at dam axis, a composite dam has been planned for the project. The dam at the right abutment and across the river width will be a concrete gravity dam while at the left abutment, it will be a concrete core rockfill dam **(Figure 3).**

A two bay gated spillway each of H x W = 12 m x 8 m has been provided with the crest level at 2775 m.a.s.l., two low level outlets each of H x W = 5 m x 5 m have been set with crest level at 2737 m.a.s.l.

The gated spillway has a dischrge capacity 1626 m^3/s which is more than 1:1000Y flood. PMF (1:10,000Y flood) will be discharged using a combination of gated spillways and low level outlets. In n-1 hydraulic condition i.e. with one spillway inoperative, the combination will pass PMF with reservoir level below the Maximum Flood Level i.e. 2790 m.a.s.l.

Low Level Oultlets (LLOs) have a discharge capacity of 1282 m^3/s. Thsese outlets will also be used for annual sediment flushing from the reservoir. The river bed level at the dam axis is 2735 m.a.s.l. and the bedrock is encountered at EL. 2727 m.a.s.l. Height of the main dam from the river bed is 58 m.

9.2 River Diversion Scheme

The river diversion works consist of the following components:

a. Rockfill cofferdam with impervious core and crest level at 2751 m.a.s.l at the upstream side.
b. Rockfill cofferdam with impervious core and crest level at 2747 m.a.s.l at the downstream side.
c. A D-shaped diversion tunnel with rectangular section W x H = 7 m x 5.5 m and arch section of 3.5 m radius having a length of 370 m has been proposed to direct the flows for the dam construction area.

9.3 Power Intake Structure

A 2-bay intake structure with trash racks has been proposed for passing the design discharge. A 5.2 m wide 5.2 m high, control gate equipped with upstream sealing has been provided.

9.4 Low Pressure Headrace Tunnel

Headrace tunnel has been optimized by considering different diameters for the design discharge with the following parameters:

a.	Manning- Stickler coefficient (shotcrete)	60
b.	Tunnel slope	0.11 %
c.	Shotcrete lining thickness	0.10-0.3 m (as per conditions)
d.	Concrete lining	0.3 m

The optimized diameter. of low pressure headrace tunnel is 5.2 m and it is 4410 m long.

9.5 Pressure Tunnel

Pressure tunnel is steel lined and has the following dimensions.

Diameter	3.5m
Length	550 m

9.6 Tailrace Tunnel

The data of the main concrete lined tailrace tunnel is as follows:

Total Length	110 m
Cross section type	‘D’ shaped
Width	5.0 m
Height	4.5 m

9.7 Head Losses in the Conduit System

The calculation results of the head loss of the conduit system indicated that the total head loss in the conduit system is approx. 9.70 m.

9.8 Surge Tank

A circular surge tank having 8.0 m diameter has been provided at the end of low pressure headrace tunnel. The surge tank is 57.0 m deep starting from EL.2765.95 m.a.s.l. and rising up to EL.2822.95 m.a.s.l.at the ceiling. Surge tank diameter throttles to 3.0 m at the junction with headrace tunnel.

9.9 Power Complex

An underground powerhouse has been proposed comprising the following structures **(Figure 4):**

a. Underground Powerhouse Cavern
b. GIS Transformer Cavern
c. Main Access Tunnel
d. Cable and Ventilation Tunnel

The powerhouse cavern is 80 m long, 12.0 m wide and 26 m high from the main inlet valve floor to the arch roof crown.

9.9.1 Multi Storied Transformer Cavern

The main features of the transformer hall cavern (L 64m x W 9.0m x H 9.0m) and the factors considered in the determination of the layout are:

a. Single phase generator transformers (3 per unit, plus one spare) will be placed in separate fire-protected enclosures.
b. Transformer transfer facility through rails starting from the unloading bay of powerhouse at El: 2570.0 m.a.s.l.
c. Placement of GIS equipment,

d. Facility for transfer of the power cable to the cable tunnel.

9.9.2 Access Tunnel

The access tunnel is the main point of entry to the underground powerhouse complex. It is sized to accommodate two-way dump truck traffic during construction, and to provide the space needed to transport heavy equipment on low bay loaders or multi-wheeled transporters into the caverns. The largest items to be transported will be the generator transformers, the main inlet valves and the turbine spiral casing. A 'D' shaped access tunnel of 247 m length and size of 7.0 m width and 8.6 m height with a slope of 10% is provided.

