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STEP I DUE DILIGENCE

INTERCONNECTION SCHEME FOR DISPERSAL OF POWER FROM
147 MW PATRIND HYDROPOWER PROJECT (PHASE I)

(Final REPORT)

November 2013

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INTERCONNECTION SCHEME FOR DISPERSAL OF POWER FROM 147 MW PATRIND HYDROPOWER PROJECT (PHASE I)

Contract No: AID-EPP-I-00-03-00004

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USAID Energy Policy Program

House 4, Street 88, Sector G-6/3

Ataturk Avenue, Islamabad, Pakistan

Tel: +92 (51) 835 7072, Fax: +92 (51) 835 7071

Email: rsmith@aeai.net

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ACRONYMS

AEAI	Advanced Engineering Associates International
AJK	Azad Jammu and Kashmir
D/C	Double Circuit
E&C	Engineering and Construction
EPP	Energy Policy Program
GOP	Government of Pakistan
GS	Grid Station
HPP	Hydro Power Project
KPK	Khyber Pakhtunkhwa
kV	Kilo Volts
MW	Mega Watts
NEPRA	National Electric Power Regulatory Authority
NTDC	National Transmission and Despatch Company
O&M	Operation and Maintenance
PPA	Power Purchase Agreement
PSRP	Power Sector Reform Program
S/C	Single Circuit
SHPL	Star Hydro Power Limited
T/L	Transmission Line
USAID	United States Agency for International Development
USG	United States Government

I. Preface

USAID's Energy Policy Program (EPP) is a multiyear initiative that increases power generation, decreases losses, and increases cost recovery in Pakistan's power sector. The EPP works with selected energy infrastructure and the Government of Pakistan (GOP) to facilitate reform efforts with technical assistance and new technology. Activities undertaken by EPP are mostly demand driven with input from USAID and the GOP implementing partners. The "USG Energy Strategy for Pakistan" called for large, highly visible power generating projects and power plant rehabilitation programs that would make significant additions to power supply.

Advanced Engineering Associates Inc. (AEAI) is the implementing partner of EPP and is contracted under USAID contract AID-EPP-I-00-03-0004-00; Task Order No. AID-391-TO-12-0002. The three major components of EPP are:

- Monitoring and supporting Pakistani counterpart management in the implementation of approved and funded G2G projects.
- Supporting policy reform and providing advice/support to the Ministry of Water and Power (MWP), Ministry of Petroleum and Natural Resources (MPNR), Ministry of Finance (MOF), and Planning Commission (PC) in the implementation of the Power Sector Reform Program.
- Conducting due diligence for new projects being considered for USG support.

As part of EPP's efforts, this Stage I due diligence report is intended to assist USAID's decision to conduct further due diligence as a precursor for USG funding to support implementation of the Transmission Line project meant for dispersal of power from 147 MW Patrind Hydropower Plant.

2. Executive Summary

2.1 Background

This document acts as the first of a two-step evaluation process for the 147 MW Patrind Hydropower Plant. Step I reviews the existing documents for adequacy to apply selection criteria and make a recommendation to USG. The selection criteria are based on technical feasibility, cost and overall approach. USAID tasked AEAI to conduct the Step I due diligence and confirm the facts from NTDC, SHPL and PESCO, evaluate whether the project meets the USAID criteria described below, highlight any particular risk or concern that needs to be mitigated or addressed, and to make recommendations. EPP's findings related to the construction of 132 kV Transmission Line for power dispersal from the 147 MW Patrind Hydropower Project are summarized in the table below:

Technical Feasibility	
Will the proposed intervention actually contribute significantly to meeting Pakistan's energy and other vital development needs, while improving the country's energy security?	Yes, because: <ul style="list-style-type: none"> (i) The Project is a requirement to interconnect 147 MW Base Load Power Generation Capacity with the National Grid and help reduce load shedding in the country. (ii) The Project will transmit clean electricity, which is generated through efficient use of renewable indigenous water resources to the Grid. (iii) The project will stimulate the economy by purchasing local goods and services and creating jobs for qualified locals in the project area and in the country.
Does project use domestic or imported resources?	Domestic
Does the project result in energy diversification?	Yes. The project will promote energy security through diversification of the energy mix to renewable indigenous water resources and help reduce reliance on imported fuel.

