SOUTH ASIA REGIONAL INITIATIVE FOR ENERGY COOPERATION AND DEVELOPMENT

ASSESSMENT OF SMALL AND MINI HYDROPOWER STATIONS – AFGHANISTAN

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Executive Summary

The water-sector development is one of the highest priorities of the Government of Afghanistan; two decades of war have deprived the country from attaining this objective. Power shortages have also prompted a return to traditional biomass and imported hydro carbon fuels for cooking, lighting, and heating.

In addressing the serious power supply shortages of Afghanistan, restoration and upgrading of a number of existing mini and small hydropower plants appears to be a promising idea. This endeavor also encourages Afghans to participate in the rural development process by promoting indigenous knowledge, using local resources, employing local labor, and possibly increasing incomes thorough productive uses of electricity.

USAID/Afghanistan and USAID/SARI/E are collaborating to assess this opportunity for rehabilitating and upgrading existing small and mini hydropower plants. The results of the study will enable decisions for further development - a feasibility study followed by detailed design and cost estimate.

The objectives of this study are:

- To assess the condition of selected existing mini and small hydro plants.
- To determine the costs required for rehabilitation.
- To provide preliminary information as a basis for more detailed comprehensive feasibility studies and detailed designs.
- To rank the projects for investment.

The ranking of sites is carried out based on a set of criteria described in (**Section-4 Site ranking criterion and Section 7- Ranking of sites based on findings**) and from the survey findings. The ranking result of sites is:

1. Charkh-Logar Power Pant- 500 kW
2. Jabal-e-Saraj Power Plant- 2.54 MW
3. Bamyan Power Plant- 300 kW
4. Khanabad (Old) Power Plant- 1.3 MW
5. Juzon Power Plant- 255 kW
6. Baharak/Badakhshan Power Plant- 200 kW

The Jabal –e –Saraj power plant also has a possibility to increase the capacity to 5 MW.

The Juzon power plant capacity is insufficient to meet the demand of one million population of Faizabad. To serve entire population at least 15-20 MW are needed. The area, however, is bountifully endowed with water resources and Kokcha River is an alternative solution establishing a higher capacity power plant to address the current demand. Hence the option shall be investigated during feasibility and detailed design of Juzon power plant.

The possibility of establishing 3 MW power plant, 200 m down stream from Baharak/Badakhshan power plant should be assessed during feasibility and detailed design.

In the vicinity of the proposed Charkh- Logar power plant another micro hydro project is operating and possibility of interconnection should be looked into.

General suggestions include:

- Research and development needs to be carried out to determine the potential benefits of introducing a range of high efficiency turbines such as Francis, Pelton, and/or more efficient cross-flow units suitable for the Afghan environment.

- Future developments, to minimize the maintenance and social issues, should consider installing low head, high flow hydropower plants in stream. If possible this approach eliminates the need for power canals and avoids right of way issues and resettlement.

- Tariff should also be established to cover administrative/management and O&M costs of the power plant.

Detailed information is presented in **Table- A.** This table summarizes the information for each site.

The approach to site rehabilitation is recommended to be model demonstration projects. Afghan engineers, supervisors and technicians will be trained and given hands on experience in the planning, design, construction supervision and management and O/M aspects of mini hydro power plants. A suggested implementation plan is:

- Training of personnel to be involved in project
- Detailed survey and investigation
- Preparation of feasibility report
- Preparation of detailed project report based of feasibility report.
- Preparation of detailed designs and technology selection
- Preparation of contract document and tender drawings
- Award contracts for Civil, E&M and T&D works
- Construction Supervision and Management.
- Training for O/M of the power plant
- Commissioning and acceptance tests

In parallel a community development action plan would be established that aims to:

- Build trust, organize, and reach consensus
- Identify productive uses and set up implementation plan (organization, permits, material/equipment lists, and funding)

- Determine staffing needs for O&M and costs, including replacements and contingencies
- Train staff
- Determine equitable tariff (cost recovery basis)

Table-A Restoration Potential for Selected Mini and Small Hydropower Plants in Afghanistan

Power Plant	Province	Ownership of Plant	Year of Construction	Original Capacity (kW)	Current Capacity (kW)	Total Cost for Restoration (US$)	Cost/kW (US$)	Households Served	Ranking
Charkh-Logar	Logar	MEW	2003	500	Not in operation	$505,648	$1,015	2,500	1
Jabal-e- Saraj	Parwan	MEW	1913	2540	1500	$2,868,265	$1,130	3,600	2
Khanabad (Old)	Kunduz	Ministry of Mines and Industries	1971	1300	Not in operation	$1,706,562	$1,320	8,000	3
Bamyan	Bamyan	MEW	1971	300	Not in operation	$865,939	$2,890	1,000	4
Juzon	Faizabad	MEW	1983	255	Not in operation	$487,870	$1920	300	5
Baharak/Badakhshan	Badakhshan	MEW	1986	200	60	$511,225	$2,560	300	6

Section 1 Background

The water-sector development is one of the highest priorities of the Government of Afghanistan; two decades of war have deprived the country from attaining this objective. Power shortages have also prompted a return to traditional biomass and imported hydro carbon fuels for cooking lighting and heating. Electricity is only being supplied to **4%** of urban households a few hours per day with rural areas significantly un-served. Of about 450 MW installed generating capacity only 270 MW is available and most of the units require overhaul and replacement[1]. Many plants in the range of 100 kW to 1000kW are in need of restoration and possibly expansion. To assess the existing situation for rehabilitation and for up gradation, United States Agency for International Development (USAID) has assigned Nexant Inc. to carryout the pre-feasibility survey of these mini-hydropower sites. This study further enables to make decision on to further investment for the comprehensive feasibility study followed by detailed design and cost estimate for rehabilitating the mini hydro project.

