PRE-FEASIBILITY REPORT

Attunli HEP (4x170 MW)

On Tangon River in Dibang Valley, Arunachal Pradesh

Submitted by:-
M/s Attunli Hydro Electric Power Company Limited

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1 INTRODUCTION

Attunli Hydroelectric Project (HEP) is proposed for development on Tangon river in Dibang valley district of Arunachal Pradesh and is being developed by the Attunli Hydro Electric Power Company Ltd. (AHEPCL), which is a joint venture between Jindal Power and Hydro Power Development Corporation of Arunachal Pradesh Limited (HPDCAPL). The Tangon river is a major tributary of Dibang river meeting it about 22 km downstream of Attunli HEP's power plant outfall. The project is located just upstream of Tangon limb of the 3097MW Etalin Hydroelectric Project, which is being developed by another joint venture company of Jindal Power and Hydro Power Development Corporation of Arunachal Pradesh Limited (HPDCAPL). Although a project, Maliney HEP, has been identified by Central Electricity Authority (CEA) upstream of the Attunli project, most of its project area apparently lies within Dibang Wildlife Sanctuary. The Attunli project can thus be considered the most upstream hydro project on Tangon. The allotted FRL and TWL of Attunli project are El. 1360m and El. 1060m, respectively.

The project is proposed to be developed as a run-of-river scheme with diurnal pondage for peak hour power generation. A concrete gravity dam is proposed on Tangon river to help divert the water into an underground water conductor system which connects to the power generating equipment located inside an underground powerhouse. The tailrace discharges the water back to Tangon river, about 1km upstream of the tip of reservoir of Tangon limb of Etalin project. The entire power (680MW) of the project is proposed to be evacuated through one double circuit, ACSR-conductor transmission system with proposed interconnection at a 400kV pooling station.

This report presents detailed planning of the project and establishes its techno-economic feasibility. It has been prepared in accordance with the "Guidelines for formation of project report for power projects (Hydro, Thermal and Transmission)" of CEA and "Guidelines for preparation of Detail Project Report (DPR) of Irrigation and Multipurpose projects" issued by Ministry of Water Resources. As per procedure stated by CEA, AHEPCL had involved different apprising groups from CEA, CWC, GSI & CSMRS during course of DPR preparation and had taken requisite pre & post DPR approvals.

AHEPCL gratefully acknowledge with thanks the valuable contribution made by apprising groups from CEA, CWC, CSMRS and GSI in the preparation of comprehensive Detailed Project Report of Attunli Hydro Electric Project.

2 PROJECT AREA – LOCATION AND ACCESS

The project is located in Dibang Valley district of Arunachal Pradesh, which is almost entirely hilly and covered mostly by forests. The project area falls in the Lower Himalayan region and is located in a remote area with very limited local infrastructure.

Access to the project area is via Roing, the district headquarter of Lower Dibang Valley district. Roing is about 113km from Tinsukia, the nearest railhead. Dibrugarh, the nearest airport, is 60km from Tinsukia. Roing and Tinsukia are connected by NH-37 and a district road, which includes crossing river Lohit at Dhola Ghat by Bhupen Hazarika Setu. Dhola Sadiya Ghat is connected by NW-2. The project site is about 318km from Tinsukia.

Attunli village, which lends its name to the project (the powerhouse site is located close to this village), can be reached by a single lane road which connects Roing to Maliney via Hunli and Etalin. The road crosses a high altitude Mayodia pass between Roing and Hunli and is frequently blocked by snow during peak winter months. The diversion structure of the project is proposed just upstream to Apanli village, 32km from Etalin village and approachable by Etalin-Maliney road.

Location of the project is shown in Figure-1 and project area accessibility is depicted in Figure-2.

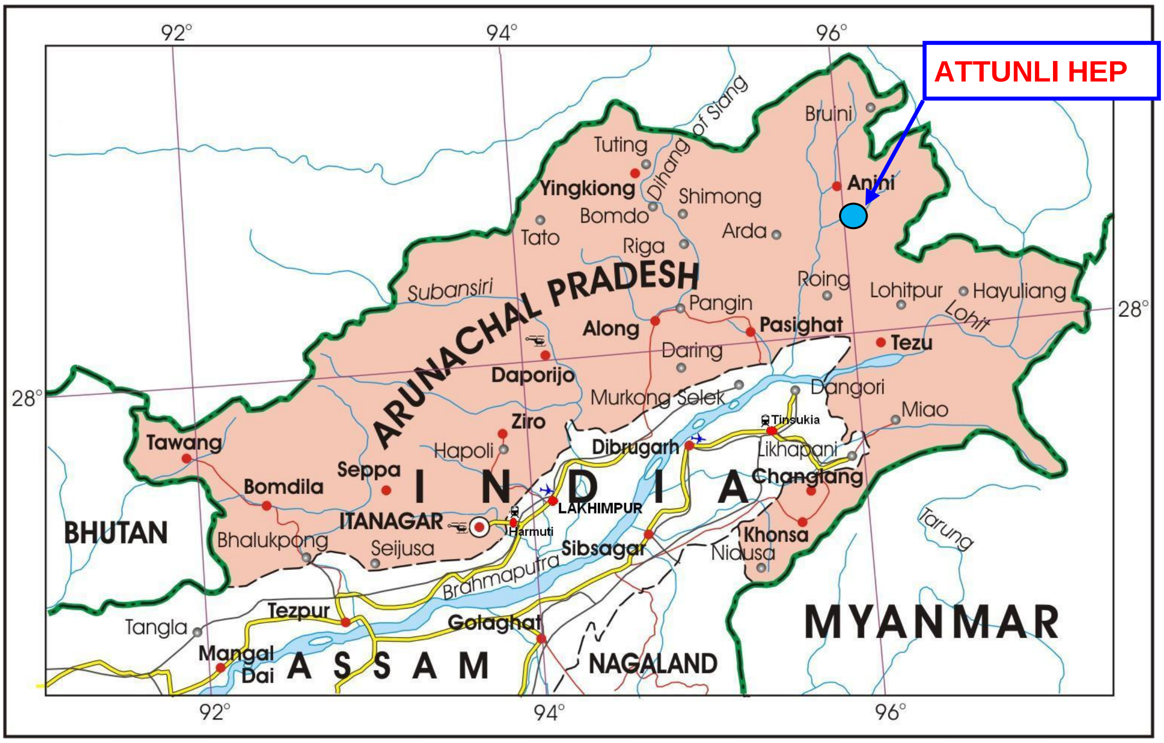

Figure-1: Project Location – Arunachal Pradesh

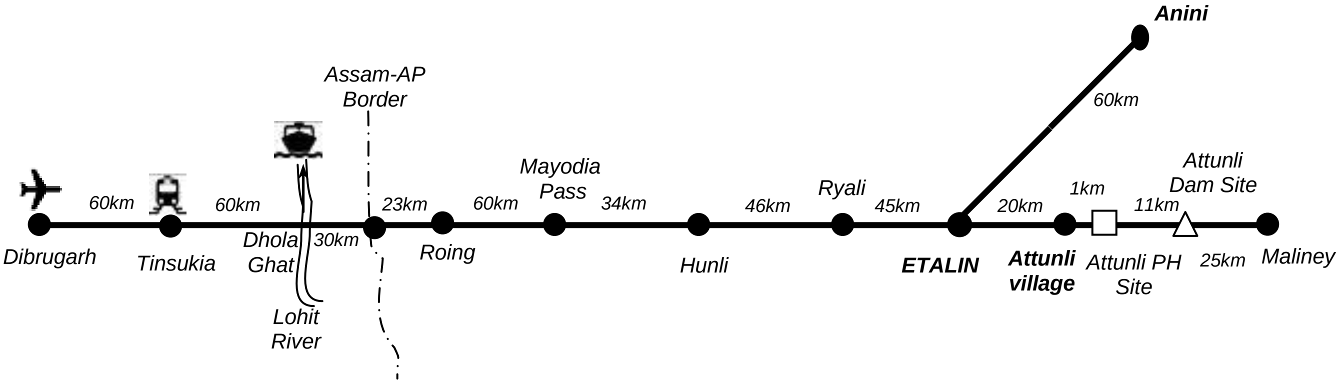

Figure-2: Project Access

3 PROJECT SCHEME

3.1 Project Background

The Project was initially conceptualized by CEA and was planned to harness a gross head of 140m (between El. 1200.0m and El. 1060.0m) to generate 175MW of power. Subsequently, under the 50,000MW Hydropower Development Program, NHPC prepared a pre-feasibility report (dated April 2004) for the Project and proposed a 500MW scheme utilizing a gross head of 300m between El. 1360.0m and El. 1060.0m. The NHPC report was concurred by CEA. Development rights of the project were subsequently accorded to Attunli Hydro Electric Power Company Limited (AHEPCL), a joint venture company of Jindal Power Limited (JPL) and Hydro Power Development Corporation of Arunachal Pradesh Limited (HPDCAPL). AHEPCL appointed SNC-Lavalin Engineering India Pvt. Ltd. (SLEI) as its Engineering Consultant for preparing the Detailed Project Report.

