CHAPTER- V

RESERVOIR & POWER

5.0 General

Spatial & temporal variability of precipitation in India makes it imminent that water storages play a leading role in the Planning & Development of water resources. The main function of a reservoir formed behind structures like dams & barrages is to regulate natural stream flow by storing water during the high flow season and to release the stored water in the dry season to meet various demands. Depending on the magnitude of natural inflows, demands at a particular time and keeping in view techno-economic aspects, attempt is made to fix the size of the reservoir.

The Ken - Betwa link project envisages creation of two major reservoirs, one on Ken river at Daudhan, 2.5 km upstream of the existing Gangau weir, and another on Betwa river at Makodia under upper Betwa Project and two barrages namely Barari(on Betwa river) and Kesari (on Keotan river, tributary of Betwa river). The total area under submergence of Daudhan reservoir at FRL comes to 90 Sq.km. The storage thus created at Daudhan is proposed to be utilised for meeting irrigation requirements of downstream commands in M.P & U.P and for diversion of 1074 MCM (including transmission losses of 68 MCM) of water from Ken river to Betwa river through a canal off taking from the upper level Tunnel. Details of Daudhan reservoir are described in the subsequent Para 5.1.1 to 5.1.12 followed by Makodia reservoir (Para 5.2.1 to 5.2.12). Details of Barari & Kesari barrages have been described in the Paras.5.3 & 5.4.

5.1 <u>Daudhan reservoir</u>

5.1.1 Fixation of storage and Reservoir Levels Approach – Criteria

The gross availability of water at 75% dependable annual yield has been worked out as 6590 MCM by the NIH, Roorkee in Hydrological studies for Ken-Betwa link project (Phase-I). Water balance for Ken basin upto Daudhan dam site at 75% dependability has been worked out as 1468 MCM after considering downstream commitment, upstream domestic, irrigation and industrial water requirements and regeneration thereof. Details of water balance studies at Daudhan dam site are furnished in Annexure: 5.1.1.

The required storage to meet the given demands depends on three factors: the variability of streamflows, the size of demands and the reliability of meeting the demands. The procedure for estimating the storage capacity needed to meet given demands or the possible yield from a given project design and data constitute the storage yield (SY) analysis to compute the storage capacity for various purposes, such as irrigation, municipal and industrial water supply, and hydropower generation. The techniques based on the critical period concepts are the earliest techniques of storage-yield analysis. The critical period is defined as the period in which an initially full reservoir, passing through various stages (without spilling), empties. One such method, known as the Mass Curve Method is the first rational method to compute the required storage capacity of a reservoir.

Simulation method is another approach for storage - yield analysis. It is basically a search procedure and is one of the most widely used techniques to solve a large variety of problems associated with the design and operation of water resources systems. This approach can be realistically and conveniently be used to examine and evaluate the performance of a set of alternative options available.

The reservoir simulation study has been carried out for estimating the live capacity of reservoirs that would provide the required yield at specified reliability. The flow data for a period of 22 years from 1981 to 2003 of Madla G&D site maintained by CWC, which is about 23 km d/s of Daudhan dam, has been used for the analysis. The analysis has been done using Simulation Programme (developed by NIH, Roorkee). This programme also takes into account the three different releases from Daudhan i.e. from Lower level tunnel, Upper level tunnel and directly from dam body through Powerhouse-I for down stream release. The result of this analysis is enclosed in the Annexure: 5.1.2, which gives detailed output for gross capacity of 2650.4 MCM. The analysis shows that for 75% dependability performance, the gross capacity of 2650.4 MCM gives the water utilization of 4080 MCM.

5.1.1.1 Dead storage level (DSL)

The Daudhan Dam shall be used for meeting irrigation requirement as envisaged under KMPP project, diversion of sizeable water of Ken to Betwa river including provision for irrigation to enroute command area and also to generate 219.03 MU of average electrical energy through two powerhouses.

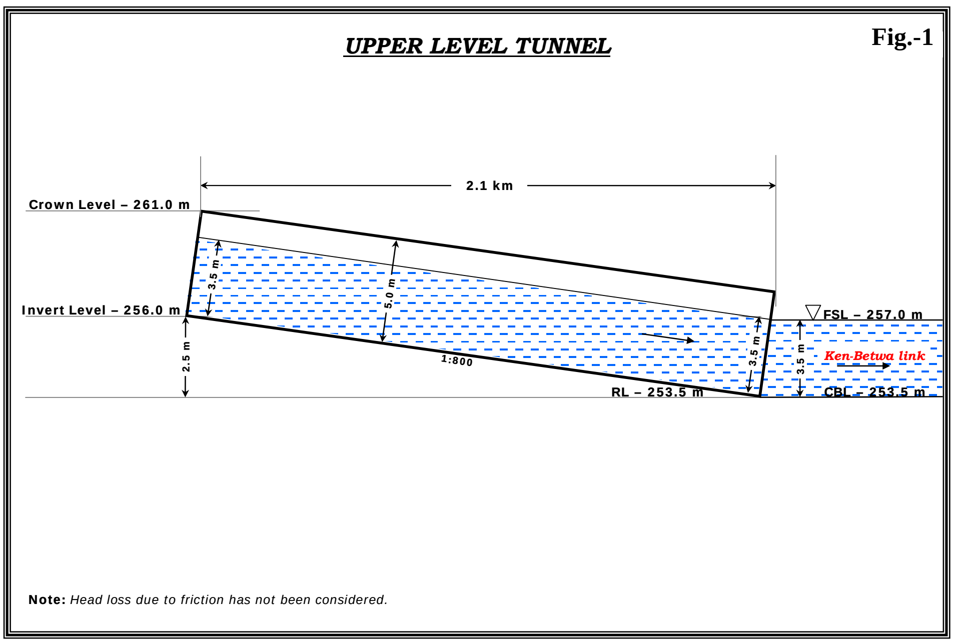
The dead storage capacity of the Daudhan reservoir, has been fixed on the basis of the guidelines given in "Fixing the capacities of reservoirs – method, Part 2 Dead storage, IS 5477 (Part 2): 1994".

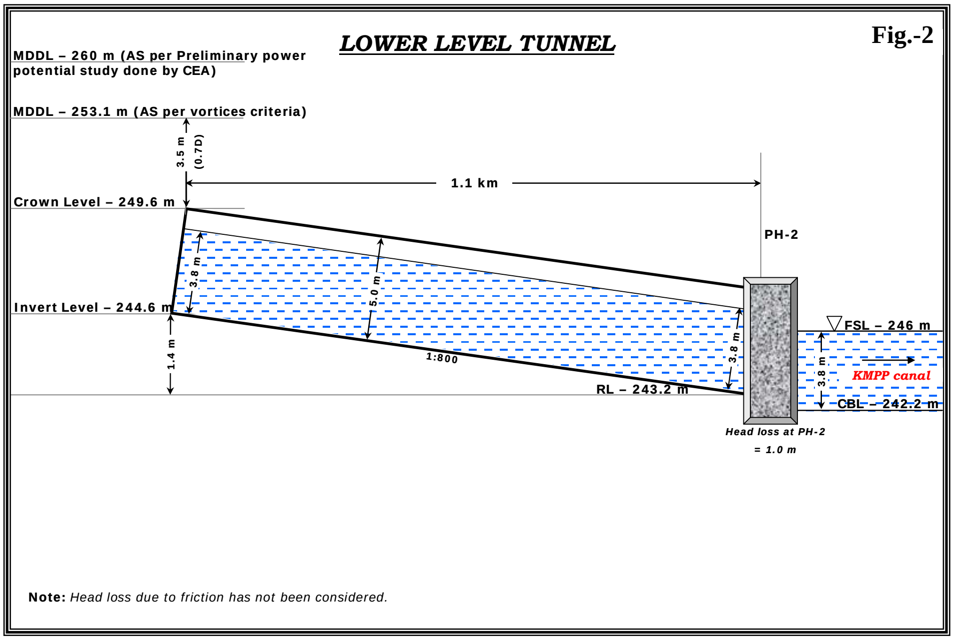
The new zero level of the Daudhan reservoir has been worked out as 236.4 m on the basis of sedimentation studies. The corresponding capacity at this level as per the original area - capacity curve comes to 100.77 MCM. However, Dead Storage Level of the reservoir has been proposed as 240m (corresponding capacity of 169.27 MCM) and sluices are proposed to be provided at this level. The details of sedimentation studies are furnished in Annexure: 5.1.3.

5.1.1.2 Low water level / Minimum Draw-Down level(MDDL)

The minimum draw down level (MDDL) of Daudhan reservoir can be fixed anywhere above 236.4 m which is the new zero elevation after 100 years of operation of the reservoir, based on sedimentation studies carried out by NIH, Roorkee.

At feasibility stage, there was only one tunnel, i.e., upper level tunnel and Powerhouse-II was proposed at the exit of that tunnel. As a result, MDDL was fixed at a level of 269 m which was major cause in reduction of live storage. At DPR stage, one additional tunnel, at a lower level has been introduced to meet irrigation requirement of the command area envisaged under KMPP and location of Powerhouse-II has been shifted to the exit of lower level tunnel. This has helped in lowering MDDL and in turn increasing live storage and power generation from the Powerhouse-II from 12 MW to 18 MW. The schematic diagram of Upper Level and Lower Level tunnels are given in Fig.1 & 2.





Various scenarios of MDDL for irrigation and provision of two tunnels at different levels etc. have been studied in detail. MDDL for lower level tunnel has been kept at 253.1m considering about 5.5m dia. tunnel and 0.7D for vortex criteria and 1m head loss in 1 in 800 tunnel slope so that the canal proposed by Water Resources Department, Govt. of M.P. for KMPP can be fed at F.S.L. 246.34 m after generating power. However, CEA has fixed MDDL for Lower Level Tunnel at 260m on the basis of their power potential study.

5.1.1.3 Full reservoir level

At feasibility stage, divertible quantity of Ken water to Betwa was 1020 MCM whereas it has been modified to 1074 MCM at DPR stage in order to meet increased enroute demand of irrigation and drinking water. So, in order to meet the enhanced demand of the link canal, FRL of Daudhan reservoir has been fixed as 288.0 m and invert level of upper level tunnel at the inlet has been kept as 256 .0 m.