Costs	
Is the cost reasonable?	EPP's conclusion is that the cost is very reasonable.
Can the project's full financing be arranged in a timely fashion?	With contribution from USAID through the EPP, this project can be financed quickly.
Overall Effect	
Is the project high visibility?	Yes. The Project will transmit 632 GWh average

	Generation annually to the National Grid.
Is it a high priority for Pakistan?	Yes, The project's contribution to dispersal of low cost energy to National Grid makes it a high priority project.
Will the power generated and other benefits be worth the time and money?	Yes.

2.2 Details

The Patrind Project is a 147 MW run-of-river hydroelectric power generation facility being constructed between the Kunhar and Jhelum Rivers costing USD 362 million, on a build-own-operate-transfer (BOOT) basis. Star Hydro Power Limited (SHPL) is a special purpose vehicle created to implement this project. SHPL was incorporated in Pakistan under the Companies Ordinance 1984 and is indirectly wholly owned by Korean Water Resources Corporation (K-Water), Daewoo Engineering and Construction Company (E&C) Ltd. and Sambu Construction Company Ltd. K-water is the main sponsor of this project (80% share) along with Daewoo E&C (20% share). The engineering, procurement and construction works (EPC) contractor for this project is Daewoo E&C. Operation and Maintenance (O&M) will be managed under O&M agreement with K-water. The SHPL have entered into a 30 year Power Purchase Agreement with the National Transmission and Despatch Company (NTDC), which has a role as Central Power Purchasing Agency. The physical layout of the project extends from the location of the weir near Patrind village on Kunhar River through a 2.2km headrace tunnel to the location of the powerhouse on Jhelum River in AJK. The powerhouse will accommodate three vertical Francis units, each of 50MW capacity. The construction works were initiated in 2012 and 27% work is completed to date. The annual energy generation of the power plant will be 632.6 Giga Watt hours and the electricity will be fed into the National Grid through 132kV Double Circuit Transmission Line to be constructed by NTDC.

NTDC has planned the interconnection scheme for dispersal of power from Patrind Hydropower Project in two phases. Phase I consists of a 132 kV Transmission line from Patrind to Mansehra Grid Station with in/out at Balakot GS to be commissioned by the year 2016. Phase II which is planned to be implemented in the year 2018, consists of an in/out from the 132 kV Patrind to Mansehra Transmission line at Muzzaffarabad GS, proposed for commissioning in 2018. The load flow studies have been performed and it shows that the proposed interconnection scheme will be suitable to evacuate the generated power from Patrind HPP in a reliable manner.

NTDC has requested USAID EPP to finance the Transmission line project to be implemented under Phase I.

The estimated cost for Phase I is US\$ 7.63 million and the estimates are very reasonable. The project is quite feasible and the average pay-back period is 7 years. The economic & financial rates of return are 13.66% and 15.93% respectively. The implementation time for Phase I is two years. The PC-I for the proposed interconnection scheme has been drafted and is in process of approval with the General Manager (Planning) NTDC. In the overall analysis, the improvement in ecological environments coupled with higher production is envisaged to bring out substantial economic gains for the people living in the project area.

This Transmission Line will interconnect 147 MW Base Load Power Generation Capacity with the National Grid bridging the demand supply gap and help in reducing the severe load shedding problem in Pakistan. This high visibility project needs to be funded on priority so that the Transmission project works is completed before the completion of the HPP.

3. Project Summary/Overview

Name of Project	Interconnection Scheme for Dispersal of Power from 147MW Patrind Hydropower Project HPP (Phase- I)
Locations	Azad Jammu and Kashmir (AJK) - Khyber Pakhtunkhwa (KPK), Pakistan
Sponsoring Agency	National Transmission and Dispatch Company (NTDC)
Description of the Project	Under Phase-I, in the year 2014-2016, a Double Circuit (D/C) 132 kV Transmission Line (T/L) will be constructed from Patrind Hydropower Project (HPP) to New Mansehra Grid Station (GS).
Scope of the Project	NTDC has requested USAID to support their scope in funding the construction of a 132 kV Double Circuit (D/C) Transmission Line using Rail conductor from Patrind HPP to New Mansehra substation. One circuit will be 45 kilometers long, direct from Patrind HPP to Mansehra GS. The other circuit will follow the same route with the exception that it will loop in and out of the Balakot 132 kV substation, adding an additional 10 kilometers to the circuit.
Commencement Date	March 2014
Completion Date	March 2016
Total Estimated Cost	US\$ 7.63 Million
Mode of Financing	Financing is being requested from USAID, Government of United States, under USAID Energy Policy Program for the Phase I Interconnection Scheme of Power Dispersal from Patrind HPP.

