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Afghanistan Clean Energy Program

Bamiyan Mission Field Assessment (April 29 – May 5, 2010)

This report was prepared by International Resources Group (an L-3 Company) for review by the United States Government for International Development (USAID).

REPORT ON TOPCHI MINI HYDRO (BAMYAN) SURVEY

Afghanistan Clean Energy Program (ACEP)

April 2010

1. PURPOSE

The purpose of the field assessment was to: (a) ascertain the condition of the old construction works previously carried out under Indian government assistance; (b) verify salient points mentioned in the previous reports including those of the Aga Khan Foundation (AKF)/Water and Power Consultants (WAPCOS) and the Ministry of Rural Rehabilitation and Development (MRRD); (c) map the generation area from intake to powerhouse to ascertain topography, amount of work previously completed and usable / to be repaired / to be re-build, new amount of work to be done, estimate volume of work and costs, so that specification and bills of quantity of works can be worked out and a bid solicited for construction; (d) conduct additional flow measurements to verify previous measurements and historical data; (e) develop a land base from satellite imagery to identify roads, houses, irrigation canal system and other physical attributes; (f) collect geo referenced data to lay out the preliminary design for the transmission and distribution system; (g) develop a model for off grid energy end-use distribution system by initiating a survey on domestic and commercial energy usage; (f) plan for the execution of a video documentary capturing life of the beneficiaries pre and post electrification.

2. CONCLUSIONS AND FURTHER WORKS:

(a) Except for part of the canal that appears to be in good condition, the rest has to be built anew. This includes headwork, gravel trap, de-silting tank, unfinished and damaged part of the canal, super passage for canal just before the forebay/reservoir, reservoir itself, penstock, and powerhouse with equipment, transmission and distribution line system.
(b) It was found that the old powerhouse location has certain draw backs in terms of site stability. A new powerhouse location has been identified.
(c) Dr Dan Waddle of NRECA along with Mr. Ramesh Nepal of IRG traveled to the site to survey the demand and transmission/distribution aspects. This effort will be coordinated with the power plant sizing.
(d) Plotting and analyzing of the topographic survey is being done.
(e) Geological investigation of the proposed project site will be carried out within the next few weeks. This will include investigation of surface geology, test pit digging at various construction locations (1 x intake, 1 x de-sanding basin, 3 x reservoir location, 1 x powerhouse location), lab testing of earth samples to ascertain quality of materials that can influence the design of structures, etc.

3. BACKGROUND

The Topchi mini-hydro was identified and initiated with Indian government aid some 32 years back with an aim to install a run-of-river type 750 kW power plant using water from the Bamyan River. The project was abandoned due to political reasons. The proposed scheme envisaged (a) intake immediate downstream of the confluence between the Bamyan River and the Ahangaran Stream to divert required flow into the headrace on the left bank (b) about 4km of waterway canal to convey water to the reservoir / forebay (c) powerhouse on the left bank of the flood plain of the Bamyan River. Geographically the project is located between latitude from 34o 48' 55" N to 34o 49' 30" N, and longitude from 67o 54' 15" E to 67o 57' 45" E. The feasibility report conducted by the Indian Government Consultant is not available.

A site assessment and cost estimates was later carried out by AKF. WAPCOS, an Indian consulting company visited the site and prepared the report in 2006 for AKF.

A general site inspection, flow measurement and review of old reports of WAPCOS/AKF were carried out by MRRD engineers in 2008.

The governor of Bamyan submitted those reports to USAID and requested assistance to implement the project.

4. PRESENT WORK

A team of hydro engineers visited the site from 19th April to 26th April 2010. The main purpose of the visit was (a) to ascertain the condition of the old construction works (b) verify salient points mentioned in the older reports including the AKF/WAPCOS and MRRD report and (c) construct additional flow measurements.

A detailed mapping of the waterway and adjacent area was conducted using a Total Station. Following are the salient points resulting from the field trip.

(a) Waterway

Intake and diversion: The earlier identified intake location appears good, with the large boulders on the left bank protecting the initial waterway from high flood. A partially constructed weir exists across the river. This weir level might need to be raised with additional construction works along the river bank to create suitable diversion and protection against high flow.

Initial headrace: There is a covered canal from the intake almost down to the de-silting basin location. Also, a (seemingly) gravel trap (without gate, access into the chamber) exists in between with flushing route dugout down to the Bamyan River. This section of covered canal in completely underground and is apparently filled with debris.