3.2 Proposed Scheme

The project scheme proposed in the DPR has been arrived at through a detailed field and desk assessment of several alternative layouts, including the one proposed by NHPC in the Pre-Feasibility Report (PFR). Three different locations of the dam were studied before finalizing the proposed location based on a techno-economic evaluation. Similarly, left bank and right bank alternatives were assessed before selecting the more suitable left bank scheme. The powerhouse location was selected considering 1km free flowing river stretch upstream of the tip of reservoir of the downstream project as well as topographic and geological features. The studied alternatives are depicted in **Plate-1**.

Based on alternative studies, most favorable project layout was selected in consultation with CEA and various other apprising groups. The scheme selected for development in the DPR envisages construction of a concrete gravity dam upstream of Apanli village; the dam axis is about 130m downstream of the Kachi nallah confluence with Tangon river. The intake is located just upstream of the dam in exposed rock on the left bank. Underground desilting chambers are proposed to help exclude suspended sediment from the diverted water which is channeled through a 7955m long headrace tunnel to an open-to-sky surge shaft. Two steel lined drop shafts bring the water from the surge shaft to the machine centerline level where each shaft bifurcates to feed two turbines. The generating equipment – four vertical axis Francis turbine-driven generators of 170MW, each – is housed in an underground powerhouse cavern. Generator transformers and GSI equipment are placed in another cavern parallel to the powerhouse cavern. The draft tubes connect to an underground collection gallery (downstream surge chamber) from where the turbined water is brought back to Tangon river through a tailrace tunnel.

The proposed scheme, with total installed capacity of 680MW, harnesses a net head of 267.13m and would produce 2796MU in 90% dependable year with 95% plant availability (design energy).

Layout of the proposed scheme is shown in **Plate-2**. Longitudinal section of the water conductor system, detailed layout of headworks and powerhouse complex are shown in **Plates-3** to **5**. Salient features of the project are enclosed as **Annexure-1**.

4 JUSTIFICATION OF PROJECT FROM POWER SUPPLY ANGLE

Hydro power is the richest renewable and environmentally benign source of energy which helps in conserving scarce fossil fuels. Hydroelectric power stations not only help in improving reliability of the power system, they are also the natural choice for meeting peak demand. The generation cost is inflation free and, in fact, reduces over time.

In India, out of a total hydro power potential of about 150,000MW only about 24.73% has been harnessed so far while another 9.04% is under various stages of development. The hydroelectric power contributes a meager 17% of the total installed capacity of 249,488MW (as on June 2014) in the country whereas, for better system reliability, this ratio should be at least around 30%.

Added to this imbalance is the overall energy and peak power shortage which the country has been facing for several years. For example, during the 11th Plan (2007 - 2012), the average energy shortage in the country was about 400 Billion kWh (10%). During the on-going 12th Plan, the peak deficit has been about 12,000 MW (9%) and the average energy shortage has been about 50 Billion kWh (8.6%).

Implementing new hydroelectric schemes is clearly the need of the hour.

4.1 Hydro Power Potential of North-Eastern Region

The North-Eastern region of the country comprises seven states: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura. The area is endowed with bountiful water resources with Brahmaputra flowing in the northern part and the Barak (Meghna) flowing through the southern margins. These two rivers, along with their numerous tributaries, have created a very dynamic and powerful hydrologic regime in the region. In particular, the tributaries of the Brahmaputra, namely Kameng, Subansiri, Siang, Dibang and Lohit, which all flow in Arunachal Pradesh, offer many attractive sites for hydroelectric projects.

As per CEA, hydro potential of the north-eastern region in terms of installed capacity is around 59,000 MW, i.e. almost 40% of the country's total hydro potential. Of this, more than 50,000MW potential is in Arunachal Pradesh, of which, only about 98 MW has so far been harnessed while projects amounting to 2810 MW are under construction (as on June 30, 2014).

It is also interesting that although the per capita consumption of electricity in north-east is the lowest in the country, the region faces peak power deficit of 6.4% and energy deficit of 5.4%, as per latest figures published by CEA.

Exploiting the remaining hydro potential to augment development efforts in the country as well as the region is a legitimate pursuit.

4.2 Justification for Implementing the Project

Considering the growth of peak demand and anticipated addition of generating capacity in the state, the region and the country, and also from the current status of development of hydro power potential of Arunachal Pradesh, it is pragmatic that earnest efforts are made for developing the hydro power sector of the state. Thus, implementing Attunli Hydroelectric Project of 680 MW capacity will not only support the power requirement of north-east but of other states as well through export of the surplus power. Such exports will earn additional revenue for the state and help in its overall development. It is worth noting that presently there is no problem in the availability of transmission systems beyond the north-eastern power region for distribution of power as the five power regions of the country are in the process of greater integration within a national grid.

Since the project is located in a remote area, its implementation will provide the added advantage of opening up avenues for development as the accessibility of the area and its infrastructure would also get developed in the process.

5 SURVEY AND INVESTIGATIONS INCLUDING ROUTE SURVEY

Extensive survey and investigation work has been carried out as part of preparation of the DPR. These include control survey, topographic survey, exploratory core drilling, drifting and other field and laboratory tests. A detailed survey has also been carried out along the main route to the project area so that transportation and other logistic constraints, if any, could be identified. All survey and investigation work has been carried out through specialized agencies. A brief summary is presented in the following.

5.1 Topographical Survey

Control survey for the project has been done by Survey of India. The whole project area has been covered by sufficient number of ground control points on which survey of all project components has been based. Detailed topographic survey has been carried out covering all permanent and infrastructure works of the project. The total area surveyed is about 711.97 ha. Longitudinal section has been taken along the river and a number of river cross-sections have also been observed near the dam site as well as in the area of tailrace outfall. All the survey work has been done in requisite scale conforming to CWC guidelines and satisfying design requirements. Contour maps have been prepared for laying out the project components, including infrastructure works, and estimating various quantities.

5.2 Route Survey

Detailed survey of the entire route from the nearest railhead and the nearest quay to the project site has been carried out through a specialized agency. It may be noted that route survey up to the dam site of Tangon limb of the 3097MW Etalin project was carried out as part of DPR preparation of that project; the same route survey has been extended to the dam site of Attunli project. Governing transport dimensions of Attunli project are less stringent than that of the Etalin project but definitely govern the stretch of road beyond Etalin’s Tangon dam site.

As mentioned above, Tinsukia is the nearest railhead for the project and Sadiya Ghat is the nearest quay. Both of these are connected to the project area via Roing. The route survey has revealed that there are 19 bridges between Roing and Etalin. Out of these 19 bridges, 13 bridges are designed for less than 40R loading. Four bridges meet the 40R loading criterion and only 2 bridges are of 70R capacity. Thus, almost all the existing bridges along the project site route would require strengthening or reconstruction. The road itself would also require strengthening and widening at several places.

5.3 Geological and Geotechnical Investigations

Extensive geological investigations have been carried out to determine surface as well as sub-surface geological conditions in the project component areas. These investigations comprised of surface geological mapping of the project area, geophysical investigations, sub-surface investigations through core drilling and drifting, as well as laboratory and in-situ testing. As discussed in subsequent paragraphs, almost 1962m of drilling and 342m of drifting including cross cuts has been carried out.

Detailed geological mapping included the sites of individual appurtenant structures as well as reservoir areas and alignments of the headrace tunnels. The headworks area and the powerhouse complex were geologically mapped on 1:1000 scale while the HRT alignments and the reservoir areas were mapped on 1:10,000 scale and 1:5000 scale, respectively. In addition, traverses were undertaken to identify landslides existing in the project area and assess their status and impact on project components. Treatment measures have been suggested, wherever considered necessary.