4. Project Description

The National Transmission & Despatch Company Ltd. (NTDC) is responsible for the planning, construction, operation and maintenance of Pakistan's National Electric Power Grid. Its vision is to efficiently provide and maintain a fault free High Voltage System that delivers energy with minimal electrical losses.

Keeping in view the fully loaded transmission grid at the moment and the increasing trend of power demand in near future, enhancement of the existing grid is required. Therefore, extension of the transmission network is constantly being carried out as determined by the NTDC Planning Department based on the planned addition of new generation.

Star Hydro Power Limited (SHPL), an Independent Power Producer (IPP), is responsible for implementing the 147 MW run-of-river Patrind Hydropower Project (HPP). Daewoo E&C is the EPC contractor for the project. This project shall generate on average 632.6 GWh of clean electricity annually at lower cost. The project will generate electricity by using indigenous water resources, and the tariff for electricity supplied will be lower than that for plants that use imported fuel. The project will also save greenhouse gas emissions of 280,000 tons of carbon dioxide per year. The Patrind project is being developed under the Government of Pakistan's Policy for Power Generation Projects and is the first Clean Development Mechanism (CDM) Pakistan registered project.

The powerhouse site is about 8.52 km upstream of the Kunhar – Jhelum confluence and the excavation work is under progress. A GIS switchyard will be constructed on the right bank of the Jhelum River. This generation facility is to be integrated with the National grid and is expected to start commercial operation by the start of year 2017. The nearest available 132 kV Transmission network are in Mansehra, Abbottabad and Muzaffarabad respectively, and are the best choices for interconnection with the northern area Transmission grid. The adequacy of these transmission lines to absorb and transmit this power is a part of this study.

Phase I (2014-2016)

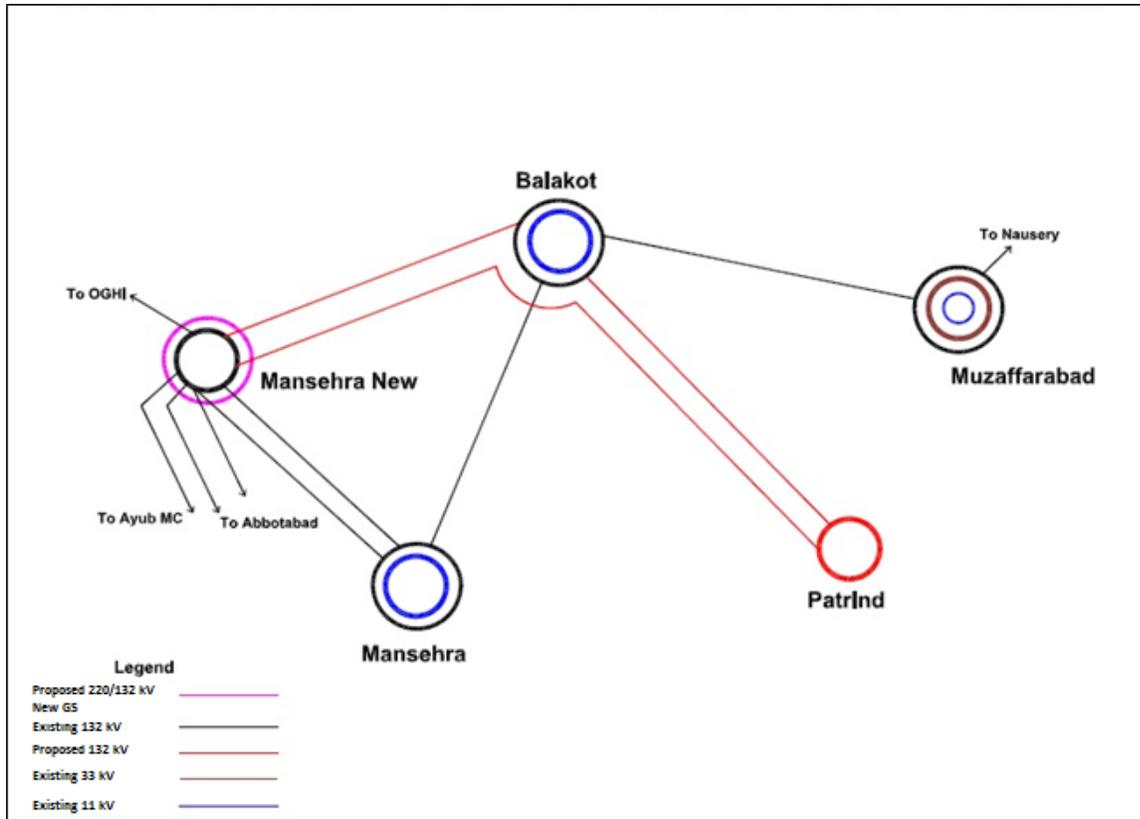
- A 132 kV Double Circuit (D/C) Transmission Line using Rail conductor from Patrind HPP to New Mansehra substation. One circuit will be 45 kilometers long, direct from Patrind HPP to Mansehra GS. The other circuit will follow the same route with the exception that it will loop in and out of the Balakot 132 kV substation, adding an additional 10 kilometers to the circuit.