- The initial headrace alignment between the intake and gravel trap may need to be re-aligned. The aim would be to keep the alignment safe from flood damage and increase the capacity to convey more water.

De-sanding basin: The de-sanding basin area is clearly identified with provision of enough excavation already carried out and passage for spillway and flushing cleared down to the stream.

Headrace: Preliminary investigation demonstrated that the canal alignment has a slope of 1:1000 whereas the AKF/WAPCOS report states the slope is 1:500.

- This means the canal capacity will be lower than anticipated by AKF/WAPCOS.
- The capacity of the present canal, allocating 25cm free board, would be about 2.7m3/sec.
- In order to carry the design discharge of 3.2m3/sec (assuming 750kW is the plant size we are aiming at), the canal height would have to be raised by at least 20 cm throughout. It should be noted that the canal width was not found consistent throughout the length (wherever the canal was constructed). It varied from 1.76m to 1.85m. Due to the bottlenecks created by the smaller widths in between, the effective height to be raised would be 21cm.
- The canal is partially constructed along its length, mostly open and small portion covered by a concrete slab.
- Of the constructed part, some portion is clearly visible and in good condition, other areas are partly filled by soil and debris, and some are fully buried under debris and need to be excavated. It is hoped that most of these partially and fully buried portions of the canal would be in usable condition. At one point the canal was buried by a land slide; this part of canal is about 50m in length and is assumed to be damaged and might need heavy earth moving equipment to clean the debris.

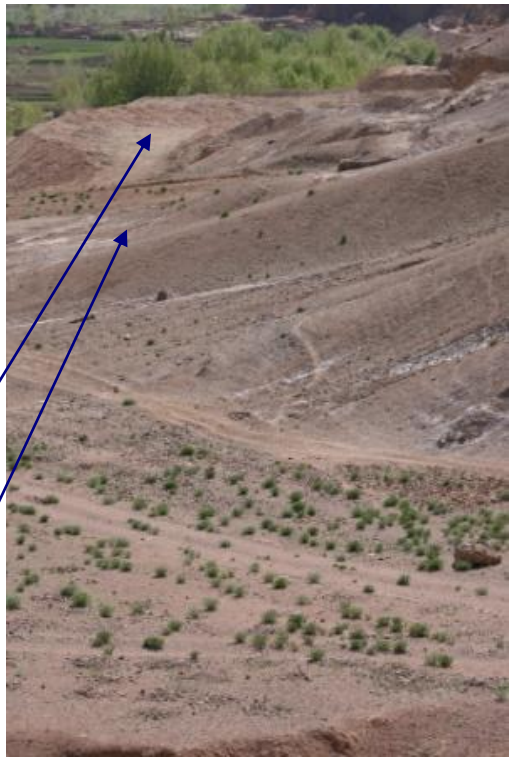
- To avoid future damages by slide and also protect children and cattle falling into the canal the whole length of canal will need to be covered by concrete slab. Man-holes will need to be provided at periodic intervals to enable future repair/maintenance of the covered canal.
- Most length of the unconstructed canal alignment is excavated and ready.
- Covered canal sections include most of the initial length down to the location where a de-silting tank is to be built. One section that passes through a small settlement also has a covered section of canal.

(b) Forebay / reservoir

The following points are worth noting regarding the proposed reservoir area in relation to the nearby road (highway) and the powerhouse location.

- It appears possible to extend / enlarge the reservoir / fore-bay area longitudinally West-North, thus allowing for more storage volume of water if required. In alternative sense, we can narrow the width of the reservoir and compensate the loss in storage volume by extending the reservoir longitudinally North-West.
- The latter is important as the main highway passes just next to and beneath the embankment of the proposed reservoir. Whereas the distance between the road and the steep fall (also slide zone) down to the proposed powerhouse location (already river flood plain) is hardly 30m. There is continuous erosion of soil along the length of the steep fall and there are signs of bulk of earth mass parting and ready to collapse along this line. It is a matter time, but in future there might be need for re-alignment of the road away from the slide zone. This means, there will be need to cut into the forbay embankment. And, this might de-stabilize the fore bay.
- So, better would be to keep the breadth of the forebay narrower and extend its length West-North. This will also add to the benefit of having a shorter penstock pipe to the new powerhouse location (see notes under power house location below).