[1] A world of science-Vol-1 No 4- July/September 2003

Section 2 Objectives

The objectives of the study are:

- To assess the existing condition of selected mini and small hydro plants
- To determine the cost figures required for rehabilitation
- To provide and information and basis for comprehensive feasibility study and detailed design
- To prioritize the projects for investment

Section 3 Survey Methodology

3.1 Basis for Site Selection

In October 2005, USAID provided Nexant Inc. a list on mini hydro power projects, reports from World Bank and anecdotal information. Based on this information six projects that lie with in the range[2] of mini and small hydropower were selected for this effort. The selection was also discussed Government of Afghanistan (GoA) stakeholders, Ministry of Energy and Water (MEW) and *Da Afghanistan Breshna Moasessa* (DABM).
The sites selected are:

1. Jabal-e- Saraj- 2.54 MW, Parwan Province
2. Khanabad (old)- 1.3 MW, Kunduz Province
3. Faizabad – 255 kW Badakhshan Province
4. Baharak/Badakhshan -200 kW Badakhshan Province
5. Charkh-Logar-500 kW, Logar Province
6. Bamyan Kalu Sathberg- 300 kW village, Bamyan Province

3.2 Source of Information and Approach

The detailed questionnaire (**Appendix- A**) was developed to collect information on the power plants. Two engineers from DABM were trained and were oriented in field to collect information. The questionnaire has categories included: Civil works; Penstocks and Electro Mechanical works and Transmission Distribution and Appliances. Based on that information preliminary costs were calculated also included on the form was information on whether the project needs rehabilitation or up-grading.

Besides information from the questionnaire, the survey team collected and verified the information such as:

- Site observations
- Discussion with engineers who are actively associated with the project
- Discussion with GoA stakeholders - MEW and DABM
- Discussion with village elders who are familiar with the project development

[2] There is no specific definition and range of hydropower plant, however, the range normally accepted in South Asian region is as follows: Pico < 1kW; Micro hydro- up to 100 kW; Mini hydro 101 kW- 1000 kW and Small hydro 1 MW to 15 MW.

Section 4 Sites Ranking Criterion

The sites are ranked to assist in identifying projects that merit further attention. The following parameters and weight are contained in Table 1. The higher the value is, the higher the ranking. The parameters and assigned weights are further multiplied by site specific importance factors. These are: high- 1.5; medium- 1; and, low- 0.5.

Table 4.1 Ranking Criterion and Weight

Parameters	Weight
People enthusiasm/participation	5
Proximity of site and accessibility	5
Behavioral Impact	6
Availability of local construction materials	7
Industrial/Commercial activities	8
Security	9
Cost per kW for project development	10

The parameters selected for ranking the projects are considered to be key elements for evaluation for each site within the context of Afghanistan. Behavioral impact, for example, provides a measurement criterion to gage the importance to the community of having electricity and the implications of having electricity. Given the years of unrest, occupation, and drought the people need to see tangible benefits from the current administration and the donor community. A brief explanation of each parameter follows:

- **Security**. Protection of human life is essential; the site should be safe
- **People enthusiasm and participation**. Village eagerness can be readily translated into a general willingness to contribute to a tariff structure to ensure sustainability and overall security of the project and its people
- **Proximity of site**. Nearer resources are to the site, the easier it will be to effectively allocate the resources, reducing time and costs. Given the terrain, road conditions, and availability of appropriate vehicles for transportation, this parameter can significantly affect a project's schedule and cost.
- **Cost per kW**. To optimize the resources and to compare impacts of other projects in the region, cost per kW installed can be used
- **Availability of local construction materials**. It is always convenient and the construction costs are substantially less if local construction materials are available in the vicinity of the project
- **Behavioral Impact**. Having electricity can validate expectations (tangible benefits) resulting in a more positive view towards the current administration and the

international support. This also allows the villagers to have a connection beyond their local community.

- **Industrial/Commercial activities**. As the backbone of economic development, these activities will gradually come up once the power project ensures reliable power supply. It shall also contribute to the sustainability of the project there by generating revenue during periods of low demand for lighting. Existing facilities as well as future are considered.

Section 5 Cost breakdown for various activities

In order to restore to the original capacity, the cost break down for components are shown in table for each site. The cost estimates include catalog and vendor pricing, judgment, and field conditions observed during the assessment survey.

6.1 Jabal-e-Saraj Power Plant

6.1.1 Introduction

The plant is located in the town of Jabal-e-Saraj in Parwan Province. MEW owns the hydro facility. The Global Positioning System (GPS) coordinates for the projects are: Longitude 69^o 14' 59'' and Latitude 35^o 08' 40''. The elevation of the project is 1,555 m above mean sea level.

The project was built in 1913 on the Salang River. The installed capacity was 2.54 MW and serves approximately 3,600 households. The project is about 94 years old and thus has historic value.

6.1.2 Observations

- **General**
  The intake is situated at the left bank of Salang River and the intake was re-habilitated in 2004 with the financial assistance from USAID. The project output is 1.5 MW out of the original 2.54 MW capacity. During off peak hours, the plant is supplying one MW to a cement factory which is located in the vicinity. The river is not equipped with any type of water gauging instruments for taking monthly readings of river discharge. Water of the Salang River as well as a portion of water from the forebay is used for irrigation. Currently, 3600 house holds[3] are using electricity from this power plant. Construction materials are available in the vicinity of power plant.

- **Civil Structures**
  The total length of the power canal from intake up to forebay is 1600 m. The canal is leaking throughout and de-silting basin and forebay is filled with silt and debris and are non functional. The trash rack and gates for regulating water flow are also in disrepair. The power house building is ruined completely. The head of the project is 27 m with a discharge of 8 m^3/sec[4].

- **Penstocks**
  The total length of Penstock is 54 m and diameter is 1.2 m. The sidewalls of the penstocks are eroded due to high slit content in river water and some portions are unable to withstand pressure.

- **Electromechanical works**
  There are four turbines. Three turbines each have 700 kW capacity and one has 500 kW capacity. These were installed ninety four years ago and have not been overhauled. One turbine is completely damaged. There is water leakage from the

[3] Figure provided by plant in charge.
[4] The data are provided by power plant engineer.

valves and main body of the other two turbines. The generators are operating but need to be replaced. The electricity produced by these generators at 60 hertz frequency and later it is transformed into 50 hertz frequency[5].

- **T & D of electricity and appliances**
  The equipments and appliances inside and outside power house were installed ninety years ago and are in poor condition. The transformers are inefficient. The wiring is poor and there are no safety mechanism installed such as auto switch off, alarming system, current leakage detector and safety signs, etc. The condition of the panel, wiring, and switch gears are in dierepair.

6.1.3 Rehabilitation works

- **Civil works**
  The entire head race canal (1600m) needs rehabilitation. De-silting basin and forebay need dredging as it is filled with silt and debris and also requires rehabilitation. Power house building skeleton can be used after major renovation. Trash racks water regulating gates need to be replaced. Power house landscaping needs improvements. Water gauging station needs to be installed.

