DUGAR HYDRO POWER LIMITED

(A Joint Venture of Tata Power & S N Power)

DUGAR HYDRO ELECTRIC PROJECT

CHAMBA DISTRICT, HIMACHAL PRADESH | INDIA

DRAFT DETAILED PROJECT REPORT

VOLUME – I

MAIN REPORT

November 2014

Innovation by experience

DUGAR HYDRO ELECTRIC PROJECT

DRAFT DETAILED PROJECT REPORT

VOLUME I	**:**	**MAIN REPORT**
VOLUME II	:	HYDROLOGY
VOLUME III	:	GEOLOGICAL AND GEOTECHNICAL STUDIES
VOLUME IV	:	DRAWINGS
VOLUME V	:	APPENDIX
VOLUME V [A]	:	GLOF STUDY
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EXECUTIVE SUMMARY

PROJECT LOCATION

Dugar HEP is located on Chenab River near Killar village in Chamba district of Himachal Pradesh. The latitude and longitude of project site are N 33° 07′ 05″ and E 76° 21′ 20.7″ respectively. The Dugar project site lies between the Sachkhas HEP (267 MW) at its upstream and the Kirthai-I HEP (390 MW) at downstream. The project site is located near Luj village which is about 10 km from the nearest town, Killar.

The nearest rail heads are the railway stations Udhampur and Pathankot. Udhampur Railway Station is in Udhampur city in the state of Jammu & Kashmir, while Pathankot Railway Station is in Pathankot city in the state of Punjab. The distance from Udampur to project site is about 270 km.

The nearest airports are Kullu-Manali and Jammu. The distance from Kullu to project site is about 279 km and from Jammu to project site is about 332 km.

The location of the project is shown in **Figure 1**.