9.9.3 Cable and Ventilation Tunnel

The cables from the transformer cavern are carried through a 4 m x 4 m cable tunnel up to the proposed 132 KV / 11 KV NTDC substation. This tunnel will also be used for ventilating the transformer and powerhouse caverns. After construction of the powerhouse roof, the construction adit will be used to ventilate the powerhouse and connect with the cable tunnel.

10 ELECTRICAL EQUIPMENT STUDIES

This section includes, specifications of generators; cooling and heating system; excitation system; fire protection system for generators; generator isolated phase bus; unit step up transformers; 132 kV XLPE cables; station DC and AC auxiliary supplies; protection equipment; main earthing and lightning protection system; plant control system (PCS); telecommunication; illumination; small power and video supervision system.

11 REMOTE CONTROL SYSTEM STUDIES

This section covers, computer supervisory and control system (CSCS) as an option for remote control of Balakot, Naran and Batakundi HPPs from the central control room of Balakot HPP; configuration and equipment description of CSCS and organogram for the joint O&M staff required for central operation of the three (3) HPPs.

12 POWER TRANSMISSION STUDIES

The interconnection of the project to evacuate maximum power of 96 MW is envisaged and studied in detail as follows:

a. According to National Power System Expansion Plan (NPSEP) of NTDC, a 500 kV double circuit (D/C) line will connect Suki Kinari HPP with Aliot S/S, a switching station located on the right bank of Jhelum River downstream of Neelum-Jhelum HPP, where Neelum-Jhelum HPP – Gujranwala S/S 500 kV D/C line will also be looped in-out.

b. Batakundi HPP will be connected by looping in-out one circuit of the D/C line of 500 kV to be constructed from Basha HPP to Aliot that would be passing near the powerhouse of the project. A double circuit 132 kV line using underground XLPE cables will be laid from Batakundi to Naran 500 kV take-off yard with provision of 500/132 kV extension.

c. The proposed scheme for 500 kV switchyard has double bus-bars of 500 kV with 04 diameters of breaker-and-half scheme.

Detailed load flow, short circuit and transient stability studies have been conducted for the peak load conditions of June 2020 for the interconnection scheme, as the plant is expected to be commissioned by the end of year 2019. Load flow analyses reveal that the scheme is adequate to evacuate the maximum power of 300 MW under normal and N-1 contingency conditions.

The transmission system is based on an interconnection study covering detailed load flow as per June 2020 forecast, short circuit analysis and transient stability analysis; configuration and equipment description of 132 kV GIS substation; 132 kV XLPE power cables ; protection and metering equipment.

The transient stability analysis of the proposed scheme of interconnection has been carried out. The stability check for the worst case of 3 phase fault right on the 500 kV bus bar of the substation followed by the final trip of 500 kV circuits emanating from this substation, has been performed for fault clearing of 5 cycles (100 ms), as understood to be the normal fault clearing time of 500 kV protection system. The system has been found to be strong enough to stay stable and recovers with fast damping, and therefore passed the transient stability checks.

The proposed scheme of interconnection has no technical constraints or problems, and is accordingly recommended to be adopted.

13 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

The broad objective of ESIA studies is to fulfil the mandatory legal requirment to assess the beneficial and adverse impacts of the project implementation on the environment including physical, biological and socio-economic parameters and to mitigate the adverse impacts.

The project area of the reservoir is under, agriculture, range land with some forest and fruit trees, mixed shrubs and rough grasses. There are no industries in and around the project area; therefore, noise pollution is generally below the EPA limits. The air quality in the area is also good.

The environmental and ecological water releases downstream of the dam will be 0.7 cumecs and 1.5 cumecs in winter and summer respectively. The flora existing in the project as well as the study areas falls under moist sub-tropical pine forests generally called Deodar forests.

Fauna of the tract consists of mammals, reptiles, amphibians and birds. Some of the most colorful and beautiful fowls like Monal pheasants and Kaleej are found in the surrounding mountains. Archaeological / historical sites in the reservoir and powerhouse areas do not exist.

The population of the project area is a mixture of Punjabi, Kashmiri and Pathan.The major language of project area is Urdu, Hindko and Gojri. In the project area, no proper medical facilities exist. Only one BHU and some private medical stores are available in Naran town, located about 17 km away from the Batakundi powerhouse. Majority (78%) of the female respondents also participate in work other than household chores and livelihood earning is the responsibility of males.