- **Penstocks**
  The entire length of Penstocks needs to be replaced.

- **Electromechanical works**
  Entire machineries including turbine and generators and valves need to be replaced. Substation within powerhouse premises needs renovation with new equipment.

- **T &D of Electricity and Appliances**
  All the equipment associated with T &D needs to be replaced.

6.1.4 Cost breakdown for various activities

Table 6.1 provides the component cost to restore the plant to its original capacity.

Table6.1 Cost for Restoration to Original Capacity

No.	Components	Cost (US$)
1	Civil works	$962,725
2	Penstocks	$30,000
3	Electro Mechanical works	$500,000
4	T &D network and appliances	$1,014,500
5	Subtotal	$2,507,225
6	Planning/design, management and training[6]	$100,289
	Subtotal	$2,607,514
7	Contingency @ 10%	$260751

[5] The information is provided by plant engineer.
[6] Planning/design, management and training cost is normally taken **4%** of sub total.

No.	Components	Cost (US$)
8	Total Cost	$2,868,265
9	Cost/kW	$1,130

6.1.5 Conclusion and Recommendation

This is the oldest power plant in Afghanistan – turbines and engineering by U.K. An additional value of the plant is a historical one. A possible joint funding effort with DFID to restore would seem to be appropriate (don't wait for the Centennial of the plant, though). Powerhouse could even be restored in period architecture. The social impact is high here – the community remembers when there was full power available and is excited about the prospects of a return to that condition. Full restoration would provide excess capacity for commercial and residential growth in demand, raising standards of living economically and socially.

The total cost to rehabilitate the project is US$ 2,868,265. The potential social and economical impacts of the project are positive and high as the introduction of electricity opens up new avenues for enterprise development thereby creating jobs so that local residents will be less inclined to seek opportunities elsewhere. Restoration of this power plant and the attendant benefits would tend to contribute to expectations for improved living conditions. The power plant was commissioned 94 years ago and little or no maintenance appears to have been carried out since its establishment. Once the plant is refurbished it will make a significant contribution to the local industry also, by supplying firm power to the cement factory located nearby which currently receives around 1 MW intermittently.

It should be noted the plant engineer suggested it is possible to increase the gross head of plant by 10 m, increasing capacity up to 5 MW.

6.2 Khanabad (old) Power Plant

6.2.1 Introduction

The power plant is located in Qala-e-Kona village, Khanabad district of Kunduz province. The plant was commissioned in 1971 with 1.3 MW generating capacity and is currently not operating. It had served approximately 8,000 households and provided power to the near by Spinzer company (vegetable oil factory). The Ministry of Mines and Industries owns the power station and the vegetable oil factory. The GPS coordinates for the projects are: Longitude 66^{o} 16' 58''and Latitude is 36^{o} 69' 06''. The elevation of the project is 523 m above msl. The project was designed for gross head 120 m and discharge of canal 2.2 m^3/sec.

6.2.2 Observations

- **General**
  The location of the intake for the power plant is inappropriate - a flood risk. The water is also being used for Irrigation. The plant used to supply power to 8000 households[7] and the vegetable oil factory, which is now not in operation. Construction materials are available in the vicinity of power plant.

- **Civil works**
  The intake and forebay are destroyed. The length of power canal is 4 km. The gates to regulate water discharge for power canal have been destroyed. The power house building is destroyed and no machinery exists. The entire length of canal is leaking.

- **Penstocks**
  Penstock is undamaged and in good condition.

- **Electromechanical works**
  No machinery exists in the power house.

- **T& D of electricity and appliances**
  The transmission and distribution (T &D) network is damaged. The T& D poles are in disrepair.

6.2.3 Rehabilitation works

- **Civil works**
  The intake structure should be suitability relocated. The forebay needs to be reconstructed. The entire length of canal needs to be rehabilitated with proper lining to control the leaks. The power house building needs to be reconstructed.

- **Penstocks**
  It is in good condition and can be reused after performing non-destructive tests to ensure the integrity of welded joints. It does need to be realigned.

- **Electro Mechanical works**
  Both turbine and generator need to be replaced. The control panel with heat sink needs to be installed.

- **T &D network and appliances**
  The T & D network with substation need to be rebuilt. Meters should be distributed and installed for the domestic and commercial customers.

[7] Data received from DABM office in Kabul

6.2.4 Cost breakdown for various activities

Table 6.2 Cost for Restoration to Original Capacity

No.	Components	Cost (US$)
1	Civil works	$691,750
2	Penstocks	$7,000[8]
3	Electro Mechanical works	$87,000
4	T &D network and appliances	$706,000
5	Subtotal	1,491,750
6	Planning/design, management and training	$59,670
	Subtotal	$1,551,420
7	Contingency @ 10%	$155,142
8	Total Cost	$1,706,562
9	Cost/kW	$1,320

6.2.5 Site specific conclusions and recommendations

The benefits of site restoration are considerable, both social and economic. Former service to almost 8,000 residents is not currently available while the plant is inoperable and power to the local oil factory is now being purchased from Tajikistan. With restoration, adequate domestic service would be available during night time and adequate service for the factory would be available during the day, along with excess for other productive uses during the day. Daytime service for 8,000 residents would not be adequate without a supplementary source, such as service from the proposed New Khanabad Power Station (10MW). Power canal is fully used for irrigation now that the power plant is inoperable and restoration will force a decision on water rights and an agreement will be necessary.

The cost for rehabilitation is US$ 1,706,526. The socio-economic impacts of the project are high and people are enthusiastic to rebuild the site. Spinzer Company, the vegetable oil producing factory is currently buying 800-900 kW of electricity from Tajikistan. The restored plant will have a local economic benefit as it saves expenditures for the power imported from a neighboring country. Further the dedicated power supply to the factory contributes to the sustainability of the project as well as the load factor, by generating revenue during periods of low demand for lighting. The river is lacking hydrological gauging station, which should be installed, so that important flow data, such as the mean monthly flow will be available for accurate capacity calculation for future expansion.