The operation of the Daudhan reservoir was simulated by assuming various values of the maximum storage. It was found that if the FRL is kept at 288 m (corresponding storage of 2650.4 MCM), the time and volume reliabilities in meeting d/s irrigation demands are 79.3% and 91.9 % and these values for the link are 95.6 % and 97.3 %. The annual irrigation reliability is 75.0% when deficit up to 10% is ignored.

5.1.1.4 Maximum water level(MWL)

Maximum water level of Daudhan reservoir has been kept as 288.0 m (same as FRL). Keeping this in view, gates of spillway have been designed to pass design flood of 57202 cumecs.

The maximum water level as worked out from flood routing study is 287.88 m with one gate as inoperative and 288.23 m with two gates inoperative. The MWL has, therefore, been fixed as 288 m.

Reservoir routing (routing of a flood wave through a reservoir) is an important part of the reservoir analysis whose major applications are for fixing maximum water level during reservoir design, design of spillway and outlet works and dam-break flood wave analysis.

For the Daudhan reservoir, flood routing was carried out using the Modified Puls method. The proposed spillway of Daudhan dam had earlier 14 gates. In order to limit the maximum water level to 288 m, more than 14 gates would be required. Computations were performed for two cases: when 30 gates are operational and when 29 gates are operational. It was assumed that the reservoir is at 288.0 m when the flood impinges.

Results of reservoir routing for the first case (when 30 gates are operational) show that the maximum water level attained was 287.88 m (maximum storage 2640 MCM) and the peak of the outflow hydrograph was at 57394 cumec. For the second case, when 29 gates are operational, the maximum water level attained was 288.23 m (storage 2676 MCM) and the peak of the outflow hydrograph was at 57125 cumec. Finally, the maximum water level at Daudhan has been fixed as 288.0 m. The details of Reservoir Routing for Daudhan dam are furnished in Annexure: 5.1.4. Thus, various levels fixed in respect of Daudhan Reservoir are given in Table - 5.1.1.

Table -5.1.1: LEVELS FIXED AS PER REVISED SIMULATION STUDY

Controlling levels	Elevation(m)
• FRL of Daudhan reservoir	288.0 m
• MWL of Daudhan reservoir	288.0 m
• FSL of link canal	257.0 m
LEVEL FOR IRRIGATION	
• Minimum level for irrigation	
1. Ken-Betwa Link through upper level tunnel	256.0 m
2. Ken LBC through Lower level tunnel	246.0 m
3. Down stream requirement through Powerhouse-I	246.0 m
UPPER LEVEL TUNNEL	
• Invert level at inlet	256.0 m
• Crown level at inlet	262.0 m
• Invert level at outlet	253.5 m
LOWER LEVEL TUNNEL	

• Invert level at inlet	244.6 m
• Crown level at inlet	250.1 m
• Invert level at outlet	243.2 m
• MDDL for Powerhouse-II Considering Vortices Criteria & 5.5m dia. of tunnel	253.1 m
• MDDL for Power House-II Proposed by CEA after carrying out preliminary power potential study	260. m
POWERHOUSE-I (At toe of dam)	
• Invert Level of pen stock at inlet	240.0 m
• MDDL for Powerhouse-I Considering Vortices Criteria & 6m dia of tunnel	252.0 m

5.1.1.5 Maximum backwater at full reservoir level and maximum water level and its impact, Maximum distance of such points from the axis of the structure

The full and maximum reservoir level of Daudhan dam has been fixed at 288 m as per simulation studies. The maximum back water level at FRL/MWL is El. 287.500m and the effect extends upto a distance of 70 km from the axis of the dam (at the periphery of the reservoir) within which no structures of significant importance have been identified.

5.1.1.6 Fetch

The fetch of the reservoir was determined to fix the free board and the top of the dam. The fetch computations were done as per the Indian Standards IS: 10635-1993, "Guidelines for Free board requirements in Embankment Dams".

The maximum & effective fetch length of 8.36 km & 4.436 km respectively has been worked out. The following factors are taken into consideration while computing the free board requirement.

(a) Wave characteristics, particularly the wave height and wave length.
(b) Upstream slope of the river and roughness of the pitching.
(c) Height of wind setup above the still water level

The detailed computations for free board required for FRL and MWL conditions have been done and the free board requirement has been worked out as 5.0 m without any wave deflector. A parapet wall of 0.9 m high is also provided.

5.1.1.7 Direction of wind - Velocity of wind - wave height - Free board-Top of dam

The direction of wind in Daudhan reservoir area is mostly from west to east. The Sagar IMD station is located near to the Daudhan dam site. The maximum wind velocity of 11 km/hr is experienced in the month of June and the minimum wind velocity of 5.0 km/hr is experienced in the month of December. The average velocity of wind is 8.5 km/hr. However, a normal wind velocity of 39m/s has been considered. The computed free board works out to 5.0 m. The top of the earthen portion the Daudhan dam has been fixed at 293.0m.

5.1.2 Sedimentation data and studies

The catchment area of Ken River up to the proposed Daudhan dam site is about 19633 sq. km. It is expected that about 10194 sq. km of the area will be intercepted by the projects likely to come in the upstream catchment. These projects may come over a period of next 15 years. Hence, to calculate the catchment areas contributing sediments, the following assumptions have been made:

(a) For the sedimentation period of 50 years, full catchment area of 19633 sq.km has been considered for the first 15 years. For the next 35 years, balance catchment area of 19633-10194 = 9439 sq. km has been considered.

(b) For the sedimentation period of 100 years, full catchment area of 19633 sq. km has been considered for the first 15 years while balance catchment area of 9439 sq. km has been considered for the next 85 years.

There is a silt observation site on the main Ken river at Banda which is about 150 Km down stream of the proposed Daudhan dam site. Sediment data of 36 years (1962-2004 excluding 1975-1981) was available for this site. The same has been used for sedimentation studies of Daudhan dam reservoir.

5.1.2.1 Rate of sedimentation

The sediment rates for some of the nearby projects, namely Tawa, Barna, Sondur, Gandhisagar, Mahanadi reservoir and Hasdeo in M.P. and Matatila in U.P. have been given in CBIP publication no. 137 on Major dams in India, 1979. It is found that the designed sediment rates of these projects are in the range from 130 to 706 m^3/sq.km/year. Hence the silt rate for the Daudhan dam as worked out in para: 5.2.5, viz. 329.8m^3/sq.km/year has been considered to be appropriate for design purpose. The details of sediment rate in various nearby reservoirs are furnished in Table-5.1.5.

Table-5.1.5: Sediment rate in various nearby reservoirs

Name of dam	Catchment Area (sq.km)	Dead Storage (MCM)	Sediment Rate (m^3/sq.km/year)
Matatila (U.P.)	20718	269.3	130
Gandhisagar(M.P.)	23140	835.0	361
Sondur (M.P.)	512	19.0	371
Mahanadi Res.(M.P.)	3670	143.0	390

Name of dam	Catchment Area (sq.km)	Dead Storage (MCM)	Sediment Rate (m^3/sq.km/year)
Tawa (M.P.)	5983	260.0	435
Hasdeo (M.P.)	6737	370.0	549
Barna (M.P.)	1176	83.0	706

Sediment Distribution

The sediment distribution is worked out for two periods, viz. 50 years and 100 years by Empirical Area Reduction method. For this purpose, the FRL 288m is adopted and bed level of the reservoir is considered as 216m. The original Elevation-Area-Capacity table for Daudhan dam is given in Table-5.1.3.

Table-5.1.3: Original Elevation-Area-Capacity table for Daudhan dam

Sl.no.	Contour area(sq. km)	Contour area (ha)	Cap = [A1+A2 + $(A1*A2)^{0.5}$]* h/3	Capacity (MCM)
1	288.00	9000	35.30	2853.01
2	287.60	8650	337.07	2817.71
3	283.50	7800	226.46	2480.64
4	280.50	7300	250.67	2254.18
5	277.00	7025	206.99	2003.51
6	274.00	6775	201.00	1796.52
7	271.00	6625	189.68	1595.52
8	268.00	6025	177.26	1405.84
9	265.00	5800	167.96	1228.48
10	262.00	5400	158.24	1060.51
11	259.00	5150	148.46	902.28
12	256.00	4750	137.98	753.82
13	253.00	4450	125.93	615.84
14	250.00	3950	111.68	489.92
15	247.00	3500	100.47	378.24
16	244.00	3200	86.07	277.77
17	241.00	2550	67.30	191.70
18	238.00	1950	36.92	124.40
19	235.50	1050	5.08	87.48
20	235.00	981	4.64	82.40
21	234.50	875	35.36	77.77
22	230.00	700	27.15	42.40
23	225.00	400	13.25	15.25
24	220.00	150	2.00	2.00
25	216.00	0	0.00	0.00

The type of reservoir is considered as gorge type and the standard classification is taken as Type IV. The new zero elevation will be as follows:

New zero elevations:

For 50 years = 230.9 m

For 100 years = 236.4 m

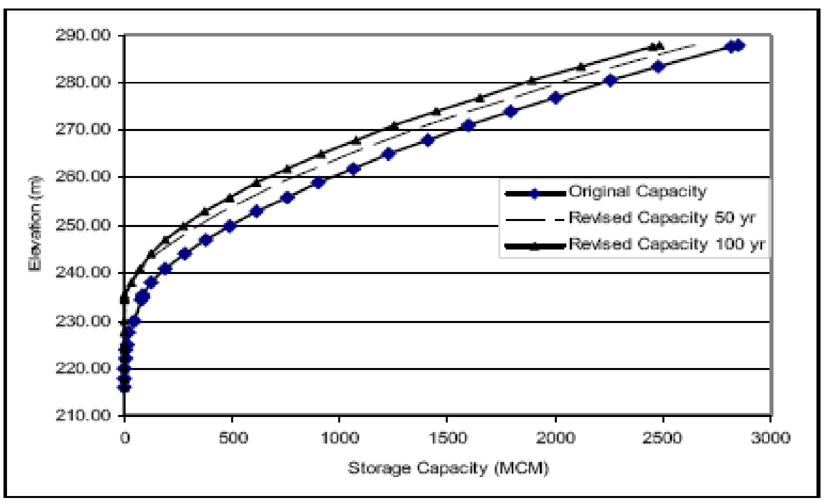
The minimum draw down level (MDDL) can be fixed anywhere above 236.4 m which is the new zero elevation after 100 years of operation of the reservoir. The total sediment during 50 and 100 years will get distributed up to and above various elevations as given in the Table-5.1.4 below.