The reservoir of the project will permanently submerge 89.0 acre land. Out of this land, 14 acre is irrigated agricultural land whereas 1, 9 and 49 acre land is residential, forest / grazing and barren respectively. One acre land will be occupied by the underground powerhouse, tailrace tunnel etc. In addition, area of 15 acres will be occupied for staff / residential colony (10 acre in combined colony in Sanghar village near Balakot HPP powerhouse, and 5 acre in Batakundi Village).

In the reservoir area, 30 trees are being impacted. There will be no danger to large wildlife due to the execution of the project, as they live in forest areas, which are located at higher altitude.

There will be positive impact on the birds and the fowl communities as a suitable habitat will be formed for this community with the creation of the reservoir. Construction of the project will result in the creation of job opportunities, better potential for business, transport and tourism development.

During construction, environmental monitoring will be done for air quality, noise and vibration, drinking water quality, sewage effluent, solid waste, explosive material used, hazardous / toxic materials and their proper disposal, flora / fauna, excavated material and traffic handling system etc. Due to the construction of the project, 15 houses are being affected, which will require resettlement or compensation.

All the owners of the land and land based assets will be resettled or compensated according to the D.C. rates or the rates assessed by the Committee constituted for this purpose by the D.C. The survey revealed that more than 90 % of the affectees favored cash compensation. A Grievance Redressal Committee (GRC) is proposed, which will look into all the grievance cases.

The project environmental and resettlement cost amounts to US$ 1.612 million, which is less than 01% of the total project cost. PEDO will be responsible for the overall implementation of environmental mitigation measures and the RAP through its Project Director and field offices, with the collaboration of district government departments.

14 COST ESTIMATES

The cost estimates for the various project works including Infrastructure Development and Site Installations, Civil, Hydro-Mechanical, Hydraulic Steel, Electrical & Substation, have been prepared. These costs also include estimates for Environmental Mitigation Program.

The unit and lump sum prices were adopted after preparing the cost rate analysis for various items, comparing and escalating the unit prices for certain items available from other on-going or recently completed similar projects. **Table - 2** presents summary of the cost estimates together with the phasing of yearly cash flow for the proposed five (5) year construction period.

Table - 2: Summary of Cost Estimates of Project

Sr. No	Description	Total Cost M. US $	Year 1	Year 2	Year 3	Year 4	Year 5
A	**Infrastructure Development, Mitigation and Preparatory works**						
1	Mobilization and Demobilization	4.902	4.902				
2	Infrastructure & Technical facilities including Access Roads, Water supply & Drainage and Power supply to Residential colonies at Dam and Powerhouse sites	1.980	1.980				
3	Camps and Housing During Construction	0.581	0.581				
4	Land Acquisition and Environmental Mitigation Measures	1.612	1.612				
5	Reservoir Slope Stabilization and Construction Difficulties Costs	1.200	1.200				
	Sub Total A	10.275	10.275				
B	**Civil Works**						
1	Coffer Dams and Diversion Tunnel	3.559	1.779	1.779	0.000	0.000	0.000
2	Dam and Plunge pool Excavation	27.365	0.000	8.209	13.682	5.473	0.000
3	Power Intake	2.984	0.000	2.089	0.895	0.000	0.000
4	Low Pressure Headrace Tunnel	20.716	2.072	6.215	6.215	4.143	2.072
5	Surge Shaft	1.057	0.000	0.211	0.846	0.000	0.000
6	Pressure Tunnel	1.705	0.000	0.341	1.364	0.000	0.000
8	Penstocks	0.130	0.000	0.026	0.104	0.000	0.000
9	Powerhouse	15.171	0.000	3.034	4.551	4.551	3.034
10	Tailrace Tunnel	0.762	0.000	0.381	0.381	0.000	0.000
	Sub Total B	73.450	22.286	28.039	14.168	5.106	14.450
C	**HSS, Mechanical and**						