6.3 Juzon –Badakhshan Micro hydro Power Plant

6.3.1 Introduction

The 255 kW Juzon Power Plant is located in Juzon village, Faizabad district of Badakhshan Province. The plant belongs to MEW. The project was constructed in 1983

[8] The cost is taken for penstock alignment and civil works associated such as construction of anchor blocks and support piers.

to serve Faizabad city; approximately 300 households. The GPS coordinates of this project are: Longitude- 70^{o} 58’34’’ and Latitude – 37^{o} 12’ 48’’ and 1200 m above msl.

6.3.2 Observations

- **General**
  Due to inappropriate site selection, the intake of the power plant is washed out. The canal and forebay are covered with landslide debris and the plant is not in operation. The river has a meandering nature and changes its courses frequently. In the past the power canal was also partly supplying water for irrigation. The power plant was supplying electricity to 300 Households[9]. The gross head of the project is 55 m with flow of 1m^3/sec[10]. Construction materials are available in the vicinity of power plant. The river is lacking gauging stations for measuring the average monthly flow of the river.

- **Civil Works**
  The power canal length is 2.5 km. The overflow and outlet gates along the canal are damaged. The structure of the power house can be utilized after renovation. Doors and windows are damaged.

- **Penstocks**
  The length of Penstock is 170 m with 500 mm diameter. It is not damaged and in good condition.

- **Electromechanical works**
  No machineries exist in power house.

- **T &D of electricity and appliances**
  Only ruins of T&D network were observed.

6.3.3 Rehabilitation works

- **Civil works**
  The intake needs to be constructed with proper site selection that should be safe from flood hazard. The debris from canal and forebay need to be removed. Rehabilitation of canal and forebay need to be carried out. The outflow gates and gates for water regulation need to be fixed. The power house requires renovation replacing new doors and windows.

- **Penstocks**
  It is in good condition and can be reused after performing non-destructive tests to ensure the welded joints are satisfactory. It needs to be realigned and fixed properly.

[9] The figure is provided by DABM office in Kabul
[10] The figures for gross head and discharge are provided by DABM office in Kabul.

- **Electromechanical works**
  Both turbine and generator need to be replaced. The control panel with heat sink needs to be installed.

- **T &D network and appliances**
  The T & D network with substation need to be rebuilt. Meters should be distributed and installed for the domestic and commercial customers.

6.3.4 Cost breakdown for various activities

Table 6.3 Cost for Restoration to Original Capacity

No.	Components	Cost (US$)
1	Civil works	$200,960
2	Penstocks	$5,000[11]
3	Electro Mechanical works	$45,000
4	T &D network and appliances	$1,755,00
5	Subtotal	$426460
6	Planning/design, management and training[12]	$17054
	Subtotal	$443,518
7	Contingency @ 10%	$44,351
8	Total Cost	$487,870
9	Cost/kW	$1,920

6.3.5 Site specific conclusions and recommendations

The village of Juzon has 300 households, lies near the city of Faizabad, a city of around 200,000 households. Although full restoration would provide adequate domestic service by a factor of three or four, there would be ample excess for domestic growth and private enterprise, but not for service to Faizabad. Past water use was also for irrigation, so that future assurances of firm power will rely on water rights agreements.

The total cost of the power plant for renovation is US$ 487,870.The socio-economic impact is positive. The community is in dire need of electricity. The Juzon power plant itself is not sufficient to serve the demand of Faizabad city as population has increased dramatically after the restoration of peace in the country. The current population of Faizabad city is about one million[13] and to serve the entire population a power plant of at least 15-20 MW would need to be constructed. *The area is bountifully endowed with water resources and the Kokcha River is an alternative solution to the current irrigation canal site at Juzon for setting up a new power plant with higher capacity to fully address the demand of the village and make a significant contribution to demand in Faizabad.*

[11] Only alignment and civil cost is considered.
[12] Planning/design, management and training cost is normally taken **4%** of sub total.
[13] The population figure is provided by DABM Kabul office.

6.4 Baharak/ Badakhshan Power Plant

6.4.1 Introduction

The 200 kW Baharak/Badakhshan Power Plant is located in Baharak village, 45 km from Faizabad district in Badakhshan Province. The project was commissioned in 1986. The GPS coordinate are – Longitude- 71^o 60’ 00’’ and Latitude 37^o 0’ 0’’. The elevation of the project is 1465 m above msl. The intake headwork is in Zardaw River and is 7 km from the power house in Malang –Ab village. Power Plant gross head is 46 m and discharge is 0.9m^3/sec. The owner of the power plant is MEW. The plant is supplying electricity to 300 house holds.[14]

6.4.2 Observation

- **General**
  The planned capacity was (2X100) kW but due to poor O/M it is barely producing 60 kW which is not sufficient to meet the demand of the villagers. The current demand is around 5 MW[15]. The area is endowed with water resources and also the construction material is available in the vicinity of power plant. Water from the power canal is also being used for irrigation during the low periods of demand. There is no gauging station for measuring the average monthly flow of the river.

- **Civil works**
  The intake is made of local material and water is leaking. The power canal is 7 km long and it has severe seepage along its length. Fifty percent of canal length is unlined and water seepage is high. The mechanical gate at the forebay is non–functional. The forebay is filled with silt and debris. The trash rack is wrecked and non-functional. The roof of the power house is damaged and the house is in poor condition.

- **Penstocks**
  The penstock is in disrepair and is incapable to withstand pressure.

- **Electromechanical works**
  The turbine and generator are destroyed; heat sink and control panel are non-functional.

- **T &D of electricity and appliances**
  T & D network along with the step up transformer are in disrepair. The distribution network of the power plant is about 12 km and 10 mm Aluminum cable is used. However the poles are in badly damaged and insulators for distribution are broken down. The appliances inside the powerhouse are also in disrepair.

[14] The house hold data is provided by Plant Engineer.
[15] The demand figure is provided by Plant Engineer.

6.4.3 Rehabilitation works

- **Civil works**

The intake needs to be made of concrete. Forebay of the power canal requires dredging and renovation to utilize its full capacity. The canal needs to be made of stone masonry and needs to be lined properly with cement mortar. The power canal should be designed and constructed to accommodate the demand for irrigation. The mechanical gates and the trash racks need to be replaced. The power house needs to be repaired and renovated.

- **Penstocks**

  Penstocks need to be replaced.

- **Electromechanical works**

  The entire electromechanical machineries of power house need to be replaced.