S. No.	Description	Estimated Cost (Million PKR)
	Phase I	
1.	132 kV D/C T/L from Patrind HPP to 220/132 kV New Mansehra substation (45 km).	471.41
2.	132 kV D/C T/L for In/Out of Patrind HPP- Mansehra S/C at Balakot (10 km).	104.49
3.	Extension at 220/132 kV New Mansehra substation (132 kV portion).	18.91
4.	Extension at 132 kV Balakot substation.	18.91
5.	General Items, Miscellaneous items, Interest during construction	192.84
	Grand Total of Phase I in Million PKR	806.56
	Grand Total of Phase I in Million US\$¹	7.63

¹ The exchange rate used: 1 US\$ = PKR 105.65

5. Project Scope

A 132 kV Double Circuit (D/C) Transmission Line using Rail conductor from Patrind HPP to New Mansehra substation. One circuit will be 45 kilometers long, direct from Patrind HPP to New Mansehra GS. The other circuit will follow the same route with the exception that it will loop in and out of the 132kV Balakot substation, adding an additional 10 kilometers to the circuit. The schematic diagram of the interconnection scheme of 132 kV D/C T/L from Patrind HPP to 220/132 kV New Mansehra GS (Phase I) is given below:



5.1 Load Flow Studies

Load Flow studies have been conducted by the NTDC Planning Department to ascertain the impact of the project on NTDC system.

5.1.1 Base Case Load Flow without Patrind HPP – Year 2016

A base case has been developed for the September 2016 peak load using the network data supplied and authorized by PEPCO.

The load flow study for the base case is available at the NTDC Planning Department. The base case load flow results show that, under normal conditions, power flows on all circuits are within their normal rating and there are no capacity constraints or voltage problems on the 132 kV network in the vicinity of Patrind HPP.

The results of the N-1 contingency test, however, identify some capacity constraints in 132 kV network surrounding Patrind HPP and the voltage rating of the bus bars do not remain within their limits during an outage of the Mansehra New to Mansehra 132 kV single circuit transmission line. This also causes the voltage of Muzaffarabad 132 kV and 11 kV bus bars to fall below acceptable limits.

5.1.2 Load Flow with Patrind HPP – Year 2016

In this load flow model, the Patrind HPP project is connected to New Mansehra Grid Station through a 45 km, Double Circuit 132 kV Transmission Line on Rail conductor. One circuit is a direct circuit between Patrind HPP and New Mansehra Grid Station whereas the other circuit is looped in/out at Balakot 132 kV substation.

The load flow results with Patrind HPP interconnected show that the power flows on the circuits are well within the rated line capacities and the voltages on the bus bars are also within the permissible operating range of $\pm 5\%$. Compared to the base study, the addition of Patrind HPP is helpful in boosting transmission voltages.

No capacity constraints on the 132 kV circuits were found when all circuits are in service. In these conditions, about 81.6 MW flows from Patrind HPP to Balakot of which 11.7 MW flows towards New Mansehra and the rest is used to feed the loads at Balakot and Muzaffarabad substations. About 64.4 MW flows on the direct circuit from Patrind HPP to Mansehra New substation.

