# USAID ENERGY POLICY PROGRAM

# DUE DILIGENCE REPORT

## TARBELA HYDROELECTRIC STATION REHABILITATION

**MARCH 2010**

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## TARBELA HYDROELECTRIC STATION REHABILITATION

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# PAKISTAN ENERGY IMMEDIATE MEASURES:
## *Tarbela Hydroelectric Station Rehabilitation*

**Summary**
In partnership with the Government of Pakistan (GOP), the United States Government (USG) is seeking to identify immediate measures that will increase power supplies or reduce electricity demand within the next 18 months. One of the proposed immediate measures to increase power supplies is to fund a partial rehabilitation of the Tarbela Hydroelectric Power Station (HPS) in order to restore some of the power capacity lost due to long-deferred maintenance of the station.

| | |
|---|---|
| Description: | The Tarbela Dam is an existing 3,478 MW hydroelectric facility that has been de-rated due to lack of maintenance. The project would involve a targeted rehabilitation to restore some of the power station's lost capacity to service. |
| Benefits: | Add additional power supply of 80 MW to the power station, which could supply an additional 192 GWh/yr of energy to the national grid. |
| Estimated Cost: | $16.5 million |
| Estimated Schedule: | 18 to 24 months |
| Implementation Mechanism: | A grant to the Water & Power Development Authority (WAPDA) , which owns and operates the Tarbela Dam, or bring on board the US Army Corps of Engineers to carry out the rehabilitation |
| Risk Factors: | Maintenance schedule will need coordinating with plant management |
| | Power will be seasonal, reducing impact of power improvements |
| | Sustainment: Will the added energy provided be paid for, creating the necessary resources to operate and maintain the facility over time? |

**Background**
The Tarbela Dam is a large dam on the Indus River in Pakistan (see Figure 1). It is located in Haripur district within the Hazara Division of the North-West Frontier Province (NWFP) about 120 km (by road) northwest of Islamabad (see Figure 2), at a height of 485 ft (148 m) above the river bed. The reservoir size of some 95 sq mi (250 $km^2$) makes it the largest earth-filled dam in the world. The dam was completed in 1974 and was designed to store water from the Indus River for irrigation and flood control, and for the generation of hydro-electric power.

The Tarbela Hydropower Station (HPS) has a nominal capacity of 3,478 MW, and is operated by the Water & Power Development Authority (WAPDA) of Pakistan. It has 14 generating units installed on three power/irrigation tunnels. The fourth tunnel has yet to be converted to a power tunnel to generate 2 x 480 = 960 MW of electrical power. On tunnels one and two, ten units of 175MW each are installed, whereas on tunnel three, four units of 460 MW each are installed.

The power plant has been operating up to 3,700 MW in high head during the high flow months of summer. However, the plant sometimes fails to operate at its maximum capacity due to following factors:

a. Lower insulation class (Class B) windings of units 1, 3, and 4
b. Unavailability of essential spare parts to carryout preventive maintenance
c. Lack of training of O&M staff to establish operations and maintenance as per prudent utility practices.

**Description of the Proposed Project**

The existing unit # 4 has a total capacity of 175 MW and can be operated at 195MW under overload conditions. However, due to damage to the generator windings, the unit is currently operated at 135 MW. With replacement of class B windings by class F windings, the unit can be operated at 195 MW; hence recovering not only the lost capacity of 40 MW but also another additional 20MW.

The existing units 1 and 3 have a total capacity of 175 MW each though both can be overloaded up to 195 MW. If the class B stator winding is replaced with class F, this would provide an additional capacity of 20 MW each. The availability of essential spare parts for preventative maintenance will improve the reliability and availability of this power plant to a substantial degree. It would also improve the plant factor, particularly due to higher utilization in the high water months, and will ultimately lead towards increased energy output from the Tarbela power plant.

The training of O&M staff should benefit improved operations which, in turn, will result in higher generation availability of Tarbela units and higher production ultimately. WAPDA O&M staff should be trained to establish O&M at the Tarbela units in accordance with prudent utility practices.

The expected increase in capacity and energy output, by implementing a short-term repair and maintenance program as recommended above, is shown in the table below:

| Condition | Generation Capacity at Present | MW Added | GWh Added |
|---|---|---|---|
| Units 1 & 3 | 175 MW | 20 MW | 48 GWh |
| Unit 4 | 135 MW | 60 MW | 144 GWh |
| Total Gain | - | **80 MW** | **192** GWh |

The following table summarizes the proposed rehabilitation works and the associated cost s. Note that the equipment costs in this case are based on supplier bids received by the plant management in response to a competitive tender.