Table-5.1.4: Distribution of total sediment at various elevations of Daudhan dam

Reservoir level	**Sediment deposition in MCM**	
	After 50 years	**After 100 years**
Upto 231 m	49.3	50.3
Above 231 m	156.8	311.4
Upto 236.4 m	85.7	98.0
Above 236.4m	120.4	263.7
Upto 244	127.5	185.7
Above 244 m	78.6	7176.0

The original elevation vs. capacity graph along with those after 50-year and 100-year of operation have been plotted and shown in Fig:3 below.

Fig.3



Original and revised (after 50 and 100 years) Elevation-Area-Capacity table for Daudhan dam is given in Table-5.1.5 below.

Table-5.1.5: Original and revised (after 50 and 100 years) Elevation Capacity table for Daudhan dam.

Elevation	Original Capacity	Revised Capacity after 50 yr	Revised Capacity after 100 yr
(m)	(MCM)	(MCM)	(MCM)
216.00	0.00	0.00	0.00
220.00	2.00	0.00	0.00
225.00	15.25	0.00	0.00
230.00	42.40	0.00	0.00
234.50	77.77	4.34	0.00
235.00	82.40	5.62	0.00
235.50	87.48	7.39	0.00
238.00	124.40	28.74	7.76
241.00	191.70	79.20	38.55
244.00	277.77	150.27	92.10
247.00	378.24	237.41	163.67
250.00	489.92	337.30	249.80
253.00	615.84	452.86	353.23
256.00	753.82	581.77	471.56
259.00	902.28	722.39	603.02
262.00	1060.51	873.92	746.72
265.00	1228.48	1036.23	902.43
268.00	1405.84	1208.93	1069.66
271.00	1595.52	1394.84	1251.18
274.00	1796.52	1592.91	1445.82
277.00	2003.51	1797.73	1648.11
280.50	2254.18	2046.74	1895.17
283.50	2480.64	2272.41	2119.93
287.60	2817.71	2609.18	2456.35
288.00	2853.01	2644.48	2491.65

Reference: *Table 7.5 of "Hydrologic studies of Ken-Betwa link project" by NIH, Roorkee.*

5.1.2.2 Sedimentation fraction

The Petrographic analysis on the silt samples collected from the Daudhan dam site has been carried out by IIT, New Delhi. The report of the analysis is appended as Appendix:2.15 in volume-II.

5.1.2.3 Quantity of sediment

(a) During 50 years

Rate of silt deposition = 329.8 m^3/sq. km/year

(i) For first 15 years the silt deposition from the catchment area of 19633 sq. km = 329.8*19633*15 = 97.12 MCM.

(ii) For the next 35 years the silt deposition from the catchment area of 9439 sq. km = 329.8*9439*35 = 108.95 MCM.

(iii) Total sediment deposition = 97.12 + 108.95 = 206.1 MCM.

(b) During 100 years

Rate of silt deposition = 329.8 m^3/sq. km/year

(i) For first 15 years, the silt deposition = 97.12 MCM (as estimated above).

(ii) For the next 85 years the silt deposition from the catchment area of 9439 sq. km = 329.8*9439*85 = 264.6 MCM.

(iii)Total sediment deposition = 97.12 + 264.6 = 361.72 MCM.

5.1.2.4 Types and shape of Reservoir

The Daudhan reservoir is considered as gorge type and the standard classification is taken as Type IV.

5.1.2.5 Sediment studies

Total sediment transport
(average of 36 years)=8356972tonnes/year
Catchment area of Ken up to Banda G/D site = 25452 sq. km.
Considering 15% bed load,
The total sediment = 1.15*8356972 tonnes/year
Transport per year = 9610518 tones/year
Average density of silt = 1.145 t/m^3
Silt inflow=total sediment / silt density=9610518/1.145
=8393465m^3/year
Silt rate=silt inflow/catchment area
=8393465/25452=329.8m^3/sq. km

The sediment rate of 329.8 m^3/sq. km/year has been considered to be appropriate for design purpose.

5.1.2.6 Sedimentation in the reservoir after 50 and 100 years

Total sediment deposition in Daudhan reservoir in 50 years and 100 years will be 206.1 MCM and 361.73 MCM respectively based on sedimentation studies carried out by NIH, Roorkee. Details are given under para 5.2.3.

5.1.3 Life of Reservoir in years

The life of the Daudhan dam has been considered as 100 years.

5.1.4 Capacity

5.1.4.1 Capacities

Daudhan reservoir

Gross storage capacity	:	2853.01 MCM
Live storage capacity	:	2683.74 MCM
Dead storage capacity	:	169.27 MCM

5.1.4.2 Storage

Various storage details of the proposed reservoirs have been mentioned above.

5.1.4.3 Water tightness of the reservoir

Study related to water tightness of the Daudhan reservoir has been carried out by GSI, Bhopal for NWDA. The study revealed the presence of stratigraphic sequence of the Vindhyan Supergroup comprising interbedded sequence of sandstone, shale and subordinate limestone. The riverward slope of topography in the area by virtue of the favourable disposition of Vindhyans provide, by and large, congenial condition from reservoir tightness point of view. There are no saddles in the topography for escaping water to the adjoining basin needing auxiliary structures for confinement of the reservoir water. Similarly, no signicant interfluve pervious horizon of water divide is present in the proposed submergence area. Litho contacts, frequent occurrence of bedding/stratification and localized inferred faults and joints are some of the geological weaknesses in the bedrocks which area unlikely to cause any outlet for reservoir water in the adjoining area due to the above favourable topography. Of the five sets of joints recorded in the area, the rolling, sub-horizontal ENE-WSW trending joint and two vertical joints at right angles trending NE-SW and NW-SE, parallel and across to the dam axis, are the predominant joints/fractures in the area.They may account for some loss of water, but appears to be within the permissible limits. Rest of the joints tends to become tighter and gradually terminate with depth. Any seepage through the foundation of the dam can be taken care of by grouting during construction. A note on water tightness of the reservoir is appended as Annexure: 5.1.5.

5.1.4.4 Annual losses

For reservoir capacity of 2853 MCM, annual average evaporation loss from Daudhan reservoir is 91.9 MCM. Highest evaporation loss (111.4 MCM) took place during year 1998 and the lowest evaporation (78.7 MCM) was in year 1989. Month of May accounts for maximum evaporation loss and December accounts for the least amount of evaporation.

5.1.4.5 Flood absorption

No flood storage is earmarked for this project. However, from reservoir routing for the first case (when 30 gates are operational), it is seen that the maximum water level attained was 287.88 m (maximum storage 2640 MCM) and the peak of the outflow hydrograph was at 57394 cumec. For the second case when 29 gates are operational, the maximum water level attained was 288.23 m (storage 2676 MCM) and the peak of the outflow hydrograph was at 57125 cumec.

5.1.5 Effects on sub soil water table in the adjoining areas particularly downstream of the dam

The sub-soil water table will improve due to the impoundment of water in the Daudhan reservoir. In addition, the regulated flows from the Daudhan dam into Ken river for irrigation of Ken command in Banda district will increase the sub soil water level in the adjoining areas.

5.1.6 Reservoir rim stability

Study regarding reservoir water tightness of Daudhan reservoir has been carried out by GSI, Bhopal for NWDA. Details of the rim stability of the reservoir is included in 5.1.5.

5.1.7 Area of submergence

5.1.7.1 Maximum water level

Area of submergence of Daudhan reservoir at MWL is 9000 ha.

5.1.7.2 Full reservoir level

Area of submergence of Daudhan reservoir at FRL is also 9000 ha since FRL and MWL are kept same.

5.1.7.3 Submergence Ratio submerged (Cultivated) area/CCA

Total area under submergence of Daudhan reservoir at FRL is 9000 ha. Distribution of land use under different types of land is as follows:

Forest land	6400.00 ha
Irrigated land by source	47.32 ha
Unirrigated land	603.42 ha
Culturable waste land	1870.20 ha
Area not available for cultivation	79.00 ha

Therefore, submergence Ratio =submerged (Cultivated) area/CCA
= 650.74/60294
=1/93 (0.011)

5.1.8 Land Acquisition-Property submerged-rehabilitation

5.1.8.1 Land acquisition (ha)

Acquisition to be made on about 9000 ha (private land of 2260 ha comprising irrigated, unirrigated and built up land & govt. land of 6740 ha comprising forest land and water bodies) for construction works and that coming under submergence upto FRL only. For colony area, approach road and store yard etc., about 105 ha land has to be acquired. About 86 ha land for Powerhouse switchyard, transformer yard, quarries etc. will have to be acquired.

5.1.8.2 Details of property submerged

Total 10 number of villages are likely to come under submergence of Daudhan reservoir. All these villages come under Bijawar tehsil of Chhatarpur district.

5.1.8.3 Rehabilitation of oustees

4338 PAPs are likely to be affected by the submergence due to reservoir. The rehabilitation of oustees/project affected persons will be governed by the State/Central policy on Resettlement & rehabilitation. Ministry of Rural Development, Government of India has finalised the National Policy on Resettlement and Rehabilitation for project Affected Families (NPRR-2007). The policy addresses the resettlement and rehabilitation (R&R) issues of the Project Affected Families (being displaced) in case of compulsory acquisition of land for public purpose including infrastructure projects. The central objective of the whole exercise is to ensure Project affected Persons (PAPs) to regain their previous standard of living, if not better, within a reasonable transition period. Keeping in view the social dimensions of the project, some measures have been envisaged for the project and described below:

- Census socio-economic survey of PAF's
- Compensation for land
- Compensation for house building
- Compensation for loss of business
- Maintenance allowance for PAF's
- Ex-gratia payment
- Shifting allowance
- Infrastructure development
- Direct and indirect employment opportunities in project
- Training of PAP's
- Institutional arrangement
- Monitoring and evaluation
- Public information system and grievance redressal.