- **T&D of Electricity and appliances**

  The entire T&D network should be redesigned. The cables, step up transformers, poles with insulators need to be replaced.

6.4.4 Cost breakdown of various activities

Table 6.4 Cost for Restoration to Original Capacity

No.	Components	Cost (US$)
1	Civil works	$197,375
2	Penstocks	$15,000
3	Electro Mechanical works	$42,500
4	T &D network and appliances	$192,000
5	Subtotal	$446,875
6	Planning/design, management and training[16]	$17,875
	Subtotal	$464,750
7	Contingency @ 10%	$46,475
8	Total cost	$511,225
9	Cost/kW	$2,560

6.4.5 Site specific conclusions and recommendations

The 200kW power plant, due to little or no maintenance and repair, is less than a third of its rated capacity. Use of power canal water also for irrigation may affect firm power. There is an overall need for adequate training and equipping of operator personnel, for example, a plant engineer told one of the survey engineers that the demand of the service area, Baharak, a town of 300 households, was 5 MW. Full restoration of the plant would provide more than adequate service for domestic demand and excess capacity for growth in domestic and private enterprise demand.

The total cost is US$ 511,225. The socio-economic impact of the power plant is positive. The plant is partially in operation and current generating capacity of the project is only 60

[16] Planning/design, management and training cost is normally taken **4%** of sub total.

kW due to condition of the turbine and generator. The electromechanical equipments have not been serviced since the date of its installation (1986). *It was suggested to the survey team that a possibility exists to install roughly 3 MW power plant, 200m down stream of this site.* Therefore, it is recommended to verify this potential while carrying out a detailed survey and design for Baharak Badakhshan power plant or perhaps before that time. An agreement must be worked out for water uses to assure firm power supply provided during the day and night and for commercial purposes or lighting bazaar shops at night.

6.5 Charkh-Logar Power Plant

6.5.1 Introduction

The Power Plant is located in the city of Pul-e- Alam of Logar Province. The plant capacity is 500 kW, belongs to MEW and serves approxiametly 2,500 households. The GPS coordinate of this project are as mentioned hereunder: Longitude- 63^{o} 55’ 22’’ and Latitude- 33^{o} 58’ 49’’. The project is 1900 m above msl. The gross head of project is 48 m and the discharge is $2.2m^{3}$/sec.

6.5.2 Observation

- **General**
  The power plant construction was begun in 2003. The work stopped due to the withdrawn of the INGO participation on the project. The city of the Pul-e-Alam has 200 shops and 2500 Households. The construction material is available in the vicinity of power plant.

- **Civil works**
  The intake is already constructed. The power canal length is 2.5 km and partially excavated. The construction of Forebay and powerhouse is incomplete.

- **Penstocks**
  Penstock has not yet procured.

- **Electromechanical works**
  Two cross flow turbine of 100 kW capacities and one Francis turbine of 300 kW capacities with generators have already been procured.

- **T&D of electricity and appliances**
  The project is incomplete and no T&D network, step up transformer, energy meter are is in place.

6.5.3 Rehabilitation work

- **Civil works**
  The remaining power canal length needs to be excavated. Entire power canal should be constructed and lined according to engineering norms and standard. Gates for regulating water flow and trash rack at forebay need to be installed as per the drawings. Forebay and power house construction need to be completed.

- **Penstocks**
  The penstock needs to be procured and aligned as per the design and drawing.

- **Electromechanical works**
  The turbines and generators are already procured should be housed inside the power house. The control panel with voltage regulating device and heat sink should be fixed. All the machineries should be placed and wiring inside and out side of the powerhouse needs to be carried out.

- **T&D of Electricity and appliances**
  T &D network with step up transformers need to be fixed. The T&D poles need to be erected. T &D cable work needs to be carried out.

6.5.4 Cost break down of various activities

Table 6.5 Cost for Restoration to Original Capacity

No.	Components	Cost (US$)
1	Civil works	$161,000
2	Penstocks	$18,000
3	Electro Mechanical works	$13,500
4	T &D network and appliances	$249,500
5	Subtotal	$442,000
6	Planning/design, management and training[17]	$17,680
	Subtotal	$459,680
7	Contingency @ 10%	$45,968
8	Total cost	$505,648
9	Cost/kW	$1,015

6.5.5 Site specific conclusions and recommendations

This site presents the possibility of successful implementation of elements of economically productive use of electricity, full cost recovery (with meters and appropriate tariff schedule), enthusiastic, even assertive, community and financial resources to contribute.

The total cost of the project is US$ 505,648. The project once complete, will supply power to about 2,500 house holds and the proposed facility will also be capable of

[17] Planning/design, management and training cost is normally taken **4%** of sub total.

providing power to serve light industries such as commercial processing[18] and cold storage[19] of agriculture produce. It could also be possible to develop other types of cottage industries with the introduction of power in this area. There is extreme eagerness to have electric power, demonstrated by a group of village representatives that visited Kabul recently.. This eagerness can also suggest a willingness to contribute to a tariff structure that will contribute to sustainability.

The representatives from Charkh village visited the Nexant office to urge site completion, stressing how hard they worked to construct the power canal out of rock on side of a hill. They also indicated that there are remaining funds in a Pakistan Bank that they can access to contribute to project completion. *There is also a micro-hydro project operating near the community and the possibility of interconnection should be looked into.*

6.6 Bamyan Power Plant

6.6.1 Introduction

This Power Plant was commissioned in 1971 by MEW in Fauladi River. It is located about 7 km from Bamyan city center. The project has 50 m gross head and water discharge1.5 m^3/sec with a generating capacity of 300 kW. The GPS co-ordinates of the project are Longitude -68^o 52' 02'' and Latitude 35^o 58'17'' and project is 2550 m above from msl.

6.6.2 Observation

- **General**
  The local construction materials are not available in vicinity of power plant. The nearest site for local construction material is Pul-e- Kumri which is about 180 km from Bamyan city. The project was then serving electricity to about 1,000 households[20].

- **Civil works**
  The intake is destroyed completely. The length of power canal is 13.9 km and covered with debris. All the civil works are destroyed.

- **Penstock**
  It is damaged, rusted and buried into the soil.

- **Electromechanical works**
  There are 3 cross flow turbines each rated at 100 kW. The units are about 35 years old and are in disrepair.

[18] Small scale commercial processing facilities are existing
[19] It is planned facility
[20] The figure is provided from DABM records.