Subsurface geological investigations included geophysical seismic refraction profiling, core drilling, exploratory drifts and in-situ tests. Altogether, nine seismic profiles of 230m length each were surveyed in the project area. In addition cross hole seismic study was carried out in two drill hole at Dam site, DH-A2/2 (right abutment) and DH-A14 (left abutment) along Dam axis.

Altogether 31 drill holes have been completed. Cores have been extracted from the completed drill holes and logged. Water pressure tests were carried out as required. The completed core drilling includes 18 drill holes at the diversion site, 3 drill holes at desilting cavern site, 3 drill holes along the headrace tunnel and Adit portal, 7 drill holes in the proposed surge shaft and underground powerhouse complex area.

Exploration through drifts has been undertaken at the dam site and in the powerhouse complex. In-situ testing for determining the geo-mechanical properties of the rock mass has also been carried out in the drifts and substantial data collected for use in engineering studies in the DPR.

5.4 Field and Laboratory Testing

Rock core samples have been collected from drill holes and tested in laboratory for assessing physical properties of the rock. In-situ rock mechanics tests are also taken up in the exploratory drift at the dam site with a view to determine the rock mass properties at structure grade.

Representative samples from proposed rock quarry and river borne material were collected from the project area and tested in laboratory to check suitability for use as concrete aggregate as per standard BIS codes.

In-situ stress analysis test was carried out in deep vertical drill hole above powerhouse cavern and test results was considered for designing.

In-situ direct shear test to determine shear strength parameters and Plate jacking test to determine deformability parameters of rock, have also been completed in left bank drift at dam axis.

6 HYDROLOGICAL STUDIES

6.1 Water Availability

Catchment area at the selected diversion site is 2358km^2, out of which 176km^2 is snow fed corresponding to permanent snow line at El. 4500.0m. Water availability at the selected diversion site has been assessed by using long term discharge data measured at Elopa and Munli G&D sites both of which are located on Dibang river. Relevant long term rainfall data available close to the catchment has also been used to transpose the measured discharge series to Attunli diversion site. The derived discharge series is for 23 years - from 1986-87 to 2008-09. The 50% and 90% dependable flows available at the dam site are estimated as 159.5m^3/s and 59.3m^3/s, respectively.

The derived flow series has been approved by Central Water Commission (CWC). The site specific hydro-meteorological measurements are also in progress at the site.

6.2 Design Flood

Design flood for determining the spillway capacity has been estimated using hydro-meteorological approach. Studies to obtain Probable Maximum Precipitation (PMP) for the project have been carried out by Indian Meteorological Department (IMD). 1-day and 2-day PMP values have been estimated as 20.3cm and 33.4cm, respectively. Unit hydrograph for the project catchment has been developed using CWC's Flood Estimation Report for Subzone-2(a). Design flood at the proposed dam site is computed as 9927m^3/s, which corresponds to the Probable Maximum Flood (PMF).

Diversion flood for temporary river diversion during construction of the dam has been computed based on flood frequency analysis of the observed flood peaks at Elopa which were transferred to the project location using Dicken's formula. The design diversion flood is estimated as 2678m^3/s which corresponds to 25-year return period non-monsoon flood.

Apart from this, Glacial Lake Outburst Flood (GLOF) studies have also been carried out. Tentative peak discharge of GLOF event at the proposed dam site has been estimated as 2227m^3/s. This corresponds to the condition that lake burst and 100-year flood occur simultaneously. Travel time of the flood wave from the lake to the dam site is taken as 1.5 hrs.

The design flood studies, including the GLOF studies, stand concurred by CWC.

7 POWER POTENTIAL STUDIES

Assessment of power potential of the project has been done using the approved flow series. As mentioned above, the project is conceived as a run of river scheme having diurnal storage; minimum stipulated peaking power requirements have been considered while determining the optimum installed capacity at the project. Gross head available for power generation is assessed as 286.3m, which is the level difference between the Full Reservoir Level and the average tailwater level in Tangon river in front of the tailrace outlet. Considering the various head losses in the water conductor system, the net head is estimated as 267.13m.

Optimization of installed capacity is done through an analysis of incremental energy for different installed capacities using 10-daily flows corresponding to the 90% dependable year. Other considerations such as capability to generate peaking power at full installed capacity for minimum three hours in a 24-hour period, percentage utilization of flow etc. are also employed to finalize the installed capacity at the project.

The 90% and 50% dependable years are determined from annual energy generation figures corresponding to all the 23 hydraulic years with unlimited installed capacity. Years 2001-02 and 2000-01, respectively, represent the 90% and 50% dependable years.

For sustainable hydropower development, the environment flows for Lean Season (December to March) as 17.60 m^3/s, for Monsoon Season (June to September) as 23.60 m^3/s and for Intermediate period as 19.80 m^3/s are approved by Ministry of Environment, forest and climate change. Conforming to the environmental requirements, these flows are considered for release downstream of the dam at all times

The MDDL has been fixed to meet the peaking storage requirements during low flow period and to provide the required storage capacity in the reservoir for convenience of operation/regulation of high flows during monsoon period. Minimum daily peaking generation is targeted as 3 hours throughout the year.

Considering the head available for power generation, Francis turbines are considered the most suitable choice at the Project.

Energy generation with different installed capacities ranging from 260MW to 750MW is analyzed. The energy computations are done for the 90% dependable year and the installed capacities are increased in steps of 35MW. In each case, energy which could be generated in the 90% dependable year with full installed capacity of the generating station is computed.

The results of energy generation are summarized in Table-1. Ratio of incremental energy to incremental installed capacity (dkWh/dkW) is plotted against the installed capacities in Figure-3.

Table-1: Incremental Energy Benefits in a 90% Dependable Year

Installed Capacity	Annual Gross Energy	Design Discharge	Annual load factor	Lean load factor	Incr. energy	Energy per IC	dkWh/ dkW	Potential Utilization
(MW)	(MU)	(m^3/s)	(%)	(%)	(MU)	(kWh/kW)	(kWh/kW)	%
260	1953.42	106.59	85.77	66.42	-	7513.17	-	69.14
295	2094.43	120.94	81.05	58.54	141.01	7099.76	4029	74.13
330	2211.47	135.29	76.50	52.33	117.04	6701.43	3344	78.28
365	2322.35	149.64	72.63	47.31	110.88	6362.61	3168	82.20
400	2433.23	163.99	69.44	43.17	110.88	6083.08	3168	86.13
435	2536.94	178.33	66.58	39.70	103.71	5832.04	2963	89.80
470	2614.01	192.68	63.49	36.74	77.07	5561.73	2202	92.52
505	2665.59	207.03	60.26	34.20	51.58	5278.41	1474	94.35
540	2709.27	221.38	57.27	31.98	43.68	5017.18	1248	95.90
575	2752.95	235.73	54.65	30.03	43.68	4787.75	1248	97.44
610	2777.20	250.08	51.97	28.31	24.24	4552.78	693	98.30
645	2795.68	264.43	49.48	26.77	18.48	4334.38	528	99.0
680	**2814.16**	**278.78**	**47.24**	**25.40**	**18.48**	**4138.46**	**528**	**99.6**
715	2825.21	293.12	45.11	24.15	11.05	3951.34	316	100.0
750	2825.21	307.47	43.00	23.03	0.00	3766.95	0	100.0