Reservoir view from upstream side



Reservoir view from downstream side
Earlier reservoir – partially dugout

Possible extension area for reservoir

(c) Powerhouse

A new powerhouse area is recommended and surveyed as it appeared to have distinct advantages compared to the AKF/WAPCOS proposed site.

- The powerhouse area recommended in the AKF/WAPCOS report lies on the flood plain of the Bamyan River. There is a flood retaining wall constructed, but it may not be sufficient to withstand the 50 or 100 year flood that need to be considered for infrastructure project of the size under consideration. This would then put the powerhouse and the expensive generating equipment at great risk of damage.
- There is also the active slide zone all along the steep ridge just next to the powerhouse area and the road up above, with hardly 30m or so remaining between the road and the slide zone. There are seemingly no rocks in the area that could to hold the land mass and further delay a landslide. The sliding mass of earth could also potentially damage the flood retaining wall below.

View of old powerhouse location and main road from reservoir embankment

- The new powerhouse location about 300m meters downstream, just at the other end of the semi-circle that river makes while flowing down around the old fort. The ground level at the

new powerhouse site is well above the river flood mark. The area can be easily enlarged. And the land profile from there is gently sloping all the way to the reservoir/forbay (the exact location of the forebay at the end of the extended reservoir will be determined later).

(d) Flow measurement

Flow measured on various occasions reveal following data.

A. Conducted by RRD engineers as per their report forwarded by to USAID by Bamyan Governor				
11 March 2008	3.024 m3/sec	Intake location, Bamyan river	Velocity area method using float	Flow data appears not reliable due to the method of measurement.
B. Conducted by IRG / Winrock / REDO consultants (See measurement sheet below)				
25 April 2010	2.964 m3/sec	Intake location, Bamyan river	Velocity area method using current meter	
25 April 2010	0.872 m3/sec	~100m upstream from intake; tributary to Bamayn river	Velocity area method using current meter	

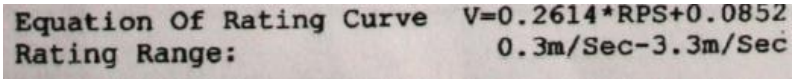
Flow measurement using pigmy bucket type current meter
Location: Bamyan River, proposed intake of the Topchi mini-hydro
~ on the partially constructed old diversion weir
Date : 26 April 2010

Time of measurement : 8 AM

Climate : clear day, no rain in the last few days

Meter calibration as approved by bureau of Indian Standard

Velocity, m/s given by



Chainage	0	1	2	3	4	5	6	7	8	9	10	11	12
Depth	0	0.2	0.2	0.23	0.31	0.2	0.31	0.34	0.31	0.26	0.21	0.15	0
Revolutions/50sec	0	97	211	179	197	87	129	199	223	296	154	190	0
RPS	0	1.94	4.22	3.58	3.94	1.74	2.58	3.98	4.46	5.92	3.08	3.8	0
Area	0	0.3	0.2	0.23	0.31	0.2	0.31	0.34	0.31	0.26	0.21	0.23	
Velocity, m/s	0	0.59	1.19	1.02	1.12	0.54	0.76	1.13	1.25	1.63	0.89	1.08	
Discharge, m3/s	0	0.18	0.24	0.23	0.35	0.11	0.24	0.38	0.39	0.42	0.19	0.24	
Total discharge, m3/s	2.964												

Flow measurement using pigmy bucket type current meter

Location: tributary stream, 50m upstream of confluence with Bamyan River; ~100m upstream from Topchi intake. Possible source stream for another smaller size mini-hydro.

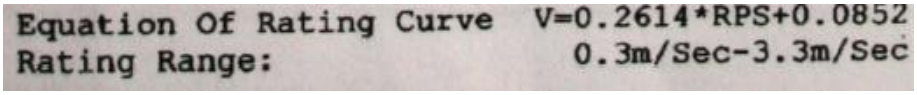
Date : 26 April 2010

Time of measurement: 7 AM

Climate : clear day, no rain in the last few days

Meter calibration as approved by bureau of Indian Standard

Velocity, m/s given by



Chainage	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5
Depth	0	0.24	0.29	0.31	0.35	0.35	0.35	0.3	0.29	0.26	0.18	0
Revolutions/50sec	0	74	96	78	119	129	152	132	70	40	32	0
RPS	0	1.48	1.92	1.56	2.38	2.58	3.04	2.64	1.4	0.8	0.64	0
Area	0	0.12	0.145	0.155	0.175	0.175	0.175	0.15	0.145	0.13	0.09	0
Velocity, m/s	0	0.47	0.59	0.49	0.71	0.76	0.88	0.78	0.45	0.29	0.25	0
Discharge, m3/s	0	0.057	0.085	0.076	0.124	0.133	0.154	0.116	0.065	0.038	0.023	0
Total discharge, m3/s	0.872											