- **T&D of electricity and appliances**
  T&D network with appliances such as transformers, control panels, energy meter, and T&D poles do not exist.

6.6.3 Rehabilitation work

- **Civil works**
  The intake and forebay need to be reconstructed. The power canal and power house need to be cleaned and reconstructed.

- **Penstock**
  It needs to be replaced.

- **Electromechanical works**
  Entirely replaced.

- **T&D of electricity and appliances**
  The entire T &D networks need to be replaced.

6.6.4 Cost breakdown of various activities

Table-6.6 Cost for Restoration to Original Capacity

No.	Components	Cost (US$)
1	Civil works	$4,104,400
2	Penstocks	$13,000
3	Electro Mechanical works	$68,000
4	T &D network and appliances	$265,500
5	Subtotal	$756,940
6	Planning/design, management and training[21]	$30,277
	Subtotal	$787,217
7	Contingency @ 10%	$78,721
8	Total cost	$865,939
9	Cost/kW	$2,890

6.6.5 Site specific conclusions and recommendations

The project was originally constructed with cross-flow turbines. A decision during feasibility assessment will concern the trade-off for cross-flow turbines that operate at, say, 50 percent efficiency and produce 300kW and imported turbines (Francis, etc.) that operate at 75 percent efficiency and produce over 500kW. The capital costs and repairs for the former are somewhat lower, but the capacity for reliable service and growth for domestic and commercial demand is greater. As with all restoration projects, cost recovery should be built in with metering, reasonable tariff schedule, proper management and adequately trained and equipped operators. In addition, all projects should be packaged with opportunities from GoA and donors for productive uses.

[21] Planning/design, management and training cost is normally taken **4%** of sub total.

The total cost is US$ 865,939. Once complete the plant will supply power to Bamyan city, an area popular for tourists. Further opportunities include agro-based entrepreneurial activities. Despite the relatively high installed cost/kW due to the combined influence of the mountainous topography and the unavailability of local construction material, the project's potential socio-economic prospects of firm power outweigh the cost/kW of the project – agricultural processing and storage, small enterprises catering to visitors and reliable domestic service.

The whole project should be redesigned and reconstructed with updated technology and to get more power other turbines with higher efficiencies may be considered such as Francis or Pelton, making cost recovery more feasible.

Section 7 Ranking of sites based on findings

The ranking of sites is based on the criteria described in **Section-4 Site Ranking Criteria**. The tabulated information provides guidelines for selecting the project that will further facilitate detailed feasibility followed by detail design for future interventions.

Projects/Parameter	*SEC	*PEP	*PSA	*C/kW	*ALM	*BI	*ICA	Total	Rank
Charkh-Logar	13.5	7.5	7.5	15	10.5	9	12	75.0	1
Jabal-e-Saraj	13.5	5	7.5	15	10.5	9	12	72.5	2
Khanabad (old)	4.5	5	7.5	15	10.5	9	12	63.5	3
Bamyan	13.5	7.5	5	5	3.5	9	12	55.5	4
Faizabad	4.5	5	7.5	10	10.5	6	4	47.5	5
Baharak/Badakhshan	4.5	7.5	7.5	5	10.5	6	4	45.0	6

***SEC –** Security**; PEP-** People enthusiasm/participation**; PSA-**Proximity of site and accessibility**; C/kW-** Cost per kilo Watt**; ALM-** Availability of local materials**; BI** – Behavioral Impact**; ICA-** Industrial and Commercial Activity

Section 8 Conclusion and Recommendations

- Rehabilitating and upgrading existing mini/small hydropower plants appears to be justified; restores power; encourages local populace of Afghanistan to participate in the rural development process by promoting indigenous knowledge, local resources, employing local labor and, by raising their income thorough productivity and efficiency enhancement brought by rural electrification.

- The estimated costs to rehabilitate each power plant which also coincides with their respective ranking is:

Rank	Power Plant	Capacity	Total Cost (US$)	Cost/kW (US$)
1	Charkh –Logar	500 kW	$505,648	$1,015
2	Jabal-e-Saraj	2.54 MW	$2,868,265	$1,130
3	Khanabad (Old)	1.3 MW	$1,706,562	$1,320
4	Bamyan	300 kW	$865,939	$2,890
5	Juzon Faizabad	255 kW	$487,870	$1,920
6	Baharak/Badakhshan	200 kW	$511,225	$2,560

- The Charkh-Logar project, once complete, will be capable of providing power to serve light industries such as commercial processing and cold storage of agriculture produce.

- The Jabal-e –Saraj power plant, once the plant is refurbished, will significantly contribute to the local economy - supplying dedicated power (1MW) to the cement factory located nearby. Currently 3,600 households are using electricity from this power plant.

- The Khanabad (Old) Power Plant is not in operation. Once the plant is refurbished, it can provide electricity to the households and vegetable oil factory. This factory is currently buying 800-900 kW electricity from Tajikistan.

- The advent of electricity will enhances the tourism in Bamyan city. Despite the relatively high installed cost/kW due to both the mountainous topography and the unavailability of local construction material, the project's potential socio-economic benefits outweigh the cost/kW of the project.

- Afghanistan's rugged and difficult topographical terrain, coupled with scattered settlements, is a constraint to connect the rural communities to the grid. The only viable alternative is to develop decentralized power.

Recommendations

General

- Standardizing civil, electromechanical and T &D works is not possible due to the variation in site conditions. Instead, standard approaches to design should be used, providing methods and criteria that enable a design to be adapted to a site condition.

- Research and development needs to be carried out to introduce the range of high efficiency turbines such as Francis, Pelton, and/or more efficient cross-flow designs suitable for the Afghan environment. If projects are further evaluated, economic tradeoffs of increased efficiency versus costs should be evaluated.

The approach to the initial site rehabilitation should be a model demonstration project. Initially supported by regional specialists, the Afghan engineers, economists, sociologists, supervisors and technicians will be associated, trained and given hands on experience in the planning, design, construction supervision and management and O/M aspects of mini hydro power plant. A suggested implementation plan might include:

- Detailed survey and investigation
- Prepare feasibility report
- Prepare detailed designs and technology selection
- Prepare contract documents and tender drawings
- Award contract for civil, E&M and T&D works
- Construction Supervision and Management
- O/M training for Operators
- Commissioning and acceptance tests

In parallel a community development action plan will be established that aims to:

- Build trust, organize, and reach consensus
- Identify productive uses and set up implementation plan (organization, permits, material/equipment lists, and funding)
- Determine staffing needs for O&M and costs, including replacements and contingencies
- Train staff
- Determine equitable tariff (cost recovery basis)
  - Future developments, to minimize the maintenance and social issues, should consider installing low head, high flow hydropower plants in stream.
  - Tariff should also be established to cover administrative/management and O/M costs of the power plant.