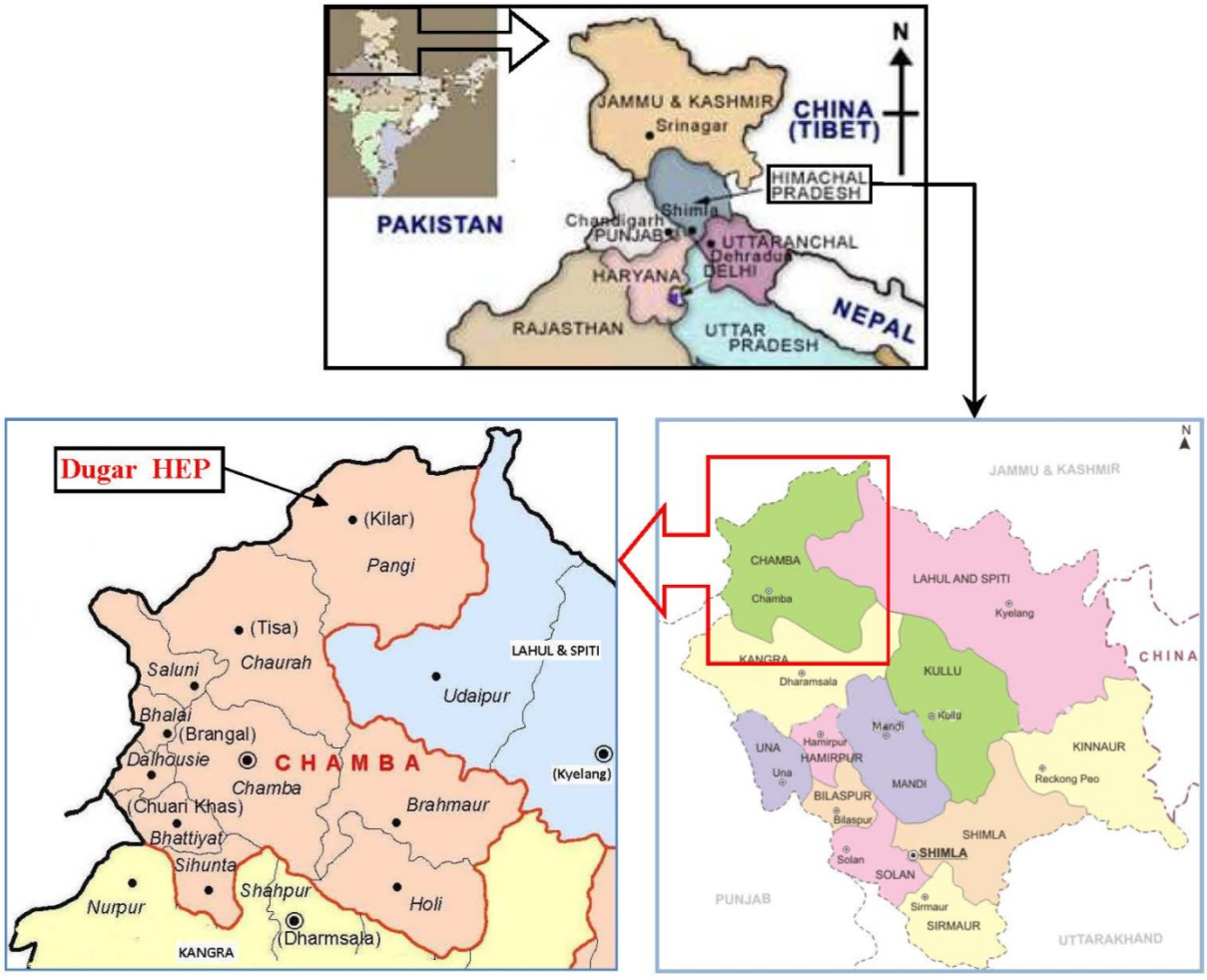

Figure 1: Location Plan of Dugar HEP

ABOUT THE PROJECT

This greenfield project has been awarded to the consortium "Tata Power Company Ltd. and SN Power Holding Singapore Pte. Ltd." (Owner) in May 2011, by Directorate of Energy - Government of Himachal Pradesh on Build-Own-Operate-Transfer (BOOT) basis for a period of 40 Years from Commercial Operation Date. To implement the project, the Owner has constituted a Special Purpose Vehicle (SPV) by the name of M/s Dugar Hydro Power Limited (DHPL).

The Dugar Hydro Electric Project (449 MW) is envisaged as a run-of-river scheme for utilizing the flows of Chenab River to harness the head created by constructing a 128 m high (from deepest foundation) dam near Luj village with FRL of EL 2114.00 m asl and the proposed underground power house located on the left bank of Chenab River just downstream of dam. It is a medium head scheme with rated net head of 91.21 m having Full Reservoir Level (FRL) and Minimum Draw Down Level (MDDL) as 2114.00 m asl and 2102.35 m asl respectively. It is essentially a run-of-river scheme with diurnal storage for generation of electricity. The project comprises of a 128 m high concrete gravity dam (from deepest foundation level), 2 Nos. underground circular pressure shafts of length 270 m and 307 m. Each pressure shaft is bifurcated upstream of the unit valves. An underground power house is envisaged followed by a tailrace surge chamber and two tail race tunnels of finished diameter as 7.8 m. The tail race tunnels, located on the left bank of the Chenab River, are discharging back into Chenab River at a distance of about 725 m downstream of dam axis with normal tail water level as 2015.00 m asl (under normal operating condition) and minimum tail water level as 2012.26 m asl.

To harness the environmental flow during lean season and non-lean non-monsoon season three units each of 23 MW are housed in the power house cavern. Therefore the total capacity of plant shall be 449 MW (380 +69 MW).

The main components of the project are:

- A 128 m high concrete gravity dam (from the deepest foundation level) located on River Chenab at Latitude N 33° 07′ 05″ and longitude E 76° 21′ 20.7″.
- Two numbers main intakes and one intake for auxiliary power house located at the left bank.
- Two numbers main pressure shafts and one pressure shaft for auxiliary power house.
- Underground cavern housing four number main units of 95 MW each and three units of 23 MW each for auxiliary power house.
- Transformer Cavern located upstream of power house cavern.

- Four number main TRTs having Surge Chamber at the upstream end and one TRT for auxiliary power house discharging downstream of dam.

To facilitate the construction and operation of the project components, suitable adits and access roads have been proposed.

CLIMATE

The sources of runoff in the Chenab basin are both rain and snowmelt. The flows during March to June are largely contributed by snowmelt, although pre-monsoon rainfall also contributes to a certain extent. From July to September, the river carries high discharges due to monsoon precipitation combined with snow melt. The minimum flows occur during the winter months of December, January and February as in all snow fed Himalayan Rivers.

DHPL has installed an Automatic Weather Station near the project site. Average maximum temperature at diversion site ranges from -2.5^{0}C in January to 20.2^{0}C in July.

HYDROLOGY

The catchment area of Chenab River upto Dugar diversion site is estimated as 7,823 km^2 from the SRTM data. With the permanent snowline at 4500 masl, the snow fed catchment is 4,458 km^2 and the remaining 3,365 km^2 is rain fed.