The main features of M.P. State Rehabilitation and Resettlement Policy as well as NPRR 2007 are as under:-

i Housing grant of Rs. 40,000 for each displaced BPL, PAF household.

ii. Each affected family that is displaced and has cattle shall get financial assistance of Rs. 15,000

iii. Each affected that is displaced shall get one time financial assistance of Rs. 15,000 for construction of cattle shed.

iv. Each affected family that is displaced shall get one time financing assistance of Rs. 10,000 for shifting of the family, building materials, belongings and cattle.

v. Financial assistance of Rs. 25,000 per each PAF household who is a rural artisan, small trader and self employed person and Rs. 40,000 agricultural or non-agricultural labour.

vi. Displacement grant of Rs. 15,360 for each PAF and major child who has lost his house or house site.

vii. Provision of land to land to the extent of land acquired, to the ST PAFs.

viii. Financial assistance to the extent of

    a) Rs. 48,000 whose total holding is acquired or

    b) Rs. 32,000 if he becomes a marginal farmer (< 1.0 ha) after land acquisition or

    c) Rs. 24,000 if he became a small farmer (>1.00 ha and <2.0ha) after land acquisition.

5.1.9 Recreation facilities

Following are the recreational facilities which are proposed to be developed.

- Development of parks/gardens in d/s of dam.
- Development of Children parks in the township.
- Development of Tourist spot with boating facilities
- Development of Guest house, inspection bungalow and dormitory accommodation.
- Development of aviary.

These facilities in the area will ensure tourism development in the area.

5.1.10 Pisciculture

There are some existing irrigation projects namely Rajghat, Matatila, Samrat Ashok Sagar. Barwa sagar, Dukwan reservoir, etc. in the vicinity of project area of Ken-Betwa link project, where pisciculture is being developed to generate revenue from fisheries. In the Rajghat project, about 3000 tonnes of fishes are produced annually from reservoir as well as fish seed centre. The submergence area of Rajghat project is 24531 ha. Accordingly, there is lot of scope for developing fisheries in Daudhan reservoir also. The submergence area of Daudhan reservoir is 9000 ha from which about 1300 tonnes of fishes can be produced annually which will increase the revenue from the project.

5.1.11 Need and recommendation for soil conservation measure in the catchment

The chances of soil erosion, if any can be prevented/minimized by adopting following measures.

- Avoid the creation of cut slopes and embankments which are of an angle greater than the natural angle of repose for local soil type.
- Implanting Shrubs and trees in the area.
- Vegetation alone may not be enough to prevent soil erosion, hence, few engineering measures may be adopted to complement the vegetation such as catchment area treatment, stone-pitching of vulnerable locations, etc.

Appropriate financial provisions have been provided for soil conservation measures in the catchment area.

5.1.12 Any other relevant information

Other than the above discussed details of Daudhan reservoir as a part of Main component of the project, other existing major projects in the Ken basin are:

Gangau Weir

Gangau Weir, located in Chhatarpur district is an old structure constructed over Ken River. It has been in operation since 1915. It is a masonry weir with maximum height of 19.2 m and top width of 5.64 m with storage capacity of about 56 MCM.

Bariyarpur Pick Up Weir

Bariyarpur weir was built in 1906 at Ajaigarh in Panna Distt. of M.P. downstream of Madla. The weir has a length, height and storage capacity of 1636m, 8.23m and 12.6 MCM respectively.

Rangawan Dam

Rangawan dam was built in 1957 on Banne river, a tributary of Ken in Chhatarpur distt. Of M.P. This is an earthen dam with a length of 2072m, height of 27.4m and live storage capacity of 155.24 MCM.

Mansurwari Dam

Mansurwari dam is built in Rehli tehsil of Sagar dist. of M.P. on Padria nalla in the Sonar sub-basin in the year 1978-79. This earthen dam has a length of 938.78m, a height of 21.86m and has gross and live storage capacity of 14.5MCM and 13.4MCM, respectively.

5.2 Makodia reservoir

5.2.1 Fixation of storage and Reservoir Levels Approach – Criteria

The gross availability of water at 75% dependable annual yield has been worked out as 508 MCM by the NIH, Roorkee in Hydrological studies for Ken-Betwa link project (Phase-II). Water balance for Upper Betwa basin upto Makodia dam site at 75% dependability has been worked out as 381 MCM after considering downstream commitment, upstream domestic, irrigation and industrial water requirements and regeneration thereof. The water balance studies of Upper Betwa basin upto Makodia dam site is furnished in Annexure:5.2.1.

The reservoir simulation study has been done for estimating the capacity of Makodia reservoir that would provide the required yield at specified reliability. The flow data of Basoda G&D site which is about 97 km d/s of Makodia dam has been used for the analysis for a period of 30 years from 1976 to 2005. The analysis has been done using Simulation Programme (developed by NIH, Roorkee). This programme also takes into account the different releases from Makodia i.e. for canal releases from the dam, downstream committed releases,etc. The result of this analysis is enclosed in the Annexure:5.2.2, which gives detailed output for gross capacity of 504 MCM. The analysis shows that for 75% dependability performance, the gross capacity of 329 MCM gives the water utilisation as 293 MCM.

5.2.1.1 Dead storage level (DSL)

The Makodia Dam shall be used for meeting its irrigation requirement and d/s requirement for meeting the ecological needs.

To fix the dead storage capacity of the Makodia reservoir, the guidelines given in "Fixing the capacities of reservoirs – method, Part 2 Dead storage, IS 5477 (Part 2): 1994" have been followed.

The dead storage level of the Makodia reservoir has been worked out as 430.0 m on the basis of sedimentation studies. The corresponding capacity at this level, as per the revised area capacity curve of 100 years sedimentation comes to 14.24 MCM.

5.2.1.2 Low water level / Minimum Draw-Down level(MDDL)

The minimum draw down level (MDDL) in Makodia reservoir has been fixed at 430.0 m which is the new zero elevation after 100 years of operation of the reservoir-based on sedimentation studies carried out by NIH, Roorkee. The details are furnished in Annexure:5.2.3.

5.2.1.3 Full reservoir level

The operation of the Makodia reservoir was simulated by assuming various values of the maximum storage. It was found that if the FRL is kept at 437.50 m (corresponding storage of 293.20 MCM), the time and volume reliabilities in meeting irrigation demands were 92.7% and 95.6 %. The annual irrigation reliability when ignoring deficit up to 10%, is 86.2%.

5.2.1.4 Maximum water level(MWL)

Maximum Water Level of Makodia reservoir has been kept as 437.50 m Keeping this level in view, gates of spillway have been designed to pass design flood of 8275.6 cumecs.

The maximum water level as worked out from flood routing study is fixed at 437.50 m.

Reservoir routing (routing of a flood wave through a reservoir) is an important part of the reservoir analysis whose major applications are for fixing maximum water level during reservoir design, design of spillway and outlet works and dam-break flood wave analysis.

For the Makodia reservoir, routing was carried out using the Modified Puls method. It was assumed that the reservoir is at 437.50 m when the flood impinges.

Results of reservoir routing show that, the maximum water level attained was 437.50m (maximum storage 293.2 MCM) and the peak of the outflow hydrograph was at 8275.50 cumec. The details are furnished in Annexure:5.2.4.

5.2.1.5 Maximum backwater at full reservoir level and maximum water levels and its impact, maximum distance of such points from the axis of the structure

The maximum backwater at FRL will be felt upto a length of 20 km along the Betwa river.

5.2.1.6 Fetch

The fetch of the reservoir was determined to fix the free board and the top of the dam. The fetch computations were done as per the Indian Standards IS: 10635-1983, "Guidelines for Free board Requirement in Embankment Dams".

The maximum & effective fetch length of 11.57 & 3.891 Km respectively has been worked out. The following factors are taken into consideration while computing the free board requirement.

(a) Wave characteristics, particularly the wave height and wave length.
(b) Upstream slope of the river and roughness of the pitching.
(c) Height of wind setup above the still water level

5.2.1.7 Direction of wind - Velocity of wind - wave height - Free board-Top of dam

The Nearest IMD observatory is located at Bhopal. The maximum wind velocity of 13.2 km/hr is experienced in the month of July and the minimum wind velocity of 4.3 km/hr is experienced in the month of November. The average velocity of wind is 8.4 km/hr. The velocity of wind has been considered as 39 m/s and the wave height as 3.85 m as per BIS. A free board of 4.5m has been provided after designs and the top of dam has been fixed as 442.00 m.

5.2.2 Sedimentation data and studies

The catchment area of Betwa River up to the proposed Makodia dam site is 1830 sq. km. It is expected that no area will be intercepted by the projects likely to come in the upstream catchment. Hence, to calculate the areas contributing sediments, the entire catchment area has been taken into consideration for the 50 years and 100 years.

There is a silt observation site on the main Betwa river at Ghareli which is about 100 Km down stream of the proposed Makodia dam site. But the data of this site are not available. Hence, the sedimentation rate has been worked out as per hydrographic survey. In 1975, hydrographic survey was made and sedimentation rate worked out was 381.8 m^3 /sq.km/year. In 1985, sedimentation rate was 422.63 m^3 /sq.km/year while in 1990, it was 408.50 m^3 /sq.km/year.

5.2.2.1 Rate of sedimentation with basis

Considering the sedimentation rates worked out by hydrographic surveys for the years 1975,1985 & 1990 as mentioned in Para:5.14 above, the silt rate for the Makodia dam has been considered as 410.0 m^3 /sq.km/year for working out the total sediment for 50 and 100 years period.

Sediment Distribution

The sediment distribution is worked out for two periods, viz. 50 years and 100 years, by Empirical Area Reduction method. For this purpose, the FRL of 440m is adopted and bed level of the reservoir is considered as 423m. The original Elevation-Area-Capacity table for Makodia dam is given in Table-5.2.1 below.

Table-5.2.1: Original Elevation-Area-Capacity table for Makodia dam

Sl.no.	Elevation (m)	Contour area (ha)	Cumulative Capacity (MCM)
1	440.00	18176	671.527
2	439.00	14175	510.186
3	438.00	11666	381.184
4	437.00	9306	276.546
5	436.00	7007	195.252
6	435.00	5339	133.711
7	434.00	3841	88.016
8	433.00	2598	56.023
9	432.00	1567	35.414
10	431.00	1008	22.641
11	430.00	682	14.244
12	429.00	384	8.985
13	428.00	228	5.959
14	427.00	184	3.903
15	426.00	157	2.200
16	425.00	121	0.814
17	424.00	31	0.103
18	423.00	0	0.000

New zero elevations:

For 50 years = 428.239 m
For 100 years = 430.000 m.

The total sediment during 50 and 100 years will get distributed upto and above various elevations as given in the Table-5.2.2 below.