N-1 contingency analysis has been carried out and is available at the NTDC Planning Department. For all 132 kV transmission line outages, the power flows on all circuits and the bus bar voltages are well within their rated limits. Hence there are no constraints in this scheme.

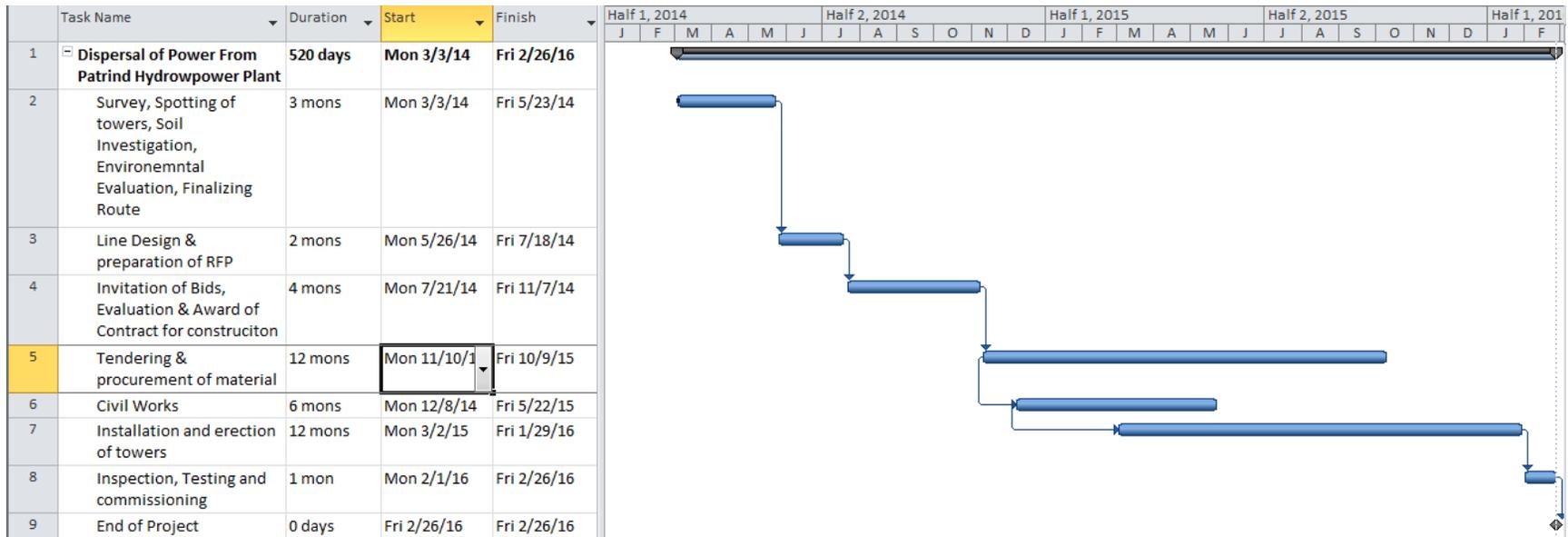
It is important to note that the New Mansehra to Mansehra 132 kV Single Circuit is overloaded without Patrind HPP. This is resolved with the addition of Patrind HPP as the load at Muzaffarabad and Balakot is then fed from Patrind HPP, reducing the stress on the New Mansehra to Mansehra 132 kV circuit.

6. Implementation

Estimated period for implementation is 24 months. Year-wise estimation of physical activities is as follows:

Year	Physical Activities
1st Year	<ul style="list-style-type: none">• Design, drawings and preparation of bidding documents.• Procurement of Materials• Preliminary works and Civil Works initiated
2nd Year	<ul style="list-style-type: none">• Civil works• Manufacturing & shipment of equipment• Installation & Erection• Testing and Commissioning

Month-wise Estimated Time Schedule of the Project



7. Cost and Benefits

The project will cost about US\$ 7.63 million, as detailed below:

S. No.	Description	Total Cost in Million PKR			
		Local	FEC	Duty	Total
1.	132 KV D/C T/L from Patrind HPP to Mansehra G/S (45 km)				
	Right of way procurement and clearing	2.25	0.00	0.00	2.25
	Steel Towers	95.96	0.00	0.00	95.96
	Conductor	0.00	142.90	10.72	153.62
	Overhead Ground Wire (OPGW)	0.00	17.59	1.32	18.91
	Insulator strings	12.45	0.00	0.00	12.45
	Insulator Hardware, grounding material, stringing & construction equipment and accessories	0.00	19.95	1.50	21.45
	Civil works @ 25%	76.05	0.00	0.00	76.05
	Erection @ 30%	90.72	0.00	0.00	90.72
2.	132 KV D/C T/L for I/O of 132 kV D/C Patrind HPP to Mansehra G/S at Balakot (10 km)				
	Right of way procurement and clearing	0.50	0.00	0.00	0.50
	Steel Towers	21.16	0.00	0.00	21.16
	Conductor	0.00	31.76	2.38	34.14
	Overhead Ground Wire (OPGW)	0.00	3.91	0.29	4.20
	Insulator strings	2.73	0.00	0.00	2.73
	Insulator Hardware, grounding material, stringing & construction equipment and accessories	0.00	4.46	0.33	4.79
	Civil works @ 25%	16.86	0.00	0.00	16.86
	Erection @ 30%	20.11	0.00	0.00	20.11
3.	Extension at New Mansehra Substation (132 kV Portion)				
	Two 132 kV line bays consisting of circuit breakers, isolators, C.Ts, P.Ts, L.As, control & protection equipment and other allied equipment.	0.00	15.99	1.20	17.19
	Civil Works and erection @ 10%	1.72	0.00	0.00	1.72

S. No.	Description	Total Cost in Million PKR			
		Local	FEC	Duty	Total
4.	Extension at Balakot Substation				
	Two 132 kV line bays consisting of circuit breakers, isolators, C.Ts, P.Ts, L.As, control & protection equipment and other allied equipment.	0.00	15.99	1.20	17.19
	Civil Works and erection @ 10%	1.72	0.00	0.00	1.72
5.	Extension at New Mansehra Substation (132 kV Portion)				
	General Items				
	Transportation and Vehicles	7.45	0.00	0.00	7.45
	Miscellaneous Items				
	Engineering and Consultancy @ 2%	7.37	5.05	0.00	12.42
	Administration and Supervision @ 2%	12.42	0.00	0.00	12.42
	Contingencies @ 2.5 %	9.22	6.31	0.00	15.53
	Security arrangements @ 1%	6.21	0.00	0.00	6.21
	Inland Transportation and handling charges etc. @ 1% of Equipment cost	6.14	0.00	0.00	6.14
	Insurance @ 0.5% of Equipment cost	3.07	0.00	0.00	3.07
	L/C Opening Charges @ 0.25 % of Equipment cost	1.53	0.00	0.00	1.53
	Interest during construction	128.07	0.00	0.00	128.07
	Sub-total in Million PKR				806.56
	Sub-total in Million US\$²				7.63

The source of the quoted cost estimates for equipment has been prepared on the basis of recent contracts awarded by NTDC for similar equipment.

7.1 Payback:

The following assumptions have been made:

1. NTDC Use of System Charges (UoSC) to the tune of Rs. 102.45 per kW per month as determined by NEPRA have been used for NTDC revenue/benefit purposes.
2. Total transmission losses have been assumed to be 20%
3. The industrial load is taken to be 20% of total load
4. The economic benefit due to industrial users are taken to be 200 Rs./kWh

² The exchange rate used: 1 US\$ = PKR 105.65

5. Cost of project 7.63 million USD
6. Cost for installing solar power plant = US\$ 362 million
7. Annual Energy Produced = 632.6 GWh

NTDC payback per annum = 88.78 million PKR/annum

No. of households benefitting from 147 MW = 245,000

Benefit to economy = 20,243 million PKR per annum

7.1.1 Economic Benefits Associated With Transmission

Economic Benefits associated with Transmission = 404.86 million PKR/annum

7.2 Financial and Economic Analysis

The following assumptions have been made in determining the rate of return for the project:

- The analysis is based on constant values, i.e. UoS as well as O&M cost during the project's useful economic life. Variation in power/energy cost, taxes and duties etc. imposed by the Government will be treated as pass through items.
- NTDC Use of System Charge of Rs 102.45 per kW per month as determined by NEPRA has been used for NTDC revenue/benefit purposes.
- The project's useful economic life has been assumed as 40 years.
- The interest rate of 14% for local cost and 17% for foreign exchange components have been used for IDC/Amortization purposes.
- Nominal Discount rates of 10% & 12% have been used for Net Present Value calculations.
- Net load of 146 MW as per load flow study has been used for benefits calculations.
- The project shall result in fuel cost savings and foreign exchange against an equivalent Coal power plant considering coal price USD 100/ton and a calorific value of 2500 Btu/kg. However these savings have not been reflected in Economic analysis to avoid extra ordinary high IRR.
- Delaying the project will escalate costs by 6.5% each year.