For the various data consistency checks it is found that the discharge data of Udaipur G&D site is consistent and reliable. The proposed Dugar HE Project is located downstream of Udaipur Gauge & Discharge site. The catchment area ratio of Dugar HEP (7823 Km^2) and Udaipur G&D site (5910 Km^2) is 1.32. The observed 10-daily flow at Udaipur for the period 1974-75 to 2011-12 has been considered for the computation of long-term flow series at Dugar HEP. The 10-daily observed flow series at Udaipur G&D of CWC for the period 1974-75 to 2011-12 has been utilized for the present study and transferred to Dugar diversion site in catchment area proportion. **The flow series of Dugar HEP has been conveyed by Central Electricity Authority (CEA) vide their letter no. 2/HP/52/CEA/2013-PAC/6826-28 dated 12th December 2013**.

The 90% and 50% dependable years works out to 1993-94 and 1980-81 respectively.

The total available flows at the diversion site are plotted as flow duration curve in **Figure 2** and also given in **Table 1.**

Table 1: Results of Flow Duration Curve

Exceedance (%)	Discharge (m^3/s)	Exceedance (%)	Discharge (m^3/s)
5	1050	55	106
10	897	60	95
15	771	65	87
20	645	70	81
25	511	75	75
30	381	80	68
35	267	85	60
40	198	90	52
45	156	95	44
50	127	100	29

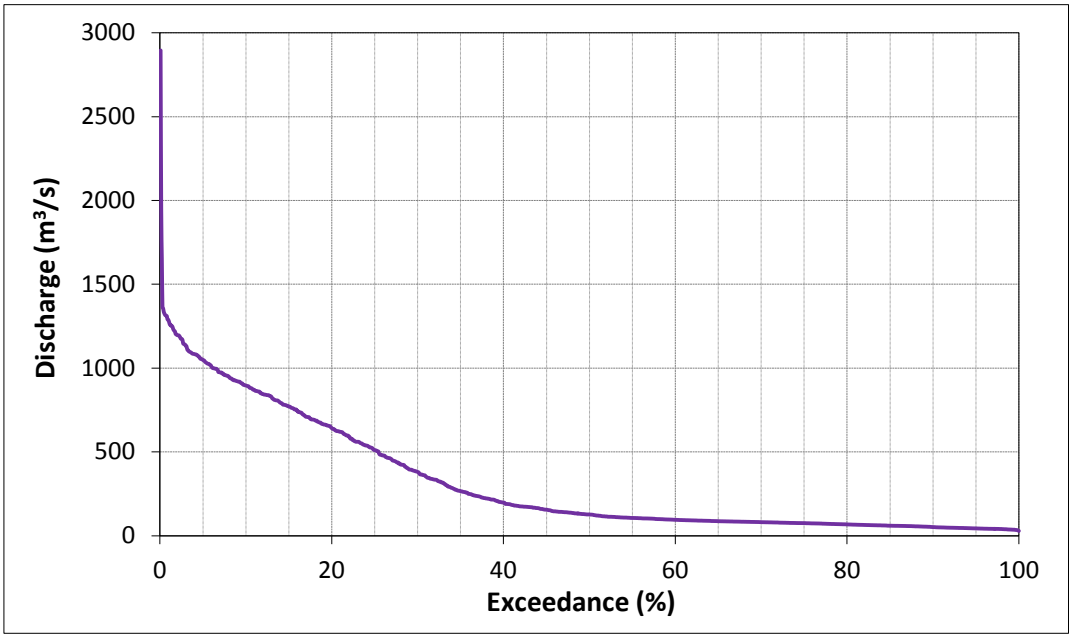

Figure 2: Flow Duration Curve for Ten Daily Available Discharges at Dugar HEP Dam Site (1974-75 to 2011-12)

The design floods for the project are worked out from hydro-meteorological approach and frequency approach. **The following design floods for Dugar HEP has been conveyed by Central Electricity Authority (CEA) vide their letter no. 2/HP/52/CEA/2013-PAC/868-70 dated 5th March 2014**.

Probable Maximum Flood (PMF)	9,425 m^3/s
25 Year return period (~Q_{25}) monsoon flow	2,700 m^3/s

INDUS WATER TREATY

Dugar HEP lies on the Chenab Main River in district Chamba, Himachal Pradesh and is governed by the relevant provisions of "Indus Water Treaty 1960" (IWT) signed between India and Pakistan. The maximum pondage as per IWT "shall not exceed twice the Pondage required for Firm Power". **Central Electricity Authority (CEA) vide their letter no. 2/HP/52/CEA/2013-PAC/163-64 dated 9th January 2014 has conveyed the maximum pondage as 19.58 Mm^3**. The live storage has been kept as 16.57 Mm^3 which is less than the maximum pondage as per IWT. The reservoir area-capacity curve is given in **Figure 3** below.