*Note: IC-Installed Capacity

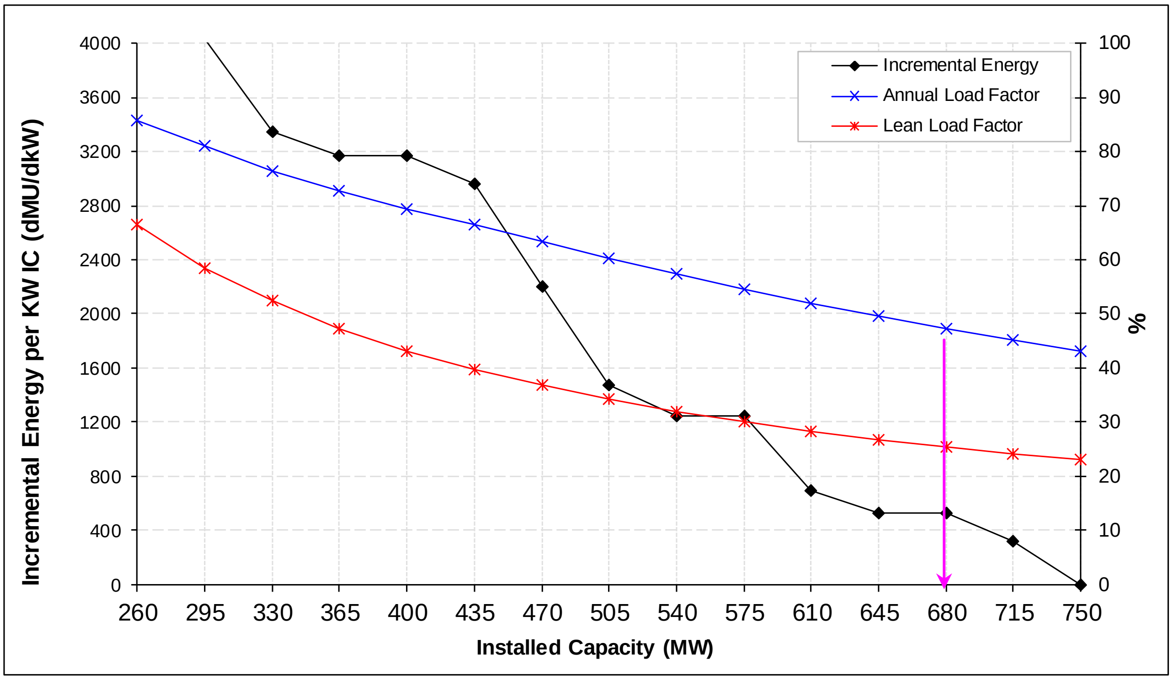

Figure-3: Incremental Energy per kW increase in installed capacity for 90%

The studies indicate that the optimum installed capacity at the project is 680MW. Further perusal of the result shows that, the annual and lean flow period load factor corresponding to 680MW installed capacity is 47.24% and 25.40% respectively, which are satisfactory. Design discharge corresponding to the optimum installed capacity is 278.8m^3/s.

Four units of 170MW, each, are proposed considering various aspects such as minimum flows, cost, flexibility etc.

The annual energy at 95% machine availability as calculated in 90% dependable year is computed as **2796GWh** (the design energy) and net annual plant load factor is 46.94%. Energy generation in the 50% dependable year is estimated as 3014GWh.

The Power Potential Studies have been approved by CEA.

8 GEOLOGY

8.1 Regional Geology

The area in and around Dibang valley, is characterized by four distinct physiographic units namely, Himalayan ranges (referred to as the Arunachal Himalaya or NEFA), Mishmi Hills of Trans–Himalaya, Brahmaputra Plain and Naga Patkoi Ranges of the Arakan Youma Mountains. Geomorphologically, the area consists of (i) glaciated region, (ii) highly dissected hills, (iii) narrow ridge & valley province and (iv) flood plain and piedmont zone. The highly dissected hills in the north are snow covered and some of the valleys just below the permanent snowline are U-shaped due to glacial and / or seasonal ice action.

Regionally, the area of the proposed project is located on the eastern limb of the Eastern Syntaxial Bend (ESB) in eastern part of Arunachal Pradesh that exposes rocks ranging in age from Proterozoic to Tertiary and Recent deposits. Trans Himalayan belt towards north east of Tiding thrust comprises rocks belonging to two distinct lithopackages viz, i) the suture package comprising Yang Sang Chu Formation and Tidding Formation with serpentinites and metavolcanics and ii) the Lohit Granitoid Complex with the EtalinFormation, the latter occurring as restites. The total assemblage of the suture package resembles an ophiolitic mélange and separated from Lohit Granitoid Complex by Lohit Thrust and delimited in the SW by Tidding Thrust, which is exposed in the northern part of the area.

The major rock units exposed in and around the Project belong to Etalin Formation and Diorite – Granodiorite – Granite Complex or Lohit Granitoid Complex.

Structurally, the region around Attunli project includes:

- Structures of the Himalayan belt comprising several thrust-bound litho-tectonic units and major tectonic features such as Main Central Thrust, Main Boundary Fault and Roing Fault (interpreted as continuation of Mismi Thrust as per recent publication of GSI - “Geology and Mineral Resource of Arunachal Pradesh” - Geological Survey of India, Misc. Publication No. 30 Part IV Vol I (i) Arunachal Pradesh; 2010) and,

- Structures of the Trans-Himalayan belt comprising rock sequence east of Tiding Suture and two major tectonic features, namely Tidding Suture and Lohit thrust.

Major structural/tectonic features around the region are Main Central Thrust (MCT), Main Boundary Fault (MBF), Mishmi Thrust, Tidding Suture, Lohit Thrust and Walong Thrust.

8.2 Geology of the Project Area

In the project area, rocks of Lohit Granitoid Complex and Etalin Formation predominate, comprising biotite gneiss with calcareous quartzite, schist and gneiss. Calcareous quartzite is occasionally observed as bands of about 30-50m width, which is assumed to be locally metamorphosed facies near the axial part of the folded sequence and varies in thickness at places. Occasional presences of gneisses of granodioritic/dioritic composition are observed due to complex deformation history of the parent rock which is intruded by diorite-garnodiorite - granite complex. Few such patches of gneissic rock of granodioritic/dioritic composition are present near the proposed powerhouse site. In general, the biotite gneiss and calcareous quartzite is massive to blocky in nature.

In addition to foliation, five sets of joints are present in the project area and show wide range of variation. Reversal in dip direction of foliation is observed in the project area, which is indicative of the presence of folded strata. Due to variation in prominence of rock discontinuities and change in attitude of foliation due to folded sequence of rocks and/or local warping, site specific analysis of rock discontinuity data has been adopted for the DPR level studies for all project component areas.

8.2.1 Headworks area

In the headworks area, the Tangon valley is characterized by moderately steep slopes on both abutments. The river Tangon flows along a straight course for a long stretch at this site with a gentle gradient. Bedrock outcrops normally observed at lower elevation along river edges up to certain height and then the upslopes are covered by slope wash deposits. Riverbed at the selected diversion site (El 1289m) is occupied by unconsolidated riverine deposits comprising pebbles, gravels, boulders of granodiorite, quartzite, gneisses in sandy matrix. Bedrock is exposed on steep to moderately steep left abutment from riverbed level to about 30m height. Beyond that, the slope is covered by thin overburden comprising slope wash deposits. The right abutment, disposed at moderately steep angle is covered by overburden comprising fluvial deposits up to El. 1300m followed by a small slide scar up to about El.1335m. Farther above, the right abutment slope is covered with slope wash deposits up to the dam top and beyond. However, bedrock is found to expose at riverbed level at about 20m downstream of dam axis on right bank. The width of river at the dam location is about 50m.

Bedrocks exposed on the abutments comprise mainly biotite gneiss belonging to Etalin Formation that represents meta-sedimentary sequence. Rock mass is traversed by five sets of discontinuities including most prominent foliation joints.

Based on drill hole results the deepest foundation of Dam below riverbed has been arrived at El.1277m. Keeping in view the configuration of the valley and anticipated hydraulic conditions, the dam axis has been oriented in 25^0-205^0 direction.

Based on surface and sub-surface investigations, it is observed that depth of overburden varies between 10.5m & 18m on the right abutment and between 0.5m & 4.5m on left abutment. Subsurface investigation carried out at dam axis revealed that depth of overburden varies in the range of 9 and 14m below river bed with the deepest bedrock level at river centre at El.1278.12m. Further, from the geological plan, it is evident that at the end of spillway and at plunge pool area bedrock is exposed along the river bank.

8.2.2 Intake

The intake structure with invert at elevation of El.1336m is envisaged about 10m upstream of the dam axis on the left bank of the river Tangon, where bedrock comprising biotite gneiss in a steep slope upto El.1355m is present. The intake is placed in line with the first spillway (bay No 3), to ensure effective flushing. The water from intake is proposed to convey through feeder tunnels aligned in 025º - 205º direction in major part up to about 200m/250m and thereafter it takes a broad turn in N243º direction to join desilting chamber. As the rockmass is traversed by five joint sets some of the joints will be unfavorable with the orientation of feeder tunnels and formation of unstable wedges may form that is to be taken care of.

8.2.3 Desanding Arrangement

After feeder tunnels three underground desander chambers of 17m (W) x 24m (H) x 350m (L) sizes are envisaged on left bank to supply silt free water to headrace tunnel excluding particles coarser than 0.2mm.

The area is characterized by presence of slope wash deposits with occasional bed rock outcrops at places. Bed rock comprises biotite gneiss with quartz and pegmatite veins occasionally. One drill hole presently in progress at top of desander area has encountered overburden comprising slope wash deposits up to about 35m depth.