5. HYDROLOGY

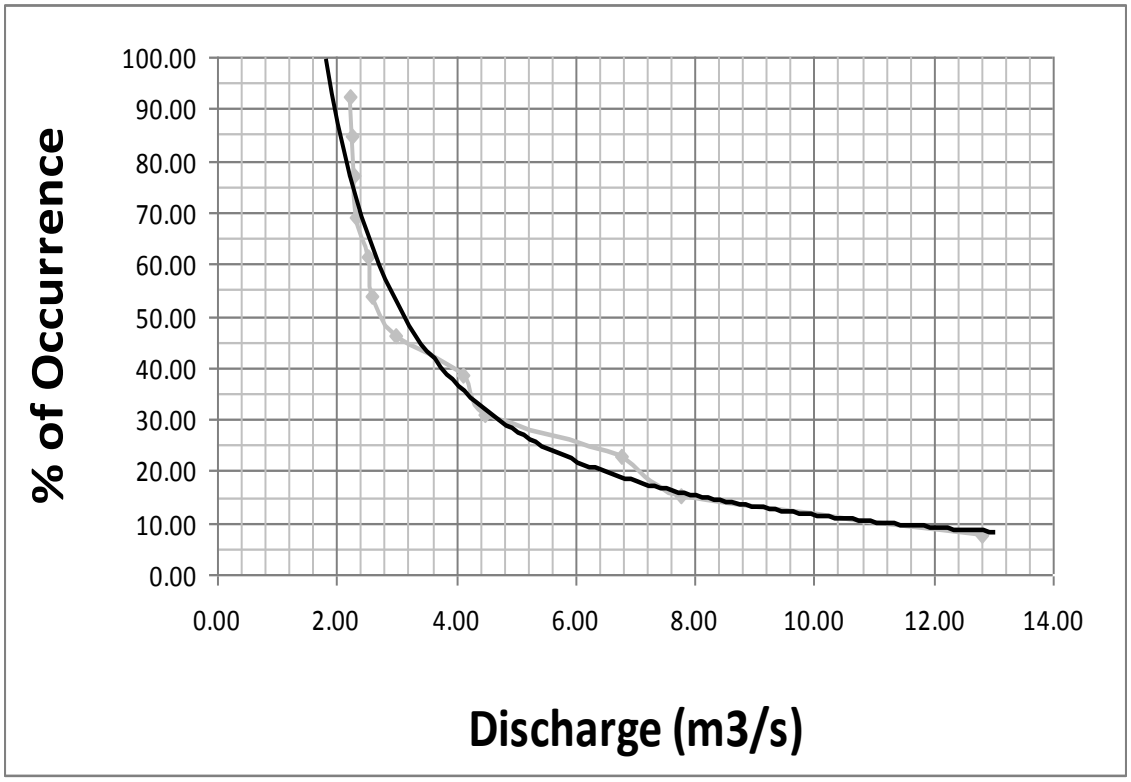
The present flow measurement data should not be taken as a definitive and representative of what can happen over a longer period of time. The Bamyan River has most likely seen cyclic change in monthly flow data over the past. It is therefore important to look into past flow records as far as they are available when we are dealing with project of this size.

Pre-war historical data are available to some extent. However, there is only one series of data available for the location about the intake site, which is presented below.