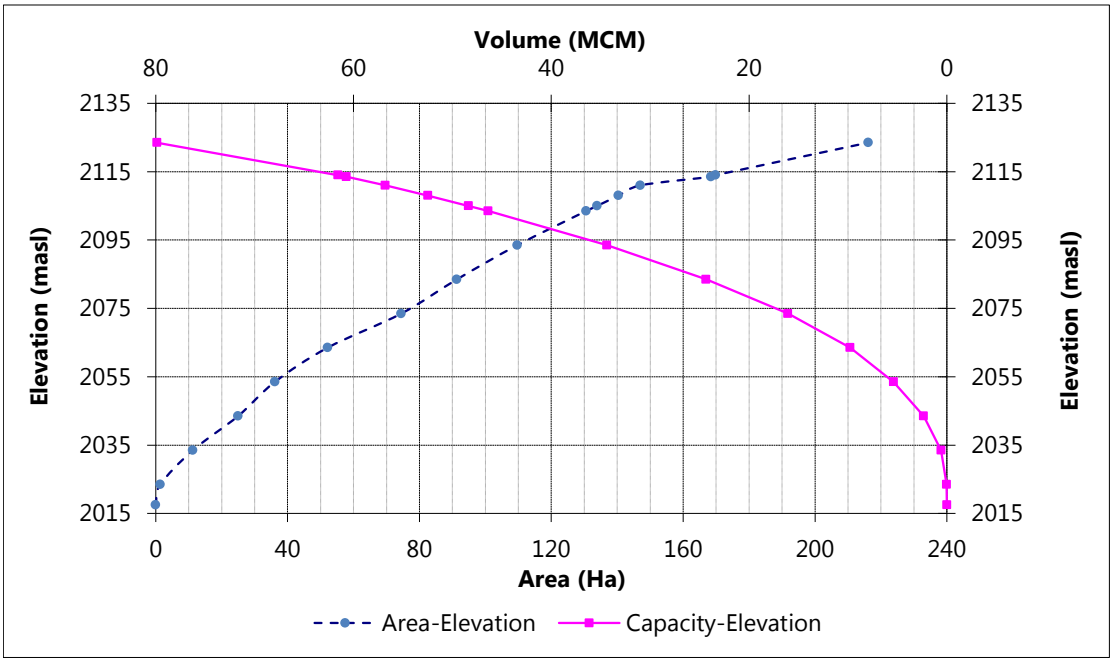

Figure 3: Reservoir Area-Capacity Curve

GEOLOGY

Regional Geology

The Dugar HEP is located within the Central Crystallines represented by the Vaikrita Group of rocks. Regionally, the area around the project comprises litho-stratigraphic sequence from Proterozoic to the Quaternary in age including Salkhala Group and Chamba, Manjir, Katarigali, Bhaderwah and Dul Formations. The regional litho-stratigraphic sequence has been summarized in Table.1 The rock formations in the immediate vicinity of the project area include granitoids belonging to the Rohtang Crystalline Complex towards north and east, and Batal Formation of Haimanta Group further north and towards south.

Project Geology

The project area lies in the zone of Central Crystallines belonging to Vaikrita Group and hence dominated by a variety of gneissic rocks. Large areas on right bank are under the colluvium cover for which rock outcrops along the roads are rather infrequent and limited in extent. Extensive rock outcrops are found exposed along Punto road. In general, biotite gneiss is the most dominant rock type in the mapped area. The strata have been intruded by a number of pegmatite and granite bodies which are both concordant as well as discordant. In addition to the biotite gneisses, beds of banded gneiss, augen gneiss, granite gneiss, micaceous quartzites and mica schist are found in the reservoir area.

In general, the broad lithological sequence in the mapped area from upstream to downstream comprises coarse grained biotite gneiss at the tail end of reservoir, followed by fine grained, dark micaceous quartzite, biotite schist, micaceous quartzite and finally medium to coarse grained biotite gneiss that continues upto and beyond dam site. The biotite gneiss towards downstream is the most prominent lithological unit occupying almost downstream half of the combined area of the project and reservoir.