In the area of headworks, two active slide zones have been demarcated at right and left bank, presence of which indicates a lineament trending NE-SW to NNE-SSW across Tangon river. This lineament may present a weak zone and may encounter at the proposed underground desander and/or initial portion of HRT. Presently a suitable orientation for the long axis of desander chamber is worked out as N63ºE-S63ºW depending on the disposition of various rock discontinuities present at this site. The results of in-situ stress parameters established through hydrofracture test in drill hole DH-A18 has given a result as N34ºE which is more or less in order. The ground cover over the proposed chambers varies between about 225m and 450m and the same can be considered adequate.

8.2.4 Reservoir area

The river Tangon just upstream of the proposed dam site flows through a narrow V shaped valley for a length of about 800m and thereafter valley becomes slightly wider for a distance of about 500m further upstream.

The reservoir formed due to impoundment of 85m high Dam (above deepest riverbed level) with FRL at El.1360m is expected to spread over an area of 31.25Ha that will extend for a length of about 2.6km along the river Tangon upstream of dam. The reservoir area indicates that valley slopes are moderate to steep and upto FRL and between FRL and MDDL expose bedrock at several places. Most of the reservoir span is devoid of any major active slide except two slide zones one located on left bank at about 450m upstream and another located at about 750m upstream of proposed dam site. In addition, one small old slide zone with bedrock exposed at base is also present on left bank at about 230m upstream of the dam axis. Treatment of these slide zones will be required for reservoir rim stabilization. No major fault or weak zone was observed at the reservoir area, which may cause major reservoir seepage. However, rim stabilization measure as necessary will be adopted.

8.2.5 Headrace Tunnel

A circular headrace tunnel of 9.4m diameter and about 7955m length is proposed on left bank of Tangon river to conveying 278.8m^3/s of design discharge. The area is rugged and characterized by steep slopes and moderately wide valley. Most of the area is covered by moderately dense vegetation. The proposed HRT along its route is likely to cross six drainages of which four, namely Goye, Tum, Layo and deep incised Abri Pani nallahs are very prominent. HRT has been finalized by ensuring adequate vertical and lateral cover around the proposed structure and optimizes the length of the intermediate construction adits. It has been provided three kinks at about RD 1652m, RD 5985m and at about RD 7551m thus dividing HRT in four sectors. To ensure rock cover and rock quality at cross drainages vis-à-vis adit portals three drill holes (DH-HRT 1, DH-HRT 2 and DH-HRT 3) along proposed HRT alignment were carried out. The HRT is likely to encounter rock mass comprising biotite gneiss predominantly with occasional calcareous quartzite and pegmatite veins. Due to folded nature of strata, reversal in dip direction of foliation joint and presence of highly deformed/distressed rock mass of axial part of folded strata may also be encountered at places. Part of tunnel is also having cover above 500m which indicates that high stress condition may also arise during tunnel excavation at places.

8.2.6 Powerhouse Complex

The proposed underground powerhouse complex for the project is located within the hill on left bank of Tangon river, near Attunli village.

The proposed underground powerhouse complex for the project is located within the hill spar on left bank of Tangon river, near Attunli village. The complex comprises an open to sky surge shaft (21m diameter, 93m high). Biotite gneiss is the predominant rock unit in this area, however, quartzite occurs as interband within biotite gneiss. Thin quartz veins occur parallel to schistosity in general. Few exposures of shear seams were observed within the bedrock at road sections.

The surge shaft of 21m diameter and 93m height is envisaged to accommodate the variable water levels with upsurge at El.1397.5m and minimum surge at El.1319.9m. Considering these water levels the top level of surge shaft is kept at El.1399m and bottom at El.1306m. The area was investigated through a drill hole DH-AS1, which has encountered fresh bedrock comprising biotite gneiss at a depth of about 30m. Drilling data indicates poor variety of rock mass to be expected along shaft at few occasions. Therefore sinking of shaft is recommended with utmost carefulness by providing concurrent supports. One self draining adit aligned in N331º direction is proposed to facilitate excavation of surge shaft at El.1305m. Bedrock comprising Biotite gneiss is exposed at portal area. The ground cover over adit varies between 20m and 100m and it is expected to encounter garnetiferous biotite gneiss associated with pegmatite bands.

Two numbers of pressure shafts have been envisaged with two horizontal limbs – the upper limb is at about El.1310m and the lower limb at about El.1065m connected by a vertical shaft of 245m drop. The area was probed by drillholes DH-AS1, DH-APS1 and DH-APH1.

DH-AS1, DH-APS1 and DH-APH1 that encounters bedrock at El.1399.69m, El.1366.399m and El.1334.25m respectively and water table at about El.1338m, El.1315m, El.1327.5m and El.1216m respectively. Bedrock in this site comprises mainly biotite gneiss and quartzite with pegmatite veins and quartzite bands at places. The upper horizontal limbs of pressure shaft will encounter biotite gneiss rock but the vertical shafts and lower horizontal limbs of pressure shaft is expected to encounter quartzite with Biotite gneiss and schist bands mainly.

The underground powerhouse is located upstream of Attunli village. Bedrock in the area comprises biotite gneiss, quartzite and pegmatite veins belonging to Etalin Formation. Bedrock is traversed by five sets of rock discontinuities including foliation joint. Presently a suitable orientation for the long axis of powerhouse cavern is worked out as N40ºE – S40ºW based on strike of prominent rock discontinuities. The results of insitu stress parameters established through hydrofracture test in drill hole DH-APH-1 has given a result as N30ºE which is more or less in order. Rock cover over the crown of the powerhouse cavern varies between around 255m and 150m. The area of powerhouse is investigated by drill holes DH-APS1 and DH-APH1. Drilling result indicates that the proposed powerhouse cavern will mainly encounter bedrock comprising biotite gneiss with pegmatite veins towards northeastern part and quartzite with schist bands towards the southwestern part of the chamber. Based on surface manifestation of isolated bedrock and sub-surface data, it is estimated that the proposed powerhouse cavern will encounter mostly fair to good rockmass along its entire length.

8.2.7 Seismicity and Seismotectonics

As per the seismic zoning map of India (IS 1893: Part- I (2002)), the area around the proposed Attunli Hydroelectric Project is located in Zone V. The site specific earthquake design parameters are approved by National committee (NCSDP). The site specific design earthquake parameters for MCE and DBE conditions are recommended as 0.56g and 0.32g for horizontal and 0.37g MCE and 0.21g DBE for the vertical ground motions. Data for time history of earthquake ground motion for the dynamic analysis of the dam (given in Appendix-C of Volume-IX) are normalised to unit ZPA. The strong motion duration is estimated to be 10s. For MCE and DBE time history analysis, ground motion data as given in Appendix-C have to be multiplied by 0.56g and 0.26g, for both horizontal and vertical components. Safety criteria as indicated in the report and as applicable may be followed in the designs of the structures.

8.2.8 Geothermics

As per Map Showing geothermal Provinces of India appended in Geothermal Atlas of India published in 1991 by Geological Survey of India, the proposed project is located in Himalayan Geothermal Province northeast of Tidding Suture Zone. Scanning of available records and data indicates that hot water springs have not been reported in the area surrounding the project. However, personal information collected from local inhabitants indicates presence of a thermal spring near Anini. But no other details about the spring could be obtained. In addition, none of the drill holes and drifts executed at the site encountered geothermic conditions till now. Therefore, possibility of encountering hot water during underground excavations can be considered remote.

Although the possibility of encountering hot water in underground excavation is remote but if at all the situation so demands, the environs inside the tunnel or cavern have to be conditioned to create proper working environments to minimize the impact of high temperature and humid condition. This would require lowering of ambient temperature and humidity, which can be achieved by circulating cold water and air and placing of ice slabs in addition to improving ventilation system. The ventilation system should be so equipped to enable taking out the hot and humid air instead pumping in fresh air.

9 PROJECT COMPONENTS

The Project comprises of the following major civil structures:

9.1 Dam-Spillway

The proposed dam is a 85m high concrete gravity structure with a central spillway. The selected dam site is located 1.2km upstream of Apanli village and 130m downstream of Kachi nallah, at latitude 28º40’01”N and longitude 96º07’01”E. River bed elevation at the selected site is 1289m. Based on subsurface geological explorations, the deepest foundation level for the dam is estimated at El.1277m; the dam crest is proposed at El. 1362.0m.