Power plant specific recommendations

- The Jabal –e –Saraj power plant's capacity could possibly be increased to 5 MW by increasing the gross head by 10 m. This needs to be further investigated during feasibility and detailed design.

- Juzon power plant capacity is insufficient to meet the demand of the one million population of Faizabad. To serve entire population at least 15-20 MW power needs to be constructed. The area is bountifully endowed with water resources and Kokcha River is an alternative solution for setting up a higher capacity power plant to fully address the demand. This option should be investigated during feasibility and detailed design of Juzon power plant.

- The possibility of establishing 3 MW power plant, 200 m down stream from Baharak/Badakhshan power plant should be assessed during feasibility and detailed design.

- In the vicinity of the proposed Charkh- Logar power plant another micro hydro project is operating. The possibility of interconnecting should be looked assessed.

Charkh-Logar Power Plant

Power Pant	Charkh- Logar
Ranking	1
Province	Logar
Town	Pul-e-Alam
Population served	2500 Households and 200 shops
Owner	MEW
Year of construction	2003
Longitude	63°55’22’’
Latitude	33°58’49’’
Elevation from mean sea level (msl)	1900m
Original Capacity	500 kW
Current Capacity	Not in operation
Status of the project	Not in operation
Gross head	48m
Water discharge	2.2 m^3/sec
Power Canal length	2.5 km
Penstock length	X
Penstock diameter	X
No of generator	3
Capacity of Generator	X
No of Turbine	3
Type of Turbine	2 Cross flow and 1 Francis
Capacity of Turbine	(2*100 kW) and (1*300 kW)
Grand total cost for restoration	$505,648.00
Cost/kW for restoration	$1,015.00
Water gauging station	Not installed
Social/Environmental issues	Positive
Time required for construction	2 years

Jabal-e-Saraj Power Plant

Power Pant	Jabal-e-Saraj
Ranking	2
Province	Parwan
Town	Jabal-e-Saraj
Population served	3600 Households
Owner	MEW
Year of construction	1913
Longitude	69^{o}14’59’’
Latitude	35^{o}08’40’’
Elevation from mean sea level (msl)	1555m
Original Capacity	2.54 MW
Current Capacity	1.5 MW
Status of the project	Partially in operation
Gross head	27m
Water discharge	$8m^3$/sec
Power Canal length	1.6 km
Penstock length	54 m
Penstock diameter	1.2 m
No of generator	4
Capacity of Generator	(3*700) and (1*500)
No of Turbine	4
Type of Turbine	Francis
Capacity of Turbine	(3*700) and (1*500)
Grand total cost for restoration	$2,868,265.40
Cost/kW for restoration	$1,130.00
Water gauging station	Not installed
Social/Environmental issues	Positive
Time required for construction	4 years

Khanabad (Old) Power Plant

Power Pant	**Khanabad (Old)**
Ranking	3
Province	Kunduz
Village	Qala-e-Kona
Population served	8000 Households
Owner	Ministry of Mines and Industries
Year of construction	1971
Longitude	66^{o}16’58’’
Latitude	36^{o}69’06’’
Elevation from mean sea level (msl)	523 m
Original Capacity	1.3 MW
Current Capacity	1.5 MW
Status of the project	Not in operation
Gross head	120m
Water discharge	2.2 m^3/sec
Power Canal length	4 km
Penstock length	X
Penstock diameter	X
No of generator	X
Capacity of Generator	X
No of Turbine	X
Type of Turbine	X
Capacity of Turbine	X
Grand total cost for restoration	$1,706,562.00
Cost/kW for restoration	$1,320.00
Water gauging station	Not installed
Social/Environmental issues	Positive
Time required for construction	3 years

Bamyan Power Plant

Power Pant	Bamyan
Ranking	4
Province	Bamyan
Town	Bamyan city center
Population served	1000 Households
Owner	MEW
Year of construction	1971
Longitude	68°52'02''
Latitude	35°58'17''
Elevation from mean sea level (msl)	2550 m
Original Capacity	300 kW
Current Capacity	Not in operation
Status of the project	Not in operation
Gross head	X
Water discharge	X
Power Canal length	13.9 km
Penstock length	X
Penstock diameter	X
No of generator	X
Capacity of Generator	X
No of Turbine	3
Type of Turbine	Cross flow
Capacity of Turbine	(3*100)
Grand total cost for restoration	$865,939.36
Cost/kW for restoration	$2,890.00
Water gauging station	Not installed
Social/Environmental issues	Positive
Time required for construction	3 years

Juzon-Badakhshan Power Plant

Power Pant	Juzon-Badakhshan
Ranking	5
Province	Badakhshan
City	Faizabad
Population served	300 Households
Owner	MEW
Year of construction	1983
Longitude	70°58'34''
Latitude	37°12'48''
Elevation from mean sea level (msl)	1200 m
Original Capacity	255 kW
Current Capacity	Not in operation
Status of the project	Not in operation
Gross head	55 m
Water discharge	$1m^3$/sec
Power Canal length	2.5 km
Penstock length	170 m
Penstock diameter	500 mm
No of generator	X
Capacity of Generator	X
No of Turbine	X
Type of Turbine	X
Capacity of Turbine	X
Grand total cost for restoration	$487,870.24
Cost/kW for restoration	$1,920.00
Water gauging station	Not installed
Social/Environmental issues	Positive
Time required for construction	3 years

Baharak-Badakhshan Power Plant

Power Pant	**Baharak -Badakhshan**
Ranking	6
Province	Badakhshan
Village	Baharak
Population served	300 Households
Owner	MEW
Year of construction	1986
Longitude	71^{o}60’00’’
Latitude	37^{o}00’00’’
Elevation from mean sea level (msl)	1465 m
Original Capacity	200kW
Current Capacity	60kW
Status of the project	Partially in operation
Gross head	46 m
Water discharge	0.9 m^3/sec
Power Canal length	7 km
Penstock length	X
Penstock diameter	X
No of generator	2
Capacity of Generator	X
No of Turbine	2
Type of Turbine	Cross flow
Capacity of Turbine	X
Grand total cost for restoration	$511,225.24
Cost/kW for restoration	$2,560.00
Water gauging station	Not installed
Social/Environmental issues	Positive
Time required for construction	3 years