River Basin:	kunduz		code:		14-0.000		Years:			1975-1976	
River :	Bamyan		code:		14-9.R00		Elavation: 2450			m+m.s.l	
station :	Ahangaran		code:		14-9.R.00-6T		Drainage aera 1660			Km2	
Gage :	Staff		Location		**Lat: 35°49'N**		**long: 67°55'**				
Peak on Record: 23.1	m3 s Jul-20-1975		Lowest on Record: 0.9				m3 s		Mean: 4.18	m3 s	
yaers	Oct.	Nov.	Dec.	jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Min.	Max.
1974														
1975								6.77	12.8	7.75	4.47	4.12	1.02	23.1
1976	2.97	2.59	2.53	2.29	2.32	2.24	2.23						0.89	12.5
1977														
Mean	2.97	2.59	2.53	2.29	2.32	2.24	2.23	6.77	12.8	7.75	4.47	4.12		
Mean/sqkm, l/s	1.79	1.56	1.52	1.38	1.40	1.35	1.34	4.08	7.71	4.67	2.69	2.48		

Note: The red font used for the latitude coordinate of the staff gauge location indicates likely wrong typing in he old record. It should be 34° 49'. The correct one indicated the exact location of the new installed gauging station site, about 300m down stream from the diversion of Topchi mini-hydro.

The above table shows a minimum of monthly mean value of 2.23m3/sec in the month of April. It should also be noted that the flow can vary appreciably in any month – the above monthly value only gives the mean of the flow data over each month. This can be seen from the minimum record of 0.89m3/sec. The flow duration curve based on the above one year period data will look as follows. Note: this will be updated later.



There are more historical data available of the Bamyan River and its tributary over a longer period of time. These can be analyzed to arrive at likely flow data about the intake after computing catchment areas. This work is in progress. We will then have better monthly mean values to arrive at any conclusion about the hydrograph and flow duration curve. It should also be noted; however, that the above one-year hydrograph is very close to the intake, while others are located a few km away. The table below show flow records at the Foladi River, which is located just west of Bamyan, about 13 km upstream and is a major tributary to the Bamyan River.

It is worth noting that the specific discharge Liters/sec per sq. km. of catchment area is slightly higher in the case of the Foladi gauge (about 8 years of data) record than in the case of Ahangaran gauge record (one year data). The resulting Flow Duration Curve (above) and power/energy availability table (below) might actually be on the safer side in terms of probability of flow availability.

River Basin:			Kunduz			code:			14-0.00			Years:		1969-1977		
River :			Foladi			code:			14-9.5R00			Elavation: 2507 m+m.s.l				
station :			Bamyan			code:			14-9.5R0-1T			Drainage aera 320 Km2				
Gauge			Recorder			Location			**Lat:34˚49´ N**			**long:67 49'E**				
Peak on Record:13.1			(m3/s)Jul-22-1972			Lowest on Record:0.00				(m3/s)		Often		Mean1.21		(m3/s)
yaers	Oct.	Nov.	Dec.	jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Min.	Max.	Mean.	Runoff
1970				1.2	1.03	0.33	0.21	0.99	2.26	2.05	1.2	0.97				
1971	1	0.69	0.63	0.8	0.53	0.28	0.07	1.52	0.6	0.09	0.08	0.69	0.07	1.52	0.58	18.38
1972	0.56	0.32	0.38	0.71	0.77	0.76	0.8	2.69	10.6	1.83	0.66	0.79	0.32	10.60	1.74	54.70
1973	1.21	1.2	1.21	0.99	0.93	0.91	1.62	4.26	5.76	2.59	2.14	1.58	0.91	5.76	2.03	64.20
1974	1.16	0.66	0.87	0.55	0.69	0.58	0.23	1.03	2.81	0.69	0.48	0.65	0.23	2.81	0.87	27.30
1975	0.74	0.73	1.11	0.6	0.4	0.49	0.1	1.01	4.71	2.64	0.76	0.68	0.10	4.71	1.16	36.77
1976	0.78	0.29	0.42	0.66	0.61	0.51	0.3	1.58	2.5	1.6	0.53	1.22	0.29	2.50	0.92	29.00
1977	1.09	0.96	1.25	1.05	0.71	0.74	0.45									
Mean	0.93	0.69	0.84	0.82	0.71	0.58	0.47	1.87	4.18	1.64	0.84	0.94				
Mean/sqkm, l/s	2.92	2.17	2.62	2.56	2.21	1.80	1.48	5.84	13.05	5.13	2.61	2.94				
Min	0.56	0.29	0.38	0.55	0.4	0.28	0.07	0.99	0.6	0.09	0.08	0.65				
Max	1.21	1.2	1.25	1.2	1.03	0.91	1.62	4.26	10.6	2.64	2.14	1.58				

6. AVAILABLE HEAD AND POTENTIAL

With the powerhouse located at the new site, the gross head between the existing weir crest level and ground level of the powerhouse would be about 35m. Allowing nominal additional to weir height, losses along the canal, losses along the penstock, etc., the net head may be about 31m. This will be ascertained after more detailed works on the topographic survey and design works.