Sr. No	Description	Total Cost M. US $	Year 1	Year 2	Year 3	Year 4	Year 5
	Electrical Works						
1	Hydraulic Steel Structures	16.777	0.000	8.389	8.389	0.000	0.000
2	Powerhouse Mechanical Works	24.569	0.000	4.914	9.828	7.371	2.457
3	Powerhouse Electrical Works	13.271	0.000	2.654	5.309	3.981	1.327
4	Switchyard Works	6.597	0.000	0.000	0.000	3.299	3.299
5	Transportation	2.800	0.000	0.477	0.954	0.923	0.446
	Sub Total C	64.015	0.000	16.434	24.479	15.574	7.529
	Sub Total A+B+C	147.739	14.126	38.720	52.518	29.741	12.635
D	Design, Tender Documents, Engineering and Supervision Consultancy Costs @ 7%,	10.342	0.141	0.387	0.525	0.297	0.126
E	Contingencies @ 5%	7.387	0.706	1.936	2.626	1.487	0.632
F	Miscellaneous (Insurance, Performance Bonds and Workmen Compensation etc.) @ 2%	2.955	0.283	0.774	1.050	0.595	0.253
G	Duties @ 5% of Equipment Cost	2.755	0.000	0.718	1.059	0.659	0.319
H	**EPC BASE COST**	171.178	15.256	42.535	57.778	32.780	13.964
	Client Expenses, Administration and Legal Costs @ 5%	8.559	0.763	2.127	2.889	1.639	0.698
	Allowance for Greater Risk and Uncertainties @ 2%	3.424	0.305	0.851	1.156	0.656	0.279
	PROJECT BASE COST	183.160	16.324	45.513	61.822	35.075	14.942
	Interest During Construction @ 3% (LIBOR Rate 0.4% and Mark up 2.5%)	5.135	0.458	1.276	1.733	0.983	0.419
	TOTAL EPC PROJECT CONSTRUCTION COST	188.295	16.782	46.789	63.555	36.058	15.361

15 PROJECT IMPLEMENTATION AND CONSTRUCTION PLANNING

Project implementation period is estimated to be 5 years including pre-construction activities **(Figure 5).**

16 ECONOMIC AND FINANCIAL ANALYSIS

Economic analysis carried out on the basis of consumer surplus indicates that the proposed investment is feasible as the NPV, at a discount rate of 12%, is 310 M-US$ and the IRR is 27%.

Economics of the project was verified on the basis of benefits quantified on the long run marginal costs (LRMC) of capacity, peak energy and off peak energy at 500 KV level. The NPV at 12% discount rate is 269 M. US $ whereas the IRR is about 26%.

The proposed investment seems to be robust as it is economic even when the benefits and costs are changed by 20%, even a combined sensitivity with benefits decreased by 20% and costs increased by 20% still results in a feasible project. The switching values (estimates of LRMC which are used as benefit parameters) at which the project is only marginally feasible are: firm capacity 153 $/kW; peak energy 5.89 c/kWh; and off peak energy 3.68 c/kWh.

The financial analysis of the project has been conducted in accordance with the procedure laid down by ADB Financial Management and Analysis of projects. All financial costs and benefits have been expressed at early 2013 constant prices. Cost streams used for the purposes of FIRR determination (i.e. capital investment, operation and maintenance, insurance costs and taxes) reflect costs of delivering the estimated benefits. The NEPRA approved tariff for Suki Kinari, a high head hydroelectric project, was used to estimate the financial benefits.

The FIRR was calculated as 10.87% (about 22% on nominal basis) for the project. The overall rate compares favorably with the estimated WACC of 6.53% substantiating the financial viability of the project. The project is financially feasible.

Risks have been quantified by the sensitivity analysis. The project is financially feasible on certain assumptions, and based on robust parameters; it will be able to withstand reasonable uncertainties. The tariff at which the project becomes marginaly feasible is 5.75 c/kWh.

However, the recommended tariff as calculated according to NEPRA/PPIB guidelines is 11.27 US c/KWH as shown in **Table - 3** below.

Table - 3: Tariff Calculation

	Summary of Tariff Calculations				
		Years			Lev.
Avg.		1-10	11-20	21-30	at 12 %
CPP	Rs./kW/m	4136	1806	1806	
EPP	Rs./kWh	0.16	0.16	0.16	
Total	Rs./kWh	13.51	5.99	5.99	
Lev.	Rs./kWh			at 12%	11.27

In conclusion, the project is both economically and financially feasible. The project is, however, sensitive to the cost overruns and reduction in tariff. It is recommended that the project be implemented after tariff determination by NEPRA.

ANNEXURES