MINI-HYDROPOWER SURVEY FORM

Survey Engineers: ____

Date: ____

Powerplant name ____

Powerplant mapping coordinates: **_lat.**_____________________________________
_long.____________________________________

Service area: (town, district, province)____

Operator(s):____

Date of start-up:____

Answers:

1. **many are judgement calls – provide short text;**
2. **others require more description – provide a summary statement and attach notes with explanation;**
3. **some answers are quantitative – if short, fill in the space, if long, attach table.**

TECHNICAL

A. Powerhouse

1. **Overall impression:**

2. **Condition of structure:**
   - roof
   - flooring

- walls
- wiring
- windows
- staff facilities
- plumbing
- lighting
- machinery
- tools
- safety (first aid, electrical grounding)
- furniture
- supplies
- operator manuals/directions/records
- storage
- parking
- space for outside structures
- communications
- office

3. Turbines

- design capacity
- estimated actual capacity
- type
- manufacturer

- operating condition
- condition of rotor
- condition of bearings
- condition of guides and vanes
- condition of shaft
- condition and type of connection to generator (gears, belts)
- condition of housing
- condition of mechanical controls

3. Generator

- Nameplate output
- Estimated actual output
- Condition of housing
- Condition of windings
- Condition of connectors
- Condition of bearings
- Consition of shaft
- Connection to busbar (if present)
- Gauges with generator

4. Controls

- Condition of panel
- Condition of wiring
- Condition of alarm

- Condition of switches
- Condition of manual/automatic voltage regulation
- Wiring/controls for batteries, if present

B. Distribution

1. Connection

- Condition of connection from distributor to transformer, if present

2. Step-up transformer

- Condition of step-up transformer (if present – rating, housing, coolant, wiring, connectors, support structures, fencing, signage, service manuals, oil collection, etc.)

3. Transmission

- Condition of transmission line – type and size of wiring, insulation, connectors, poles

4. Step-down transformer

- Condition of stip-down transformer (if present – rating, housing coolant, wiring, connectors, support structures, signage, etc.)

5. Distribution

- Sizes and type of wiring
- Service drop wiring and connections
- Insulators
- Condition of poles
- Presence of wiring insulation

C. Civil Works

1. Impoundment (if present)

- Condition of dam
- Type of dam with dimensions
- Condition of reservoir (bank, sediment, etc.)
- Estimated capacity
- Condition of sluice gates, doors, controls
- Condition of spillway

2. Run-of-river (if present)

- Type and condition of diversion
- Dimension of diversion
- Flow of water in canal or pipe
- Relief gates, if canal, pressure relief if pipe
- Condition of canal
- Type of construction material
- Presence of leaks

3. Headrace

- Condition of trashracks
- Gate(s)
- Penstock connection
- Walls

4. Penstock

- Type of material

- Stabilization (burial, anchor blocks, other)
- Gross head of power plant

5. Tailrace

- Type and condition
- Length
- Tendency to flood
- Dimensions
- Materials

ECONOMIC

A. Powerhouse SUB-TOTAL ______________________

1. total cost for rehabilitation or new construction to include

- physical structure
- furnishings
- equipment
- tools
- communication
- electrical
- plumbing
- servicing and maintenance supplies and equipment
- office supplies and equipment
- operation manuals
- safety equipment;

2. cost estimates for outside restoration of property

- parking
- dedicated area for transformer (if needed)
- signage
- waste handling

3. **cost estimates for turbine(s) replacement (same or different capacity) or restoration**

4. **cost estimates for generator(s) replacement (same or different output) or restoration**

5. **cost estimates for controls for equipment and for panel for monitoring output and controlling voltage, alarm**

6. **cost estimates for parts and supplies for the physical structure and operation and maintenance of all equipment**

7. **schedule**

B. Distribution **SUB-TOTAL ________________**

1. **cost estimates for**
   - wiring and connection to transformer (if present)
   - step-up transformer replacement or rehabilitation
   - fencing
   - wiring
   - fittings
   - drainage

2. **cost estimates for transmission from step-up to step-down transformers, including**
   - connectors
   - insulation wiring
   - poles

3. cost estimates for transformers (if needed) – reconditioned or replaced

4. cost estimates for

- distribution wiring
- insulators
- poles

5. cost estimates for service drops

- wiring
- connectors

6. cost estimates for breaker/fuse boxes (if needed) in the system

7. schedule

C. Civil Works **SUB-TOTAL _______________**

1. cost estimate for

- dam reconditioning
- cost for reconditioning or replacing
  - = sluice gates
  - = doors
  - = intakes
  - = trash racks
  - = gate controls

2. **cost estimates for dredging the reservoir (if needed)**

3. **cost estimate for rehabilitation of**
   - take-off
   - power canal or diversion pipe

4. **cost estimate for rehabilitation or replacement of**
   - headrace
   - gate
   - rack
   - penstock connection

5. **cost estimate for rehabilitation or replacement of penstock – connections at headrace and powerhouse, stabilizing methods**

6. **cost estimate for rehabilitation of tailrace**

7. **schedule**

GRAND TOTAL ________________________

NOTE: all cost figures should reflect current figures for equipment, parts, materials and labor. Imported equipment, supplies and materials, should be so designated with estimates for duty.

SOCIAL

A. Demand

1. **estimate current and future demand for electricity for existing and potential service area**

   - residential
   - commercial
   - industrial

B. Institutional

1. consideration of suitable institutional arrangements for system management, including information on present management institution capabilities vs. future requirements for management – included should be evaluation of current system operator(s)

C. Impacts

1. **estimate of the potential social impacts of plant restoration**

   - positive
   - negative

2. **estimate of the potential economic impacts of plant restoration**

   - positive
   - negative

3. **estimate of current and potential environmental considerations, including**

   - estimated hydrologic scheme
   - current and future impacts on available flow for plant operation
   - current and future impacts of plant operation on land and water use

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