The width of valley at top of dam is about 170m. The total length of dam at top is about 204m with 13 concrete blocks. Plan layout comprises of central overflow blocks (five nos), one block on the right adjacent side having an auxiliary spillway. They are further flanked by non-overflow bays, three on left bank and four on right bank.

Each spillway opening has a size of 8.0m (W) x 12.8m (H) and the log bay is of size 5.0m (W) x 4.0m (H). Sill of the main spillway is placed at El. 1310.0m and that of log bay at El. 1356.0m.

9.2 Reservoir

The full reservoir level and minimum drawdown level of reservoir have been fixed at El. 1360.0m and El. 1349.0m, respectively, providing a live storage volume of 2.76 x 10^6 m^3 which is sufficient for three hour peaking requirements at full installed capacity. The total area of submergence is 31.25 ha.

9.3 Intake

The intake is located on the left bank of the Tangon river, about 10m upstream of the dam axis. Three intake openings, each having five trash rack bays, each 3.2m wide and with invert at El.1336m, are provided. Each bay is equipped with trash racks to remove floating debris/logs.

9.4 Inlet Tunnels

The water is conveyed from intake to each desilting chambers through independent inlet tunnels. Three modified horseshoe shaped inlet tunnels of 5.8m finished diameter are provided. Lengths of the three tunnels are 271m, 302m and 333m.

9.5 Desilting Chambers

Three underground desilting chambers have been envisaged to help eliminate suspended sediment from the diverted water. Dufour type chambers have been designed to extract suspended particles greater than 0.2mm in size with a settling efficiency of 90%. Each chamber is 350m long and has cross sectional dimensions of 17.0m (W) x 24.0m (H), which ensures a desired flow velocity.

9.6 Headrace Tunnel (HRT)

Based on the detailed alternative studies, the HRT is aligned on the left bank of Tangon river. A 9.4m diameter circular tunnel has been proposed with a length of 7955m. Flow velocity for design discharge of 278.8m^3/s would be 4.02m/s. The HRT is envisaged to have three kinks/bends along its alignment. In addition to the adits at the inlet end and near the surge shaft, three intermediate adits are also provided to facilitate the tunnel construction. These adits are 358m, 297m and 179m long.

9.7 Surge Shaft

A restricted orifice type vertical shaft of 21m internal diameter and 93m height is provided to accommodate the variable water levels during transient conditions in the system. The maximum upsurge in surge shaft for the critical loading condition is computed as El. 1397.5m and minimum surge levels is computed as El. 1319.9m. Considering these water levels, the top level of surge shaft is kept at El. 1399.0m and bottom at El. 1306.0m (the level of the top of orifice slab).

9.8 Butterfly Valve Chamber

Butterfly valves have been provided in the upper horizontal portion of each of the pressure shafts that emanates from the surge shaft. A 58.0m (L) x 10.0m (W) x 21.0m (H) cavern is provided to accommodate these valves. The valves are 5.2m in diameter and centerline of the valves is at El. 1308.6m.

9.9 Pressure Shaft

Two 5.2m diameter main pressure shafts originate from the surge shaft and after an initial horizontal alignment drop down vertically to the machine centerline level. Length of each pressure shaft is about 318m out of which 247m is in vertical drop. At the machine centerline level, each of the shafts gets bifurcated into two unit penstocks of diameter 3.7m, each, to feed the four turbines in the powerhouse cavern. Steel liner of ASTM A-537 Class-II and ASTM A-517 Grade-F are proposed to be provided in the pressure shaft with a limiting plate thickness of 40mm.

9.10 Powerhouse

An underground powerhouse is provided to accommodate the four 170MW turbine-generating units and their auxiliary equipment. Size of the powerhouse cavern is 135.0m (L) x 23.5m (W) x 52.0m (H). A 20m long control block is provided at one end of the cavern and a 35m long service bay is provided at the other end. An 8m wide D-shaped tunnel is provided as the Main Access Tunnel for the powerhouse. The tunnel is 465m long. Another 265m long adit is proposed for construction of the cavern, meeting it at the crown level. The service bay level is at El. 1074.0m, turbine centerline at El. 1061.0m and crown of powerhouse cavern is at El.1099.0m.

9.11 Transformer Hall

Thirteen single phase generator transformers have been provided, housed in an underground transformer hall cavern. The gas insulated switchyard equipment is also proposed to be located in the same cavern on a concrete floor above the transformers. The total size of transformer cavern is 153.2m (L) x 16.5m (W) x 25m (H).

9.12 Collection Gallery

A rectangular chamber, 90m (L) x 13.5m (W) x 47m (H), is provided to collect the turbined water from machine draft tubes, which culminate in this chamber. The minimum, normal and maximum tailwater levels in the gallery will be El. 1067.8m, El. 1073.7m and El. 1089.7m, respectively.

9.13 Tailrace Tunnel (TRT)

From collection gallery the water is conveyed through a 10m wide D-shaped tailrace tunnel and is discharged back into the Tangon river. Total length of TRT is about 570m. At the outfall, the TRT gets transitioned into two rectangular sections of 5.0m (W) x 9.5m (H), each. Gates of the same size are provided at this location to control the flow of water when required. The minimum, normal and maximum tailwater levels in the river at outfall location are El. 1067.7m, El. 1070.6m and El. 1083.0m, respectively.

10 HYDRO-MECHANICAL EQUIPMENT

Hydro-mechanical (HM) equipment on the project comprise spillway radial gates and stoplogs, auxiliary spillway gate, gates for the diversion tunnels, the intake, desilting basin, silt flushing tunnel, draft tubes, tailrace outfall and adits (access doors). Trash racks and trash rack cleaning machine comprise the other hydro-mechanical equipment. A brief description of the HM equipment is provided below.

The spillway is equipped with five radial gates for opening size 8m (W) x 12.8m (H). One set of sliding type stoplogs is proposed to cater to the maintenance requirement of the radial gates. The auxiliary spillway is provided with a vertical lift fixed wheel type gate along with bulkhead gate.

Closure of the diversion tunnels will be achieved by lowering individual vertical lift, fixed wheel type gates. All the gates will be lowered by individual fixed rope drum hoists of adequate capacity mounted on steel trestle.

Inclined trash racks are provided on the upstream face of all the intake. Trash collected on the trash rack panels shall be removed by trash rack cleaning machine. The intake is also equipped with vertical lift fixed wheel type intake gates, along with slide type bulkhead gates.

The desilting basins are provided with gates on their downstream end. The flushing tunnels are also equipped with gates.

All draft tubes are provided with fixed wheel type vertical lift gates to cater to their maintenance requirement. All draft tube gates will be operated by means of individual rope drum hoists.

Fixed wheel type gates of requisite size have been provided at the Tailrace Tunnel outfall structure to stop the flow from the river into the tailrace tunnel during high flood.

Manually operated hinged type gate is provided in the concrete plugs in Adit A-2 of the HRT.

11 ELECTROMECHANICAL EQUIPMENT

Principal electromechanical equipment in the powerhouse include

- Four Francis turbines, each of rated capacity corresponding to generator output of 170 MW at rated net head of 267.13m and rated speed of 250 rpm; along with their governors and oil pressure system
- Four spherical type main inlet valves
- Two butterfly type penstock valves
- Four vertical shaft, salient pole and semi umbrella type synchronous generators along with their excitation system and isolated phase bus ducts. The generators are rated for 200MVA with 0.85 PF lag, 250 rpm, 50 Hz with an output voltage of 13.8kV. The generator will also be capable of operating at 10% continuous overload.
- Thirteen (12 in service and one as spare) 75 MVA, 13.8 kV, 400 kV, 50 Hz, single phase step-up transformers
- GIS equipment
- Mechanical auxiliaries, such as Cooling water system; Drainage and dewatering system; Low pressure compressed air system; Oil handling system; Heating, Ventilation and Air Conditioning system; Fire fighting system; Electric overhead traveling cranes; Elevators; DG Sets; Mechanical workshops;
- Electrical auxiliaries such as Station Auxiliary AC Supply system; Station DC Supply system; Digital distributed control system and SCADA; Protection system; Cabling system; Communication system; Illumination system; Grounding system; Electrical workshop

The above equipment is located in an underground powerhouse complex situated close to Attunli village. Given the ~270+m of operating net head, Francis turbines are provided in a vertical axis configuration. The turbines are directly coupled to the synchronous generators. Main inlet valves of spherical type are provided at the inlet of each turbine for isolation during shutdown and maintenance.