Table-5.2.2: Distribution of sediment at various elevations

Reservoir level	Sediment deposition in MCM	
	After 50 years	After 100 years
Upto 430 m	11.355	14.240
Above 430 m	26.160	60.790

Original and revised (after 50 and 100 years) Elevation-Area-Capacity table for Makodia dam is given in Table-5.2.3 below.

Table-5.2.3: Original and revised (after 50 and 100 years) Elevation Capacity table for Makodia dam.

Elevation	Original Capacity	Revised Capacity after 50 yr	Revised Capacity after 100 yr
(m)	(MCM)	(MCM)	(MCM)
423.00	0.000	0.000	0.000
424.00	0.103	0.000	0.000
425.00	0.814	0.000	0.000

426.00	2.200	0.000	0.000
427.00	3.903	0.000	0.000
428.00	5.959	0.000	0.000
429.00	8.985	0.493	0.000
430.00	14.244	2.889	0.0003
431.00	22.641	8.304	1.4665
432.00	35.414	18.016	7.1273
433.00	56.023	35.528	20.538
434.00	88.016	64.429	45.345
435.00	133.711	107.084	83.975
436.00	195.252	165.691	138.697
437.00	276.546	244.223	213.573
438.00	381.184	346.363	312.405
439.00	510.186	473.286	436.575
440.000	671.527	634.017	596.500

Reference: *Table 7.4 of "Hydrologic studies of Ken-Betwa link project-Phase-II" by NIH, Roorkee.*

5.2.2.2 Sedimentation fraction

Since no power component is proposed under Makodia dam, no petrographic analysis is done by collecting silt sample.

5.2.2.3 Quantity of sediment

(a) During 50 years

Rate of silt deposition = 410 m^3/sq. km/year

(i) For 50 years, the silt deposition from the catchment area of 1830 sq. km = 410*1830*50 = 37.515 MCM.

(b) During 100 years

Rate of silt deposition = 410 m^3/sq. km/year

For 100 years, the silt deposition from the catchment area of 1830 sq. km = 410*1830*100= 75.03 MCM.

5.2.2.4 Types and shape of Reservoir

For computation of type of the Makodia reservoir, the depth and capacity have been plotted on log log scale as shown in Fig.5. From the best fit line, the equation of the line is obtained and from the equation, slope of the line obtained is 3.46 which is the value of 'm'. From the standard classification, this value of 'm' falls in TYPE II.

5.2.2.5 Sediment studies

As per the hydrographic survey carried out in 1975, the sedimentation rate was worked out as 381.8 m^3 /sq.km/year. In 1985, sedimentation rate was 422.63 m^3 /sq.km/year while in 1990, it was 408.50 m^3 /sq.km/year. Considering these factors, the silt rate for the Makodia dam has been arrived as 410.0 m^3 /sq.km/year.

5.2.2.6 Sedimentation in the reservoir after 50 and 100 years

Total sediment deposition in Makodia reservoir in 50 years and 100 years will be 37.515 MCM and 75.03 MCM respectively based on sedimentation studies carried out by NIH, Roorkee. Details are given under para 5.14.3.

5.2.3 Life of Reservoir in years with basis

The life of the Makodia dam has been considered as 100 years.

5.2.4 Capacity

5.2.4.1 Capacities

<u>Makodia reservoir</u>

Gross storage capacity	:	328.87 MCM
Live storage capacity	:	314.63 MCM
Dead storage capacity	:	14.24 MCM

5.2.4.2 Storage in MCM

Various storage details of the proposed reservoirs have been mentioned above.

5.2.4.3 Water tightness of the reservoir

Study related to water tightness of the Makodia reservoir has been carried out by GSI, Bhopal for NWDA. The study revealed that the reservoir area is fully water tight in view of the favourable geotechnical attributes. The riverward slope of topography by virtue of favourable disposition of bedrocks under a thick overburden cover provide, by and large, congenial condition from reservoir tightness point of view. There is not saddle in the topography for escaping water to the adjoining basin needing auxiliary structures. Similarly, no significant interfluve pervious horizon of water divide is present in the proposed area of submergence. Litho contacts, frequent occurrence of bedding and joints are some of the geological weaknesses in the bedrocks which are unlikely to cause any outlet for reservoir water in the adjoining area due to favourable topography. The mutually perpendicular joint sets may account for some loss of water, but appears to be within the permissible limit. The seepage, if any, through the foundation rock mass can be taken care of by grouting during construction. A note on water tightness of the reservoir is appended as Annexure: 5.2.5.

5.2.4.4 Annual losses

For reservoir capacity of 293.20 MCM, annual average evaporation loss from Makodia reservoir is 71.25 MCM. Highest evaporation loss (124 MCM) took place during year 1998-99 and the lowest evaporation (18 MCM) was in year 1979-80. Month of May accounts for maximum evaporation loss and January accounts for the least amount of evaporation.

5.2.4.5 Flood absorption

From the results of reservoir routing, it is seen that the maximum water level attained was 437.50 m (corresponding maximum storage 293.20 MCM) and the peak of the outflow hydrograph was at 8275.6 cumec.

5.2.5 Effects on sub soil water table in the adjoining areas particularly downstream of the dam

The sub-soil water table will improve due to the impoundment of water in the Makodia reservoir. In addition, the regulated flows from the Makodia dam into Betwa river for river ecology will also increase the sub soil water level in the adjoining areas.

5.2.6 Reservoir rim stability

Study regarding reservoir water tightness of Makodia reservoir has been carried out by GSI, Bhopal for NWDA. The details of rim stability of the reservoir is included in Annexure : 5.2.5.

5.2.7 Area of submergence

5.2.7.1 Maximum water level

Area of submergence of Makodia reservoir at MWL is 10486 ha.

5.2.7.2 Full reservoir level

Area of submergence of Makodia reservoir at FRL is 10486 ha since FRL & MWL are kept same.

5.2.7.3 Submergence Ratio submerged (Cultivated) area/CCA

Total area under submergence of Makodia reservoir at FRL is 10486 ha. Distribution of land use under different types of land is as follows:

Forest land	74 ha
Irrigated land by source	5060 ha
Unirrigated land	3912 ha
Culturable waste land	618 ha
Area not available for cultivation	823 ha

Therefore, submergence Ratio submerged (Cultivated) area/CCA = 9589/42300=1/4.4(0.23)

5.2.8 Land Acquisition-Property submerged-rehabilitation

5.2.8.1 Land acquisition (ha)

Acquisition to be made on about 9143.83 ha of private and govt. land for works and that coming under submergence upto FRL only. For colony area, approach road and store yard etc., about 59ha land has to be acquired. About 50 ha land for quarries etc. will have to be acquired.

5.2.8.2 Detail of property submerged

Total 28 nos. of villages, consisting of 13499 human population and 7189 live stock population will be affected due to the submergence of Makodia reservoir. All these villages come under Raisen & Goharganj tehsil of Raisen district except one village Berasiya, which comes under Huzur tehsil of Bhopal district.

5.2.8.3 Rehabilitation of oustees

13499 PAPs are likely to be affected by the submergence due to reservoir. The rehabilitation of oustees/project affected persons will be governed by the State/Central policy on Resettlement & rehabilitation. Ministry of Rural Development, Government of India has finalised the National Policy on Resettlement and Rehabilitation for project Affected Families (NPRR-2007). The policy addresses the resettlement and rehabilitation (R&R) issues of the Project Affected Families (being displaced) in case of compulsory acquisition of land for public purpose including infrastructure projects. The central objective of the whole exercise is to ensure Project affected Persons (PAPs) to regain their previous standard of living, if not better, within a reasonable transition period. Keeping in view the social dimensions of the project, some measures have been envisaged for the project and described below:

- Census socio-economic survey of PAF's
- Compensation for land
- Compensation for house building
- Compensation for loss of business
- Maintenance allowance for PAF's
- Ex-gratia payment
- Shifting allowance
- Infrastructure development
- Direct and indirect employment opportunities in project
- Training of PAP's
- Institutional arrangement
- Monitoring and evaluation
- Public information system and grievance redressal.

The main features of M.P. state Rehabilitation and Resettlement Policy have been furnished in para: 5.1.9.

5.2.9 Recreation facilities

Following are the recreational facilities which are proposed to be developed.

- Development of parks/gardens in d/s of dam.
- Development of Children parks in the township.
- Development of Tourist spot with boating facilities
- Development of Guest house, inspection bungalow and dormitory accommodation.
- Development of aviary.
- Tourist spot with boating facilities

These facilities in the area will ensure tourism development in the area.

5.2.10 Pisciculture

There are is of scope for developing fisheries in Makodia reservoir also. The submergence area of Makodia reservoir is 10486 ha from which about 1100 tonnes of fishes can be produced annually which will increase the revenue from the project.

5.2.11 Need and recommendation for soil conservation measure in the catchment

The chances of soil erosion can be prevented / minimized by adopting following measures.

- Avoid the creation of cut slopes and embankments which are of an angle greater than the natural angle of repose for local soil type.

- Implanting Shrubs and trees in the area.

- Vegetation alone may not be enough to prevent soil erosion, hence, few engineering measures such as catchment area treatment, stone-pitching of vulnerable locations, etc.

Appropriate financial provisions have been provided for soil conservation measures in the catchment area.

5.2.12 Any other relevant information

In addition to the above Daudhan and Makodia dam, two barrages namely Kesari and Barari are also proposed. The details of these barrages are furnished in paras.5.3 & 5.4 below:

5.3 Barari barrage

The proposed barrage site is located on Betwa river near the village Barrighat in the district & tehsil of Vidisha of Madhya Pradesh. The latitude and longitude of the barrage site is $23^0$40'30" N and $77^0$50'30" E respectively. The proposed barrage site is about 28 km from Vidisha – Lashkarpur-Barrighat Road. Vidisha is the nearest town. The nearest railway station is Vidisha. Bhopal is the nearest airport, which is about 80 km from the site. The total catchment area of Betwa river upto Barari barrage is 5474 sq.km which is about 32.47% of the total catchment area (i.e. 16861 sqkm) of upper Betwa sub-basin. The water available at 75% dependability works out to 1558 MCM based on Basoda G&D site. The water balance at Barari barrage site at 75% dependability has been assessed to be 770 MCM and the details are furnished in Annexure: 5.2.1.