**Essential Works and spares required for immediate rehabilitation**

| Sr. No. | Unit No. | Details of Works/spares | Original manufacturer | Estimated Cost US $ mln |
|---|---|---|---|---|
| 1 | 4 | Replacement of damaged generator stator windings with class F windings | Hitachi, Japan | 4 |

| | | | | |
|---|---|---|---|---|
| 2 | 1&3 | Replacement of damaged generator stator windings with class F windings | Hitachi, Japan | 8 |
| 3 | 11-14 | Up-gradation of SCADA system | ABB, Sweden | 0.5 |
| 4 | 1-10 | Spare Seats and guides for Relief and Bypass valves on turbine side | Hitachi for 4 units.<br>DBS/Antritz Hydro-Switzerland | 0.5 |
| 5 | 1-10 | Replacement of Electromechanical Governors by Digital ones | Woodward | 3 |
| | **Total** | | | **16** |

**The proposed program will produce additional energy of 192 GWh per annum and an additional peaking capacity of 80 MW in summer months when there is an acute shortage of power.** The supply of essential spare parts, replacement of class B Windings and training of O&M staff will enhance the reliability of the overall power plant. This will ensure production at all times during the high head period in summer, in addition to the increased energy generation and peaking capacity.

**Summary of costs and Schedule**

**Summary of costs**

| Description | Total Estimated Cost |
|---|---|
| Units 1&3 | $ 8 Million |
| Unit 4 | $ 4 million |
| Essential Spares | $4million |
| Training | $ 0.5 million |
| **Total =** | **$ 16.5 million** |

According to WAPDA, the suppliers of new class F windings have asked for 12-13 months for manufacturing and delivery, and an additional 6-7 months for the installation of new windings while old windings are dismantled by WAPDA. If WAPDA places an order now, the earliest shutdown on units would be in October 2010 with a six months completion schedule. Therefore, the emergency repair and maintenance work along with replacement of windings will take ~18-24 months.

**Implementation Arrangements**

To carry out this work, two possible arrangements exist.

One arrangement is for the USG to make a grant to the Water & Power Development Authority (WAPDA), and let this company purchase the equipment and work with the personnel of the Tarbela HPS to carry out the necessary rehabilitation.

Another approach is to bring on board the US Army Corps of Engineers (USACE) to purchase the equipment and perform the rehabilitation in concert with the staff of the Tarbela HPS. The USACE has extensive project management experience, as well as hydro experience in the Pacific Northwest of the US. However, the people of Pakistan may see use of USACE as a takeover of a national asset by the US military.

**Risk Factors**

While the Tarbela Dam rehabilitation provides an attractive opportunity, it is not without several risks that need to be managed.

Maintenance Schedule Issue

Installation of the USG-funded equipment and carrying out the rehabilitation will need to be coordinated with the outage schedule of the plant. No other risks are foreseen in the proposed capacity enhancement program of generators except for any manufacturer or supplier delays in supply or installation of windings within the given time schedule - suitable and effective contractual safeguards will have to be built into the supply contracts to address these concerns.

Seasonal Power Issue

Like all hydroelectric facilities, the power output from the Tarbela Dam is dependent on water flows that change with the seasons (see table below). Thus, the power output is not uniform throughout the year, thus reducing some of the potential benefits of this upgrade project.

**Monthly Variation in Maximum Hydel Generating Capacity**

| Sr. No. | Month | Tarbela | Mangla | Ghazi Broth | Warsak | Chashma | Small Hydels | Total (MW) |
|---|---|---|---|---|---|---|---|---|
| 1 | July, 06 | 3567 | 930 | 1250 | 200 | 176 | 57 | 6180 |
| 2 | August | 3692 | 1150 | 1425 | 195 | 184 | 62 | 6708 |
| 3 | September | 3692 | 1150 | 1450 | 200 | 184 | 66 | 6742 |
| 4 | October | 3497 | 1150 | 1450 | 200 | 178 | 71 | 6546 |
| 5 | November | 3120 | 1150 | 1160 | 170 | 72 | 69 | 5741 |
| 6 | December | 2482 | 997 | 1450 | 133 | 184 | 45 | 5291 |
| 7 | January,07 | 1434 | 840 | 1160 | 136 | 48 | 28 | 3646 |
| 8 | February | 2186 | 440 | 1160 | 171 | 87 | 19 | 4063 |
| 9 | March | 2263 | 640 | 1160 | 171 | 161 | 39 | 4434 |
| 10 | April | 2493 | 1146 | 1450 | 210 | 184 | 52 | 5535 |
| 11 | May | 2925 | 1150 | 1450 | 210 | 184 | 53 | 5972 |
| 12 | June | 2652 | 1150 | 1450 | 210 | 149 | 55 | 5666 |

Source: National Power Control Centre (NPCC)

Sustainment Issue

Given the financial frailty of the Pakistan energy sector and the heavy demands on the GOP budget, the sustainability of any investment in the sector must be seen as a risk

factor. Improving the flow of resources throughout the sector to both sustain current operations and support public and private investment in badly needed expansion will require strategic physical investments, commercial enhancement of operations, and GOP political will to introduce the needed economic reforms. Three examples can serve to illustrate the needed changes.