The following is a tentative estimate of flow/power availability over the year (based on the historical data of 1975-76, which seems to more or less match with the flow measured at the intake). The following table of estimates of availability of design flow/installed capacity, design flow, installed capacity of plant and annual energy generation has been calculated.

Availability	Flow	Instal Cap	Annual
%	m3/sec	kW	GWH
80%	2.05	496	4.12
70%	2.4	581	4.58
60%	2.7	654	4.89
50%	3.15	763	5.27
45%	3.4	823	5.48
40%	3.75	908	5.78
35%	4.15	1,005	6.08

7. FURTHER WORKS

Plotting and analyzing of the topographic survey will be carried out over the next few days.
Geological investigation of the proposed project site will be carried out within the next few weeks. This will include investigation of surface geology, test pit digging at various construction

locations (1 x intake, 1 x de-sanding basin, 3 x reservoir location, 1 x powerhouse location), lab testing of earth samples to ascertain quality of materials that can influence the design of structures, etc.

Apart from the flow availability, plant capacity finalization will depend upon the practical size of the reservoir, when the peak load cannot be met by the flow available, and any diesel plant back up when even the reservoir cannot meet the demand. This will depend on the forecast of:

(a) Anticipated daily load curve during a typical peak loading season
(b) Peak load and anticipated growth
(c) Availability and size of diesel plant to supplement during times of power shortage
(d) A Memorandum of Understanding (MoU) is to be signed with the Aga Khan Development Network (AKDN) in synchronizing the transmission of electricity generated from a 480 kW generator.
(e) Load estimation will be gathered by conducting a household and commercial end use energy survey. The energy survey will be conducted in the villages of three valleys, commercial units and government buildings of Bamyan city. A proposal has been requested from Bamyan University to conduct the survey.

It was concluded that this project will provide a new face to Bamiyan by providing electricity to its villages and city, and by helping to stimulate economic productivity and improve the quality of life of the its residents. Demand for electricity is expected to increase every year, and the 750 kW of power may be sufficient for about two years after its operation with a limited load controller. Consequently, the project has to synchronize its efforts to make use of backup generation options in order to satisfy consumers during peak hours and increased demand. It will be essential to carefully plan accordingly for the need for new energy generation in the coming years.

8. TENTATIVE SCHEDULE

A tentative schedule for the implementation of the project is as given in the next page. But this will very much depend on ground condition.

TOPCHI MINIHYDRO (750 - 1000 KW), BAMYAN

TENTATIVE IMPLEMENTATION SCHEDULE

Task	Activities	Project period, tentative scheduling of tasks																												
		Quart. 2, 2010			Quart. 3, 2010			Quart. 4, 2010			Quart. 1, 2011			Quart. 2, 2011			Quart. 3, 2011			Quart. 4, 2011			Quart. 1, 2012			Quart. 2, 2012		
		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
A	***Pre-construction activities***																													
A1	Detail design works, specifications																													
A2	Design / specification review, bidding documents																													
A3	Bidding process local procurement (civil, HM, TL)																													
A4	Bid evaluation local procurement																													
A5	Bidding process international procurement (gen equip)																													
A6	Contract award and mobilization local procurement																													
A7	Contract award and mobilization internl. procurement																													
B	***Construction activity***																													
B1	Civilworks construction								← winter →												← winter →									
B2	Hydromech works fabrication / supply / installation																				← winter →									
B3	Transmission line mat. fabrication / supply / erection																				← winter →									
B4	Generating equipment fabrication / inspectn. / supply																													
B5	Generating equipment installation																													
B6	Testing and putting into service																													
C	***Training/mangmt support***																													
C1	Instututional and management modality																													
C2	Operator selectn, training in trade sch. (kabul, nepal)																													
C3	Operator training cum working on house wiring																													
C4	Operator training at site																				← winter →									
C5	Managt team selection, training in Kabul, Nepal																													
C6	Regular operation																													
D	***Monitoring, evaluation, management support***																													