At pond level of 407.72m, Barari barrage is likely to submerge an area of 597 ha. As the barrage is proposed within the gorge portion of the river, therefore no village is coming under submergence. Hence human population and livestock population will not be affected. The Gross storage capacity at pond level of 407.72m works out to 14 MCM. The elevation-area-capacity table of Barari barrage is furnished in Table-5.3.1 below:

Table-5.3.1 Elevation-Area-Capacity table for the Barari barrage

Elevation(m)	Area(sq.km)	Capacity(MCM)
397	0.00	0.000
398	0.01	0.003
399	0.05	0.029
400	0.14	0.119
401	0.32	0.341
402	0.54	0.766
403	0.81	1.439
404	1.31	2.491
405	1.59	3.937
406	2.35	5.893
407	5.68	9.789
408	6.08	15.670
409	9.53	23.413
410	13.57	34.905

It was found that for the Barari barrage if the FRL is kept at 407.72m (corresponding storage 14.0 MCM), the time and volume reliabilities in meeting irrigation demand were 80.1% and 92.6%. The annual irrigation reliability when ignoring a deficit up to 10%, is 79.3%.

5.4 Kesari Barrage

The proposed barrage site is located on Kevtan river, a tributary of Betwa, near village Didholi in the Basoda tehsil of district Vidisha of Madhya

Pradesh. The latitude and longitude of the dam site is $23^0$52'32" N and $78^0$01'34" E respectively. The proposed dam site is about 11 km from Basoda. Basoda is the nearest town. The nearest railway station is Basoda about 11 km from the site. Bhopal is the nearest airport, which is about 110 km from the site. The catchment area of Kesari barrage is 506 sq.km. This is 3.02% of the total catchment area (i.e 16861 sqkm) of upper Betwa sub-basin. The yield at Kesari site on 75% dependability works out to 127 MCM based on Basoda G & D site. The water balance at Kesari barrage site at 75% dependability has been assessed to be 127 MCM and the details are furnished in Annexure:5.2.1.

Keeping in view the topographical features and the pattern of the submergence vis-à-vis storage, pond level of 403.90 m is considered more appropriate. The Gross storage capacity at pond level of 403.90m works out to 10 MCM . The elevation-area-capacity table of Kesari barrage is furnished in Table:5.4.1 below:

Table:5.4.1 Elevation-Area-Capacity table for the Kesari barrage

Elevation(m)	Area(sq.km)	Capacity(MCM)
395	0.00	0.00
396	0.06	0.02
397	0.17	0.13
398	0.39	0.41
399	0.79	0.99
400	1.20	1.98
401	1.45	3.30
402	1.89	4.97
403	2.55	7.18
404	3.74	10.31
405	5.14	14.73
406	6.99	20.76
407	11.51	29.92

The barrage can also been used as storage. Due to topographical constraints, sufficient command will only be possible after proposing lift upto 410m. Therefore, MDDL of Barrage has been fixed tentatively as 401 m. The results of simulation studies show that the time and volume reliabilities in meeting irrigation demands were 80.7% and 92.7% when FRL is kept at 403.90 m (corresponding storage 10.0 MCM). The annual irrigation reliability when ignoring deficit upto 10% is 79.3%.

At pond level of 403.90 m, Kesari barrage is likely to submerge an area of 362 ha. As the barrage is proposed within the gorge portion of the river, therefore no village is coming under submergence. Hence, human population and livestock population will not be affected.

5.5 Power Potential & Benefits*

5.5.1 Introduction

The Ken-Betwa Link Project is an Inter-Basin Water Transfer Project which envisages diversion of surplus waters of Ken Basin by means of a Ken-Betwa Link Canal, to the water deficit areas of Upper Betwa basin including Raisen & Vidisha districts of M.P. The project also aims to provide enroute irrigation in the drought prone areas of Chhatarpur and Tikamgarh districts of Madhya Pradesh and Hamirpur and Jhansi districts of Uttar Pradesh and also irrigation benefits in Chhatarpur and Panna districts of M.P. under Ken command through a low level tunnel and through Daudhan Power House via. existing Gangau Weir/ Bariarpur Pick-up weir.

The project is located about 19 km from Chattarpur-Panna State Highway. The nearest Railhead and the nearest airport is at Khajuraho (31 km). The major components of Ken-Betwa Link Canal Project include :

- Daudhan dam across the Ken river, about 2.5 km upstream of the existing Gangau Weir
- Two Power Houses viz. one each at Daudhan Dam and another at the end of Lower Level Tunnel
- 220 km long Ken-Betwa link canal & cross drainage structures
- Upper Betwa Projects, namely, Makodia, Barari & Kesari dams/barrages

5.5.1.1 Present status of power development in the state/region

Details of Installed Capacity of various power projects of M.P as on 30th January 2008 are given in Table:5.5.1:

'' Prepared by CEA*

Table:5.5.1 Installed Capacity of various power projects of M.P as on 30th January 2008

L. No.	Power Station	Installed Capacity (MW)	MP SHARE (MW)
	Thermal Power Station		
.	Amarkantak I (30+20 MW)	50.0	50.0
.	Amarkantak II (2x120 MW)	240.0	240.0
.	Satpura I (5x62.5 MW)	312.5	187.5
.	Satpura II (200+210 MW)	410.0	410.0
.	Satpura III (2x210 MW)	420.0	420.0
.	Sanjay Gandhi, Birsinghpur–I (2x210 MW)	420.0	420.0
.	Sanjay Gandhi, Birsinghpur–II(2x210 MW)	420.0	420.0
.	Sanjay Gandhi, Birsinghpur–Extn (1x500 MW)	500.0	500.0
	Sub-Total	**2772.5**	**2647.5**
	Hydro Power Station		
.	Gandhi Sagar (5x23 MW)	115.0	57.5
.	Pench, Totladoh(2x80 MW)	160.0	107.0
.	Rani Awanti Bai Bargi (2x45 MW)	90.0	90.0

.	Ban Sagar I tons (3x105 MW)	315.0	31 5.0
.	Birsinghpur (1x20 MW)	20.0	20. 0
.	Rajghat (3x15 MW)	45.0	22. 5
.	Ban Sagar II Silpara (2x15 MW)	30.0	30. 0
.	Bansagar – III Deolond (3x20 MW)	60.0	60. 0
.	Bansagar - IV Jhinna (2x10 MW)	20.0	20. 0
0.	Madhikha (3x20 MW)	60.0	60. 0
Jawaharsagar & Ranapratapsagar Station of Rajasthan (99MW & 172 MW), 50% of 271 MW		---	13 5.5
	Sub-total	915.0	91 7.5
C	Mini/Micro Hydel*	5.455	5.4 55
	Grand Total	**3692. 955**	**35 70.455**

5.5.1.4. Details of Energy Generation

A) State Generation

5.5.1.4.1 Thermal

The Target for annual thermal generation of Madhya Pradesh Power Generation Corporation Limited (MPPGCL) was 14623 MU fixed by CEA, New Delhi. MP's share out of this was 13803 MU. The actual thermal generation was 14017 MU which is 95.85% of CEA Targets. This generation during the year 2006-07 is 3.51% more compared to the previous year generation.

The annual Plant Load Factor of thermal station of MPPGCL in the year 2006-07 is 70.41% . The previous year PLF was 68.02%

5.5.1.4.2 Hydel Generation

The total generation situated in MP STATE (irrespective of share) was 3051 MU. The total hydel generation MP's share was 3034 MU.

B. Central Sector Generation

The generation from Central Sector Station has increased by 1681 MU as compared to year 2005-06. The Stationwise Generation and PLF as compared with year is as given in Table:5.5.2 :

Table:5.5.2 Stationwise generation of PLF

STATION	Year : 06-07		Year : 05-06	
	MU	P.F.L	MU	P.F.L
KORBA STPS	16500.10	89.69	15818.39	85.99
VINDHYACHAL STPS	18426.67	88.32	18305.60	92.46
KAWAS GPP	3606.82	62.76	2884.41	50.19
GANDHAR GPP	4550.50	79.11	4477.86	77.76
KADRAPAR APP	2445.59	63.45	2366.94	61.41
TARAPUR APP	4005.19			
TOTAL	**45534.68**		**43853.20**	**82.13**

C.Unschedule Interchange

During the year 2006-07, State of MP has overdrawn 105.18 MU and under drawn 357.35 MU from the western grid and earned UI Charges amounting to Rs. 56.54 Crore, whereas during the year 2005-06, MP has overdrawn 439.91 MU from the western grid and paid UI charges amounting to Rs. 157.82 Crore.

D. ISP (NHDC) Generation

Total eight ISP units are commissioning in M.P. The total injection into MP grid from ISP was 2592 MU during the year 2006-07 as against target of 2698 MU. This capacity addition into MP Grid has helped to improve the voltage profile in the Western part of Madhya Pradesh.

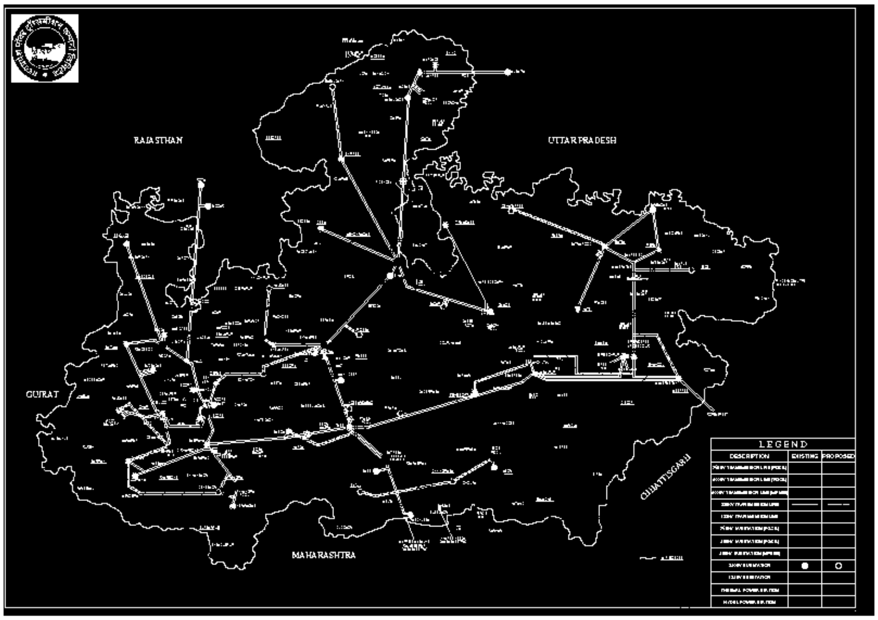
E. Sardar Sarovar Project

The unitwise commissioning dates of units are as given in Table:5.5.3.