The generators are directly connected to step-up transformers through isolated phase bus ducts. The step-up transformers are located in a separate transformer cavern adjacent to the main powerhouse cavern. GIS equipment is located on a concrete floor provided in the transformer hall above the transformers. HV side of the transformers will be connected to the

GIS through GIB (Gas Insulated Bus). Power generated from the Project will be evacuated through XLPE cables to a surface pothead yard and pooled into the nearest pooling station through a 400 kV double circuit overhead transmission line.

A 3-Phase, 400/11 kV Station Auxiliary Transformer (SAT) of 50 MVA is provided for meeting station and unit loads. The transformer shall be connected to GIS.

The GIS shall be double bus arrangement with ten bays comprising 4nos. of Generator/Transformer incoming bays, 2nos. outgoing bays, 2nos. of shunt reactor bays, 1no. Bus Coupler and 1no. Station Auxiliary Transformer bays.

The pothead yard area shall accommodate PTs, CTs, DIS connecting switch, earthing switch, CVT, wave traps and lightning arresters.

Interconnection between GIS and outdoor pothead yard equipment shall be through XLPE cables.

Two 200/32/10 MT EOT cranes are provided in the machine hall of the powerhouse. One 100/20 MT EOT crane is provided in butterfly valve chamber for handling valve components during erection and maintenance. One 10 MT pendant operated EOT crane is provided in the GIS hall for handling the GIS equipment.

Two 11 kV, 800 kVA DG sets are provided as emergency source of power.

Power Evacuation

Entire power generated at the project will be evacuated through a 400 kV double circuit, ACSR-conductor line to the nearest pooling station.

12 PROJECT CONSTRUCTION PLANNING

The Project lies in an area with heavy rainfall. In developing the schedule, 8 months of working is considered for surface works. The work has been planned for three shift working throughout the year as the work involves cyclic operation.

Period of construction of the project has been estimated as 7.5 years (90 months), including 2.5 years (30 months) for pre-construction activities. The pre-construction period is from April 2018 to September 2020. It is envisaged to commence the main construction works by October 2020. The total period of construction for the main works is estimated as 5.0 years (60 months), with the commissioning of all units for power generation by September 2025.

13 INFRASTRUCTURE WORKS

13.1 Project Approach

Project site is accessible by railway up to Dangari railway station on the south bank (Assam side) of Lohit river which is connected with broad-gauge rail line. Tinsukia is the nearest rail yard from this head. Tinsukia is connected to Project via Dhola/Sadiya Ghat by road which is about 290km. The bridge on Lohit river connecting Dhola and Sadiya Ghats is now complete and known as Bhupen Hazarika Setu.

The nearest sea port is Haldia port at Kolkata. The Haldia port is connected to nearest waterway head at Sadiya Ghat through India-Bangladesh protocol route from Haldia port to Bangladesh border and from Bangladesh border to Sadiya Ghat by national waterway number 2. The nearest airport is at Dibrugarh which is 378km from project site via Dhola/Sadiya Ghat. The nearest operational helipad is at Anini which is 60km from Etalin and about 80km from project site.

13.2 Roads

A single lane road exits in the project area. A network of roads is required to approach various locations of project components such as dam, adit portals, surge shaft, powerhouse, pothead yard, Main Access Tunnel (MAT) and Tailrace Tunnel (TRT) portal, dumping yards, quarry locations etc. It has been assessed that about 22km length of new roads are required to be constructed to facilitate construction of various components.

Apart from the proposed new road, 16km stretch of existing roads in the project area (from Etalin Tangon dam site to Attunli HEP dam site) needs to be widened and strengthened for the movement of heavy equipment and machinery round the year.

The exiting single lane road from Roing to project site having length of 200km also needs to be widened to double lane to transport the electro-mechanical equipment to site. The upgradation of existing road as well as construction of low altitude new road from Roing to Anini are presently under progress and is being undertaken by National Highways and Infrastructure Development Corporation (NHIDCL), which shall help immensely for the logistics of Attunli HEP. However, the time for completion is estimated as 2021, which needs to be expedited to match the construction schedule of Attunli HEP.

13.3 Bridges

About ten bridges in project area with span ranging from 10m to 60m needs to be strengthened to 70R loading. There are 19 bridges between the Roing to Etalin stretch of road which is maintained by BRO. Out of these 19 bridges only 2 bridges are of 70R capacity, whereas only 4 are of 40R capacity and remaining 13 bridges are designed for less than 40R loading. All these bridges need to be strengthened for 70R loading. This work is also likely to be completed during the implementation of the Etalin project.

Five bridges of span ranging from 60m to 45m, needs to be constructed to approach various project components.

13.4 Quarries

Requirement of raw material for coarse and fine aggregates has been estimated as 9.10 Lac and 6.20 Lac cum, respectively. In order to meet this obligation, quarry locations have been identified within the project area, out of which 3 are shoal quarries and 3 are rock quarries.

13.5 Muck Disposal

The total quantity of excavation for various structures works out to 46.40 Lac cum, out of which about 15.7 Lac cum shall be reused as construction material. The quantity to be disposed off to dumping sites works out to be 45.27 Lac cum (includes swell factor). About 81ha area has been demarcated at nine locations for muck disposal. Nine muck dumping sites have total capacity of about 50 Lac cum.

13.6 Land Requirement

Total land requirement for various project components is estimated as 261.53 ha, of which 14.19 ha is a notional area for underground project components.

13.7 Construction Power

There is no grid power available in the region. Power requirement during project construction is estimated to be 9.6MW (12 MVA) and is proposed to be supplied through DG sets.

14 ENVIRONMENTAL AND ECOLOGICAL ASPECTS

A brief description of environment and ecology related aspects of the project is given in this section. Detailed Environment Impact Assessment is underway as part of a separate study for which ToR have been established by Ministry of Environment, forest and climate.

14.1 Soils

The general and average soil character of cultivable land in the Dibang valley district is mainly alluvial and composed of a mixture of sand and clay in varying proportions. Soils in the area are results of degradation and weathering of rocks as well as depositional features in the form of river terraces. The soil on the slopes is mainly composed of silt and support good vegetation. The clayey soils formed on river terrace due to river deposits are fertile and have been developed into paddy fields by the local inhabitants.

14.2 Water Quality

The atmospheric temperature was recorded from 12ºC to 14ºC during the study period. Temperature of the river water ranged from 8.0ºC to 11.5ºC and its electrical conductivity ranged from 61 to 72 μS/cm. The pH of the river water was slightly alkaline. The dissolved oxygen of the river water was quite high and ranged from 11.04 to 11.34 mg/l. The chloride concentration in the water ranged from 11.36 to 13.06 mg/l while, nitrate and phosphate ranged from 0.021 to 0.031 mg/l and 0.005 to 0.010 mg/l at different locations in Tangon river. The water quality of the river is good.

14.3 Forest Types

Dibang Valley District is almost entirely hilly and covered mostly by forests which are almost 52% of the total geographical area of the valley. The Tangon valley is characterized by dense tropical evergreen, tropical semi-evergreen, subtropical forests at lower elevation and pine, temperate broadleaved, temperate conifer and Alpine forests at higher elevations.

The primary forests are destroyed due to the impact of various adverse biotic and abiotic factors like shifting cultivation or “Jhumming”, development activities and urbanization, landslides, fires, etc. and develop into secondary forests which can be classified as Degraded Forest, Bamboo and Musa Forest and Grasslands.

14.4 Vegetation in the Project Area

The right bank slopes in the project area are sun facing while left bank has north facing slopes. The right bank is composed of grass lands and bamboo breaks on hill tops with some *Pinus merkusii* and dense forest canopy near river bank. Left bank is represented by dense canopy forests interrupted by bamboo breaks and patches of *Musa* sp*.*

Dam site area is characterized by the Sub-tropical and Pine forest on the higher elevations and Temperate broadleaved forest nearby the river bank.

The project area harbours number of plants of economic and medicinal importance.

14.5 Faunal Elements

The project site falls in the Anini Social Forestry Division in Dibang Valley district.

Wildlife is encountered only in the upper reaches and the upper catchment of the project area and comprises number of mammalian species, comprising primates, cats, dogs, civets, etc. The avifauna is comprised of hornbills, pheasants, jungle fowl, stork, pigeons, owls, cuckoos, kingfishers, babblers, drongos, mynas, parrotbill, magpies, robins, owlets, etc. The reptiles are comprised of *Varanus bengalensis* (Bengal monitor) and 9 species of snakes.