	Results of		
	Financial (IFRR)	Economic (IERR)	Sensitivity Analysis
Internal Rate of Return	13.66%	15.93%	12.74%
Payback Period (years)	7.51	6.37	6.05

7.3 Social Benefits

The power demand in the country as a whole is continuously increasing due to momentum of economic activities in the agricultural sector and manufacturing.

- Fast urbanization has increased the household demand for electricity where a greater number of electrical gadgets and appliances are being used.
- An increase in the production of electricity is much needed for Tube well electrification which provides additional water for irrigation and thereby increases crop production.
- The availability of more electricity also provides incentive for the establishment of new industries based on local raw materials, creating gainful employment opportunities throughout Pakistan.
- Providing a basic electricity infrastructure in rural areas will go a long way to check large scale migration of rural labor force to urban centers.

In the overall analysis, the improvement in available electricity will bring about substantial economic gains for the people in the project area.

7.4 Environment and Resettlement

Detailed Environment Impact Assessment studies will need to be carried out before the implementation of the project. However during construction of 132 kV Double Circuit Transmission line, maximum efforts will be made to mitigate the possible environmental hazards.

- The work on the project will be carried out in a manner so that the impact is minimal on natural landscape, forests, crops, wild life, livestock, both private and public buildings, archaeological centers and buildings of historical significance.
- Effective coordination will be maintained with the concerned local authorities to ensure that the route of new transmission line will be selected to have minimum environmental impact on urban and rural areas.
- The construction equipment used on this project will have acceptable noise limits.
- Adequate safety standards will be followed to minimize hazards to human life and property.
- NTDC's design and protective specifications provide reliable safety by specifying suitable clearances for transmission lines.
- Proper occupational health safety practices will be adopted in the installation and maintenance of the project facilities.

8. Status, Recommendations and Risks

8.1 Status

The time schedule and technical studies for the associated generating plant and transmission expansions have been determined. The construction of Patrind HPP started in December 2012 and is expected to be commissioned for commercial use in early 2017. The draft PCI for associated interconnection scheme has been compiled and will be submitted for approval by NTDC. The financing for the construction of 220kV New Mansehra Grid Station is arranged through Asian Development Bank (ADB) and grid is expected to be commissioned in June 2016.

The PC-I for this project includes the Phase II but it is dependent on the commissioning of 132 kV Muzzaffarabad II Grid Station, which is planned to be commissioned by 2018.

8.2 Recommendations

Analyzing the results of load flow studies and schedules of all associated projects, the implementation of power dispersal scheme from this net additional installed capacity of 147 MW (equivalent to 3.5% of the current energy shortfall in the country) to the National Grid is highly recommended. Through this interconnection scheme, an average of 632.6 Giga Watt hours will be transmitted annually to the consumers at a lower cost. This project solves the identified grid power flow and voltage issues in the area, is cost effective, and will be completed on a schedule that helps reduce Pakistan's energy crisis. Patrind HPP is a highly visible priority project for the Government of Pakistan and the National Transmission and Despatch Company and meets all relevant USAID criteria and is recommended to be funded.

8.3 Risks and Issues

No major risks and issues are expected to evolve in the execution of the project except for the law and order situation in the country.

The success of this project is closely linked with timely realization of the implementation schedule of the associated Generation Plant by IPP and all other necessary Transmission expansions to be done by NTDC. The construction of the 132 kV Transmission Lines will have to be scheduled closely with execution program of the generating source in order to harness full benefits of the project in timely manner. There will be a need of close coordination throughout the project execution.

Energy Policy Program

House 4, Street 88, G-6/3, Islamabad, Pakistan

Tel: +92 51 835 7072, Fax: +92 51 835 7071

www.ep-ep.com.pk