Tabel:5.5.3 Unitwise commissioning dates

Unit No	**Date of Commissioning**	**Date of Commercial Operation**
Canal Head Power House (5x50 MW)		
1	04.10.2004	08.10.2004
2	16.08.2004	26.08.2004
3	31.08.2004	04.09.2004
4	03.09.2004	09.09.2004
5	15.12.2004	19.12.2004
River Bed Power House (6x200 MW)		
1	01.02.2005	12.02.2005
2	30.04.2005	12.06.2005
3	30.08.2005	06.09.2005
4	13.10.2005	20.10.2005
5	07.03.2006	12.11.2006
6	20.05.2006	27.06.2006

The total Share of MP in Sardar Sarovar was 2017 MU during the year 2006-07 as against target of 1590 MU.



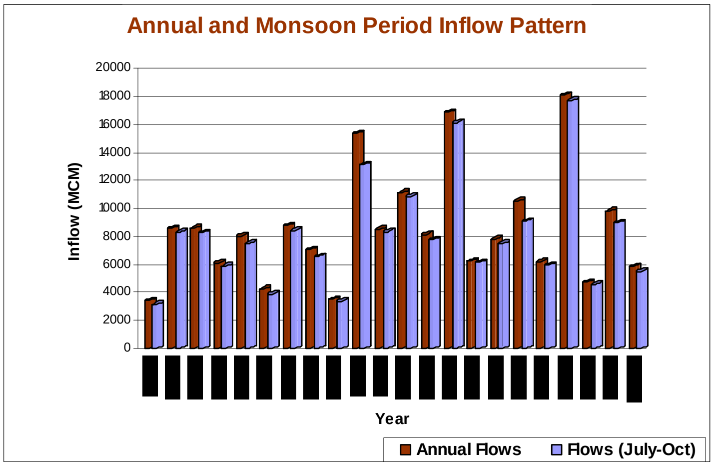
5.5.2. HYDROLOGY

5.5.2.1 The river drains a catchment area of about 19534 km^2 upto the proposed dam site. The hydrological studies for the project have been carried out by National Institute of Hydrology (NIH), Roorkee.

5.5.2.2 In absence of observed data at the Daudhan dam site, the yield data of two down stream sites viz. Banda and Madla were used to generate yield data at Daudhan. The variability of annual rainfall ratio for Banda catchment (ratio of annual rainfall at Daudhan catchment to that of Banda catchment) was observed to be high compared to Madla catchment. Hence, the yield series at Madla gauging site, which is also nearer to the proposed Daudhan dam was used for estimation of monthly yields at Daudhan.

5.5.2.3 Based on the above hydrological studies, an inflow series has been developed by NIH, Roorkee for the Initial as well as the Final scenarios of upstream utilization figures (as worked out considering all existing, on-going and proposed projects) and have been vetted by Central Water Commission (CWC). The flow series for the above two scenarios have been rearranged in the cycle of hydrological years from June to May (1981-82 to 2002-03) for the purpose of planning of the project/ simulation studies.

5.5.2.4 The analysis of hydrology indicates that, in the initial scenario, the annual runoff during the study period vary from a maximum of 18113 MCM (year 1999-2000) to a minimum of 3443 MCM (year 1981-82) with the average being 8536 MCM. It is seen that the average inflows in the river during monsoon months from July to October constitute about 94.5 % of the total average annual run-off. Thus, the power generation during non-



monsoon months would mainly depend upon the stored water available in the reservoir.

5.5.2.5 In the Final Scenario of upstream utilizations, the average run-off will get reduced to 8142 MCM with maximum and the minimum run-off being 17525 MCM (year 1999-2000) and 2950 MCM (year 1981-82) respectively. The contribution of inflows during monsoon months from July to October would be of the order of 98.3 %.

5.5.3 Input Data for the Power Potential Study

For carrying out the simulation studies, the hydrological, topographical and other data including the demands of drinking water and irrigation, as given below, have been considered:

5.5.3.1 Hydrological Flow Data

For the preliminary power potential study, the hydrological flow data for the period 1981-82 to 2002-03 developed by NIH, Roorkee for initial as well as ultimate scenarios of upstream utilization figures, as discussed in para: 5.5.2.3, has been utilized.

5.5.3.2 Evaporation Data

The month-wise Evaporation Data from the proposed Daudhan Reservoir, as furnished by NWDA, considered for the studies is as given in Table:5.5.4:

Table:5.5.4 Monthwise evaporation of Daudhan reservoir

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
EVAP. in mm	70	89	171	292	400	260	114	95	114	95	70	64	1834

5.5.3.2 Area Capacity Characteristics

The Area-Capacity Characteristics of Daudhan Reservoir, as considered for the reservoir simulation studies are as given in Table:5.5.5:

Table:5.5.5 Elevation-Area-Capacity table for Daudhan reservoir

Elevation (m)	Area (ha)	Capacity (MCM)	Elevation (m)	Area (ha)	Capacity (MCM)
216.00	0	0.00	**253.00**	4450	615.84
220.00	150	2.00	**256.00**	4750	753.82
225.00	400	15.25	**259.00**	5150	902.28
230.00	700	42.40	**262.00**	5400	1060.51
230.90	735	49.48	**265.00**	5800	1228.48
234.50	875	77.77	**268.00**	6025	1405.84
235.00	981	82.40	**271.00**	6625	1595.52
235.50	1050	87.48	**274.00**	6775	1796.52
238.00	1950	124.40	**277.00**	7025	2003.51
241.00	2550	191.70	**280.50**	7300	2254.18
244.00	3200	277.77	**283.50**	7800	2480.64
247.00	3500	378.24	**287.60**	8650	2817.71
250.00	3950	489.92	**288.00**	9000	2853.01

From the above table, the gross storage available at FRL has been worked out as is 2853 MCM.

5.5.3.4 Tailrace Water Level (TWL)

Low Level Tunnel Power House

Full Supply Level of the proposed Ken Left Bank Canal would be 246m. In absence of any information on Tail water data for the proposed power house, a constant average TWL of 246 m has been adopted for Low Level Tunnel Power House for the power potential study.

Daudhan Power House

The top of Pond level at the existing Gangau Weir is 234.9m while the minimum operating level is 232.4 m. A constant average TWL of 234 m has been adopted for Daudhan Power House for the power potential study.

5.5.3.5 Drinking Water & Irrigation Requirements

The Monthwise Water Utilization flows from Daudhan Reservoir, as considered for power potential studies, are given in Table:5.5.6 below :

Table:5.5.6 Monthwise Water Utilization Flows from Daudhan Reservoir

Month	Daudhan dam (Cumec)	Ken-Betwa link (Cumec)	Lower Level Tunnel (Cumec)	Total (Cumec)
June	15.04	0.00	17.44	32.48
July	103.82	57.31	58.02	219.16
Aug.	133.70	37.41	59.27	230.37
Sept.	111.51	36.77	40.17	188.46
Oct.	123.58	56.74	29.26	209.58
Nov.	100.61	69.55	57.54	227.70
Dec.	30.28	56.55	42.94	129.76
Jan.	47.74	50.00	42.50	140.24
Feb.	56.45	44.38	34.85	135.68
March	25.42	0.00	1.22	26.64
April	11.04	0.00	0.00	11.04
May	0.00	0.00	0.00	0.00

5.5.3.6 Full Reservoir Level (FRL)

The full reservoir level for the project was initially envisaged as 287 m. However, to avoid/ minimize the pumping requirements to cater to the irrigation requirements to be met through Ken-Betwa Link Canal during certain periods when the Daudhan reservoir level falls below the level 262m, the FRL has been proposed to be kept as 288 m in order to make available additional live storage for the purpose.

5.5.3.7 Minimum Draw Down Level (MDDL)

The project, envisages the three irrigation outlets at different levels from Daudhan Reservoir to cater to the downstream irrigation and drinking water requirements are furnished in Table:5.5.7.

Table:5.5.7 : Levels & Storages for irrigation outlets

Description of Irrigation Outlet	Draw Down Level from Irrigation Considerations (m)	Gross Storage Available
For releasing water to **Bariarpur** through Ken river with generation at PH-I	246 m	344.7 MCM
For **Ken command** through lower level tunnel with generation at PH-II	246 m	344.7 MCM
For Barwasagar through **Ken-Betwa Link Canal**	256 m	753.20 MCM

5.5.3.8 Draw Down Level for Power Generation

The draw down levels for power generation at Daudhan Power House and Low Level Tunnel Power House would be 252 m and 260 m from the consideration of permissible head variations on Kaplan Turbine which has been proposed for the two power houses. No power generation has been proposed across the Ken-Betwa Link Canal.

As per the sedimentation studies carried out by NIH, Roorkee, the New Zero Elevation after 50 years and 100 years of sedimentation would be 230 m and 235.5 m respectively which are considerably lower than the proposed outlets for irrigation and the draw down level for power generation and, therefore, may not pose any problems.

The live storage available between the FRL 288 m and the proposed draw down levels of 252 m and 260 m for power generation at Daudhan Power House and Low Level Tunnel Power House respectively would be 2279.14 MCM and 2541.75 MCM respectively.

5.5.3.9 Head Availability & Head Loss in Water Conductor System

For carrying out the power potential study, available head and the head loss in Water Conductor System for Daudhan Power House and for Low Level Tunnel Power House have been considered as given in Table:5.5.8 below:

Table:5.5.8 Maximum and Minimum Head for Power Houses

	Daudhan PH				Low Level Tunnel PH			
	Gross Head	Head Loss		Net Head	Gross Head	Head Loss		Net Head
	m	%	m	m	m	%	m	m
Max. Head	54	2%	1.08	52.9	42	5%	2.10	39.9

Min. Head	18	4%	0.72	17.3	14	8%	1.12	12.9
Avg. Head	43.33	4%	1.73	41.6	32.67	9%	2.94	29.7

From the above table, it is observed that the maximum gross head in case of Daudhan Dam Power House and the Low Level Tunnel Power House would be around 54 m and 42 m with minimum head as 18 m and 14 m respectively. Accordingly, for the above head range, maximum head would be three times the minimum head, which is permissible for operation of Kaplan Turbine proposed for the above project.