14.6 Aquatic Ecology

The phytoplankton communities in Tangon River are dominated by Bacillariophyta. The phytoplankton, zooplankton and benthos population in the project area was much lower as compared to the rivers in the plains.

The primary productivity in river Tangon at the project site is low mainly because of high water velocity and low water temperature.

Fish fauna of river Tangon is comprised of 12 species. *Badis badis*, *B. dario*, *Barileus* barna, *B. bendelisis*, *B. bola*, *Puntius chola* and *Chagunius chagunio* are some of the common fish species. Some of these fishes are of commercial importance and are used by local for food and sustenance.

14.7 Socio-economic Aspects

The total area covered by Dibang Valley district is 9129 sq km and population according to 2011 census is 8004; male population is 4414 and female population is 3590. Density of population per sq km is 1 (approximate). The population belongs to mainly Idu-Mishimi tribal group.

Sex Ratio is 813 per 1000 male compared to 2001 census figure of 697. In 2011 census, child sex ratio is 889 girls per 1000 boys compared to figure of 874 girls per 1000 boys of 2001 census data.

<u>Literacy</u>

Dibang valley district has average literacy rate of 64.10%. Literacy rate of male and female population in the district is 68.07% and 59.16%, respectively.

<u>Miscellaneous</u>

Agriculture is one of the major occupations of the locals in the area. Dibang valley district is home to one of the main tribal population group of Arunachal Pradesh i.e. the Idu Mishmis. While this tribe is witnessing a steady change in the field of socio-cultural, economic and to some extent in religious aspect, people who are living in the more remote interior villages have not been much exposed to modern life style.

14.8 Assessment of Impacts

The following impacts are envisaged as a result of construction of the project. Suitable mitigating measures will be suggested during the detailed Environmental Impact Assessment study.

<u>Impacts on Land Environment</u>

The total land requirement for various project activities is about 261.53ha ha. The 85m high dam would submerge about 31.25ha of area. As a result changes in land use pattern of the project area is likely to take place.

<u>Impacts on Terrestrial Flora and Fauna</u>

During the construction phase, a large number of machinery and construction labour will have to be mobilized. There would be some impacts due to increased human interference.

Impacts on Avi-Fauna

The damming of the river will lead to formation of reservoir, which will have a daily fluctuation in the water level keeping the reservoir banks wet throughout the year. Grasses would grow along the reservoir banks attracting water birds to flock the area in a large number. This can become an ideal habitat for migratory birds during winter.

Impacts on Aquatic Ecology

The major physical change in the upstream of the proposed dam will be formation of a lacustrine habitat from a riverine habitat, whereas below the dam site, there will be regulated water in river course downstream of the dam (up to the outfall of the Tailrace Tunnel). As such free movement /migration of migratory fishes may be affected resulting in some changes in the aquatic ecology in this stretch. Changes in the physico-chemical parameters of the reservoir water are anticipated due to conversion of lotic environment to lentic environment.

Impacts on Socio-Economic Environment

The relevant impacts are being studied as part of detailed Environment Impact Assessment and would include formulation of detailed Resettlement & Rehabilitation Plan (R&R) as per the guidelines of NRRP 2007 and Arunachal Pradesh State R&R Policy (2008) for the project-affected.

14.9 Environment Management Plan

Based on the assessment of environment impacts, the following management plans are proposed to minimize the same.

Catchment Area Treatment Plan

Entire catchment (2358 sq km) would be taken up for the preparation of CAT plan. The area falling under severe and very severe category will be identified for treatment, based on sediment yield index (SYI) method. Suitable engineering and biological measures would be adopted.

Resettlement and Rehabilitation

The number of project affected families, if any, shall be known after the conduct of the field studies. R&R package would be formulated as per NRRP 2007 and Arunachal Pradesh State R&R Policy (2008).

Compensatory Afforestation Scheme

As project would require diversion of forest land for non-forest use, under the Forest (Conservation) Act 1980, a compensatory afforestation plan would be prepared which will be undertaken by the State Forest Department of Arunachal Pradesh and shall be implemented along with other soil conservation measures.

Biodiversity Conservation Plan

It is proposed to take every measure to minimize the habitat fragmentation and loss by taking up biodiversity conservation measures. Implementation of the plan will be done in consultation with the State Forest Department of Arunachal Pradesh.

Sewage and Solid Waste Disposal Plan

The sewage and solid waste generated from the residential colony is planned to be treated before disposal.

Reservoir Rim Treatment Plan

The creation of reservoir might result in instability of slopes situated on the reservoir rim. Different engineering and biological measures would be adopted depending upon topography, vegetation, soil types etc.

Reservoir Fishery Development

In order to alleviate the effects of the proposed project, fish transport and fish rearing and stocking schemes would be taken up in consultation with State Fisheries Department. A minimum flow of water to cater to ecological needs as approved by Ministry of Environment, forest and climate is proposed to be released below the dam to create a reasonable flow condition for sustenance of aquatic life.

Restoration of Quarry Areas

Construction of dam and other civil structures shall require construction material. After quarrying of the selected areas, these will be properly restored by restoration measures comprising biological measures (such as seeding and planting) and technical measures such as re-grading.

Restoration of Muck Disposal Area

Large amount of muck would be excavated during construction phase of the Project especially from the headrace tunnel. Although considerable quantity of the muck will be utilized for construction of project infrastructure and permanent structures, the balance quantity will be dumped at selected muck disposal sites which will be suitably restored.

Green Belt

Based on climate, soil type and vegetation composition in the area, a green belt plan shall be formulated to enhance forest cover, prevent land degradation, and minimize soil erosion.

Provision of LPG/ Fuel Wood Depots

It is proposed to make proper arrangements to meet the demand of fuel supply to the work force so that illegal felling of trees by the labourers working in the project is minimized.

Health and Hygiene

Sanitary latrines will be constructed for the entire workforce so that water bodies are not contaminated with faecal coliforms. Suitably equipped hospital and other medical facilities would also be ensured.

14.10 Environmental Monitoring Program

An Environment Management Cell will be created at the project site to co-ordinate the implementation of various environmental management plans suggested in the EMP Report and for monitoring of the same for assessing the progress and preventing the lapses if any.

A periodical monitoring system on water quality, soils, land use, erosion, siltation, ecology, health measures etc. would be evolved to address the various environmental issues around the project area.

15 PROJECT COST AND ECONOMIC ANALYSIS

Project's capital cost has been determined as per the standard guidelines issued by the Central Electricity Authority (CEA) and Central Electricity Regulatory Commission (CERC) norms for hydro projects.

The project cost is estimated at November 2015 price level and works out as under

- Cost of Civil Works including HM works ₹ 2,650.32 crores
- Cost of E&M Works ₹ 1,055.92 crores

Total Hard Cost ₹ **3,706.24 crores**

In order to determine the completed cost, phasing of these costs is carried out using the implementation schedule. The following factors are used to calculate escalation and interest during construction:

- Base date of estimate – November 2015
- Pre-Construction period – 30 months from April 2018 to September 2020.
- Start date of main construction – October 2020.
- Total construction period including commissioning - 60 months from 1st October 2020 to 30th September 2025.
- Commission period of 4 units – 4 months.

Phasing of expenditure has been done on six monthly basis. Escalation rate of 5.35% p.a. in Civil Works and 6.10% for Electromechanical Works is considered.

For DPR level studies, the project is considered to be financed at a Debt: Equity ratio of 70:30. The interest rate is taken as 11.50% per annum on loan component and 12.75% on working capital. The interest during construction is calculated for a period of five years starting from October 2020. As per calculation the IDC for the project is estimated as ₹ 1063.87 crores and financial charges as ₹ 43.87 crores.

The financial analysis is based on the Design Energy of the project, i.e. 2796 million units. Auxiliary consumption including transformation losses as per CERC (@1.2%), and free power to the state (13%) have been considered in the financial evaluation. The net saleable energy is 2403.33 million units.

Levelized tariff at bus bar has been calculated. The results of cost and financial analysis are summarized below:

- Installed Capacity 680 MW
- Annual Design Energy (for 95% machine availability) 2796 MU
- Capital cost*
  - Total Hard Cost ₹ 3,706.24 Crores
  - Escalation ₹ 1,453.83 Crores
  - IDC and Financing charges ₹ 1,107.74 Crores
  - Total Project cost ₹ 6,267.81 Crores
- Project Cost / MW ₹ 9.22 Crores/MW
- Levellized Tariff as per CERC (with 12%+1% free power to state) ₹ 5.46 / kWh

* Transmission Line cost are not included.