Dam

The River valley at the proposed dam site is characterized by steep rocky cliffs on both banks. The cliff is developed mainly within massive bed of pegmatite which is found exposed from river bed level to the top of the cliff on right bank and from River bed level to the portal of the upper drift on left bank. Biotite gneiss is found exposed above this pegmatite bed on both banks at dam site. The biotite gneiss is also found as an approximately 9 m thick xenolithic bed on the right bank and in view of gentler slopes on the banks is found widely exposed.

Pressure Tunnels & Power House Complex

Almost the entire layout of the water conductor system and the powerhouse complex lies within thickly forested area developed over a gentle slope & confined between rock cliffs both towards the River as well as mountain side. A part of this forested area around the dam axis is particularly flatter where a rock terrace could be expected. By virtue of the thick forest cover and the consequent inaccessibility, the geological details are limited, but, based on the well exposed geological setting in the dam abutment area, it is interpreted that the layout lies within biotite gneisses with overwhelming cover of colluvium. The traverses within the accessible zones of the forest reveal the presence of thick overburden.

PROJECT FEATURES

After examining possible alternatives optimal layout has been considered as shown in attached drawings. The proposed Dugar HEP comprises of the following structures:

Concrete Gravity Dam: The dam is located near Luj village. The waterway is provided with seven orifice spillways with crest elevation 2074 m asl and two upper level overflow spillway with crest level 2102.30 m asl.

Main features include:

- Dam height from deepest foundation level	128.0 m
- Top width of dam	214.8 m
- Design Flood (PMF)	9,425 m^3/s
- Maximum Reservoir Level (MRL)	2114.00 m asl
- Full Reservoir Level (FRL)	2114.00 m asl
- Minimum Draw-Down Level (MDDL)	2102.35 m asl
- Energy Dissipation	Flip bucket

Pondage: Since Dugar HEP lies on Chenab River, therefore it is governed by Indus Water Treaty (IWT). The pondage i.e. live storage of the project has been worked out as per the prevailing provisions of IWT. Live storage of 16.57 x 10^6 m^3 has been provided between FRL of 2114.00 m asl and MDDL of 2102.35 m asl. The gross storage at FRL is 61.58 x 10^6 m^3 and dead storage at MDDL is 45.01 x 10^6 m^3. The total extent of reservoir is about 12.2 km from the dam axis.

Intake: The intake structures are located at the left bank of the Chenab River about 25 m upstream of the dam axis. To guarantee the submerging criteria with respect to the MDDL of 2102.35 m asl, the invert level is fixed at an elevation of 2084.65 m asl. The main intake structure comprises of two segments and each segment is designed for a design discharge of 229.58 m^3/s. Intake gates, trash rack and trash rack cleaning machine have been provided.

One intake for auxiliary plant is also provided along with the main intake structure with the design discharge of 87.25 m^3/s.

Pressure Shafts/Tunnels (HRT): Two underground circular pressure shafts of length 260 m and 290 m are proposed to convey water from reservoir two power house. The upper horizontal portion and the vertical shaft upto lower bend are proposed to be concrete lined. The lower bend of vertical shaft and the lower pressure tunnel are proposed to be steel lined. The internal diameter of concrete lined and steel lined pressure shaft is proposed as 8.1 m and 6.7 m respectively. Each pressure shaft is bifurcated upstream of the unit valves. The internal diameter of bifurcated pressure shaft is 4.75 m.

For three auxiliary units one combined pressure tunnel/shaft if proposed bifurcated just upstream of MIV. The total length of pressure tunnel/shaft is about 229 m. The upper horizontal portion and the vertical shaft upto lower bend are proposed to be concrete lined. The lower bend of vertical shaft and the lower pressure tunnel are proposed to be steel lined. The internal diameter of concrete lined and steel lined pressure shaft is proposed as 5.6 m and 4.1 m respectively. The internal diameter of trifurcated pressure shaft is 2.4 m.

Power House Cavern: An underground power house is foreseen on the left bank of Chenab River just downstream of the dam. Power house will accommodate four units of 95 MW each and three units of 23 MW each. The overall dimensions of power house cavern are 173.0 m (L) x 22.5 m (W) x 44.5 m (H). The turbine setting elevation for units of 95 MW is 2002.50 m asl and for 23 MW units it is 2006.50 m asl. Access to power house is through 665 m long Main Access Tunnel (MAT).