First, while the World Bank and the Asian Development Bank are making investments to reduce technical losses and improve the efficiency of both the distribution and transmission networks, they must also make sure that sufficient metering is put in pace to monitor the energy balances within the system as power is transferred between and within the power sector enterprises (e.g., a genco selling power to a disco). Such metering is critical to supporting commercial transactions between the enterprises, as well as narrowing the space for non-technical losses (e.g., theft).

Second, the distribution companies must concentrate on improving customer metering, billing, and collections in order to prevent theft from existing customers, improve revenues, and identify major non-payers, such as government enterprises. Increasing tariffs as per the World Bank/IMF agreement will not improve the commercial performance of the sector nor encourage customers to rationalize their energy consumption as effectively as possible unless collections bring the price increases home to consumers.

Third, the GOP needs to support the distribution companies in their efforts to increase funds flowing to the sector by: 1) allowing non-paying and thieving customers to be cut off; 2) budgeting for and requiring government entities to pay their electric bills in cash; and 3) rationalizing tariff and subsidy schemes to cover the costs of service provision and attract investment while protecting the socially needy.

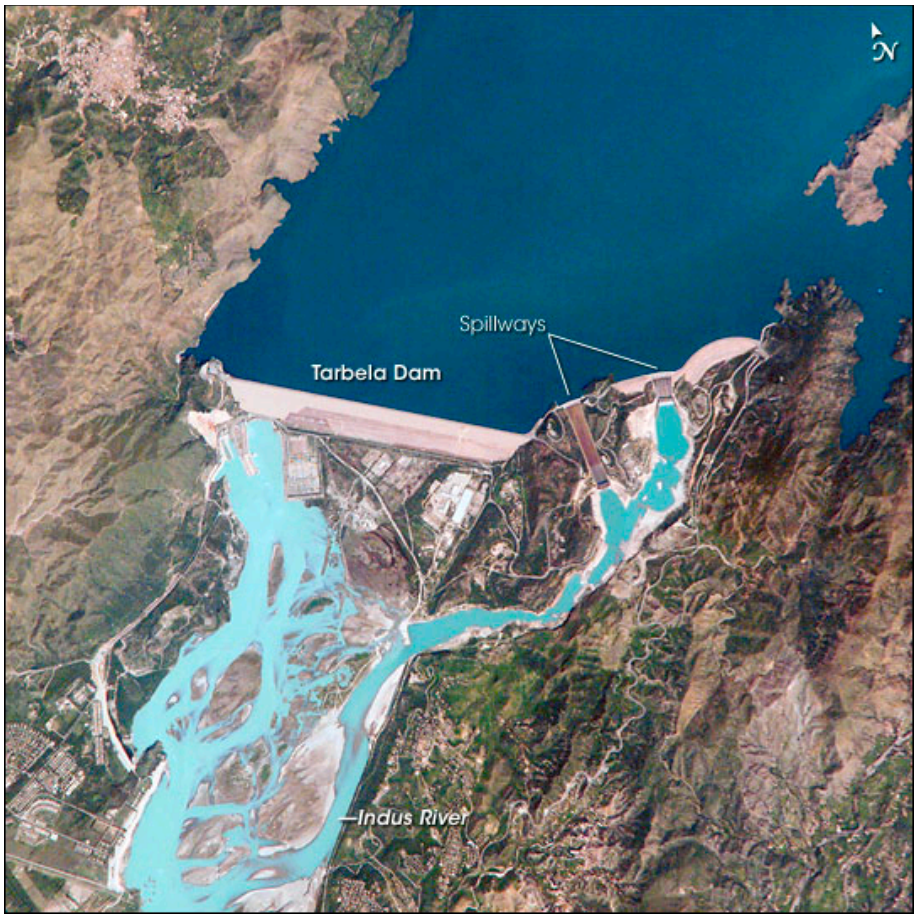


*Figure 1 – Picture of Tarbela Dam*

*Figure 2 – Location of Tarbela Dam within Pakistan*