Transformer Cavern: The transformer cavern is located 40 m upstream of power house cavern. In total fourteen transformers, thirteen single phase transformers of 43 MVA each for the main power house and three three phase transformer of 13.5 MVA for the auxiliary plant will be housed in an underground cavern. The overall dimensions of transformer cavern are 155 m (L) x 14.0 m (W) x 20.5 m (H). Transformer cavern will house the 400kV GIS.

Surge & Draft Tube Gate Cavern: The underground surge cavern is located approximately 40 m downstream of the powerhouse cavern. For inspection and maintenance of the turbines, four draft tube gates are provided, within surge chamber, which will be operated from the deck at EL 2036.00 m asl. The dimensions of the each compartment are 28 m (L) x 22 m (W) x 37 m (H). The cavern comprises of four individual surge chamber of finished size 28 m (L) x 22 m (W).

Tail Race Tunnels: Four numbers unit tailrace tunnels of finished diameter 5.7 m are provided starting from the downstream of power house upto downstream surge chamber. The length of the each unit tailrace tunnel is 87.4 m. After the downstream surge chamber two unit tailrace tunnels are merged into one tailrace tunnel of 8.1 m diameter. Lengths of the two tailrace tunnels of 8.1 m diameter are 385 m and 408 m for right and left tunnel respectively. Tailrace tunnels are fully concrete-lined. Finished shape of tailrace tunnels is circular whereas the excavated profile in modified horseshoe type. At the downstream end tailrace tunnel of 8.1 m diameter is again bifurcated to two D- shape tunnels of diameter 5.7 m to reduce the size of TRT outfall structure. The tail race tunnels, located on the left bank of the Chenab River, are discharging back into Chenab River at a distance of about 725 m downstream of dam axis.

POWER PLANT

Central Electricity Authority (CEA) has conveyed the capacity of Dugar HEP as 449 MW (380 MW + 69 MW).

The generating equipment, the group of four turbines and generators each unit of 95 MW and three units of 23 MW will be of vertical shaft type accommodated in the machine hall. The centre to centre spacing of Turbine-generator units is kept as 18.5 m for 95 MW units. The lengths of Unit-1 to Unit-4 bays are kept as 18.50 m. The Erection Bay will be 26 m long and control block will be 20 m long proposed longitudinally adjacent to Unit # 7.

DESIGN ENERGY

In order to maximize the benefits of the project the optimization of installed capacity has been carried out by studying incremental energy with increase in installed capacity for 90% dependable year and takes into account the following features:

a. The hydraulic average gross head has been considered with an average reservoir level corresponding to level as 2/3(FRL-MDDL) + MDDL and considering normal Tail Water Level.

b. All major head losses which include friction loss in pressure shaft/tunnel and tailrace tunnel are determined for each installed capacity. In addition to major losses, the minor losses are also considered.

c. The combined efficiency factor for the electro-mechanical equipment is taken as 92.5%

d. The design energy for the project evaluation is considered as annual energy available in a 90% dependable year with installed capacity restricted to 95%.

The reservoir created by the dam located near the Luj village will operate between FRL 2114.00 m asl and MDDL 2102.35 m asl. The installed capacity of the main power house will be 380 MW (4 x 95 MW). The rated head of the scheme is 91.21 m and the nominal discharge is 114.79 m^3/s for each unit of 95 MW. Plant load factor for 90% and 50% dependable years are 40.5% and 46.9% respectively. The design energy during 90% dependable year at 95% plant availability is 1315 GWh. The rated head for auxiliary power plant is 89.57 m and the rated discharge is 29.08 m^3/s for each unit of 23 MW. The auxiliary power plant will have an installed capacity of 69 MW. The design energy at 95% plant availability works out to be 302.4 GWh. The total design energy from main plant as well as auxiliary plant is 1617.4 GWh (1315.0 + 302.4 GWh).

INFRASTRUCTURE WORKS

Since the project components are on the left bank of Chenab River, a permanent bridge is proposed downstream of the dam to approach the left bank and power house complex construction adits through this bridge. The road to this bridge (about 4.5 km) is planned from the existing road at right bank which is at higher elevation. One more permanent bridge is proposed to access the MAT and TRT gate operation chamber. One temporary bridge is proposed upstream of the dam axis to access the intake structure.

In addition to the permanent access roads, temporary access roads to DT inlet, DT outlet, u/s and d/s cofferdams etc., strengthening and widening of existing roads, bridges and culverts are also foreseen. One new permanent bridge is foreseen in place of the existing Shukrali Bridge (connects Killar to Chamba via Sach Pass) which is coming under submergence.