5.5.3.10 Operation of the Power Houses

The Ken-Betwa link project is primarily to be operated in the interest of irrigation and drinking water supply. There is no re-regulating barrage/ structure in the downstream of Low Level Tunnel Power House. Therefore, the power house is proposed to be operated as a base Load Station.

The Daudhan Power House would be operated as a Peaking Station with re-regulation at the existing Gangau Weir where adequate diurnal pondage is available for re-regulation of the daily peaking flows.

5.5.4. Simulation Strategy

5.5.4.1 The Daudhan Reservoir is proposed to be operated on '*Carry Over Basis*' viz. surplus flows available at the end of a hydrological cycle, after meeting the Irrigation and Drinking Water Requirements and also after generation of the Secondary Power, would be carried over for utilization in the next cycle.

5.5.4.2 For carrying out the Simulation studies, the irrigation and the other requirements to be met through different outlets of the Daudhan reservoir, have been clubbed together and the reservoir has been proposed to be operated in such a manner to cater to these irrigation requirements on 75% dependable basis.

5.5.4.3 In order to obviate the need of pumping the water into Ken-Betwa Link Canal, efforts would be made to maintain the reservoir level close to 256 m during all months except the months of March, April, May and June when the irrigation requirement through the Ken-Betwa Link is zero and the level of the reservoir during these months would be allowed to be depleted up to 246m in order to meet irrigation requirement through Daudhan Dam and Low Level Tunnel power houses, if required.

5.5.4.4 As the reservoir level decreases below 260 m, the power generation at Low Level Tunnel power house would be stopped while Daudhan Dam Power House would continue to generate power. Subsequently, after the reservoir level decreases further viz. below 252 m, both the power houses would stop generation. However, irrigation requirement would continue to be met till the level reaches the elevation of 246 m.

5.5.4.5 The surplus water after meeting the committed irrigation and other releases would be utilized for generation of secondary power at Daudhan Power House up to the installed capacity. Any surplus waters after generation of secondary energy at Daudhan Power House would be utilized at Lower Level Tunnel Power House upto the design discharge of the canal while rest of the water would have to be spilled.

5.5.5 Results of the Simulation Study

5.5.5.1 Based on the available input data and the simulation strategy described above, Reservoir Simulation Studies have been carried out by using 'SIMHYDE Model' for both Initial as well as the Final scenarios of the upstream utilizations. The installed capacity and the energy benefits from the project have, however, been finalized based on the hydrological flows available in the initial scenario.

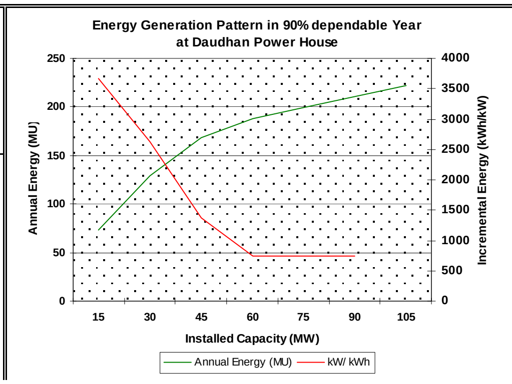
5.5.5.2 Installed Capacity & Unit Size

5.5.5.2.1 Daudhan Power House

i) Due to availability of diurnal pondage at Gangau Weir, the Daudhan power House has been proposed for operation as a peaking Station. For selection of installed capacity, Simulation studies have been carried out for Daudhan reservoir and annual energy benefits in 90% dependable year have been estimated from the project in alternative installed capacity scenarios ranging from 15 MW to 105 MW at an interval of 15 MW. Subsequently, installed capacity for Daudhan Power House has been optimized based on Incremental Benefit Analysis. Results of the studies are summarized in Table:5.5.9 below:

Table:5.5.9 Annual Energy Generation at Daudhan Power House in 90% Dependable Year (1986-87)

I.C. (MW)	Annual Energy (MU)	Incre-mental Energy (MU)	kW/ kWh
15	73.62	-	-
30	128.70	55.08	3672.0
45	168.04	39.34	2622.7
60	188.51	20.47	1364.7
75	199.67	11.16	744.0



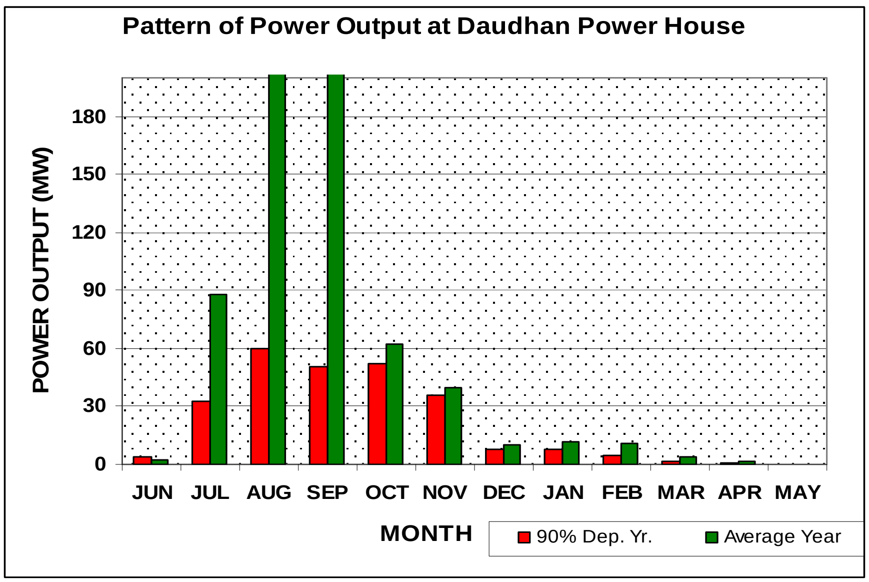
90	**210.83**	**11.16**	**744.0**	
105	**221.99**	**11.16**	**744.0**	

ii) Based on the above Incremental Benefit analysis, the following observations are made :

- the annual energy exhibits an increasing trend as the installed capacity is increased from 15 MW to 105 MW.
- the incremental energy falls to a low value for installed capacities beyond 60 MW.

iii) In view of the above, installed capacity for Daudhan Power House has been proposed as 60 MW. With the installation as 60 MW, the station would operate at an annual load factor of about 35.9 %.

iv) The month-wise power output pattern in 90% dependable year and on an average basis has been graphically depicted below :



It is observed from the above that there would be either no generation or significantly less generation during a number of months due to lack of irrigation demand as well as lower head availability during these month.

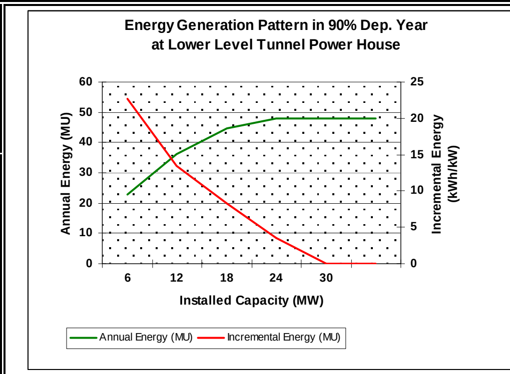
v) Daudhan power house has been proposed to be operated as a peaking station with re-regulation at the downstream Gangau weir where adequate pondage is available. The alternative unit sizes of 20 MW and 30 MW were considered for Daudhan Power House. However, unit size is being proposed as 30 MW since the project is located close to Chattarpur-Panna State Highway and as such, there is unlikely to be any major constraint in transportation of heavy equipment to the project site. The higher size unit would also offer greater economies due to lower per kW cost as well as savings in cost of civil works.

5.5.5.2.2 Lower Level Tunnel Power House

The Low Level Tunnel power House has been proposed to be operated as a peaking station. For selection of the installed capacity for Low Level Tunnel power House, annual energy benefits have been estimated from the project in 90% dependable year corresponding to alternative installed capacity scenarios up to 30 MW at an interval of 6 MW. Further, Incremental Analysis has been carried out for selection of optimum installed capacity for Low Level Tunnel power House. Results of the studies are summarized in Table:5.5.10 below:

Table:5.5.10 Annual Energy Generation at Lower Level Tunnel PH in 90 % Dependable Year (1982-83)

I.C. (MW)	Annual Energy (MU)	Incre- mental Energy (MU)	kW / kWh
0	0.00		
6	22.71	22.71	0.0
12	36.19	13.48	2246.7
18	44.54	8.35	1391.7
24	48.07	3.53	588.0
30	48.07	0.00	0.0

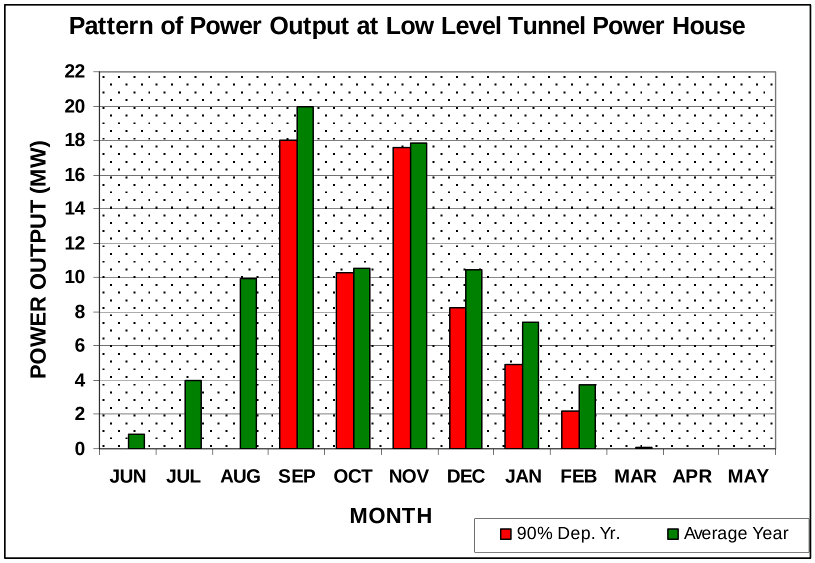


ii) Based on the above Incremental Benefit analysis, the following observations are made :

- the annual energy exhibits an increasing trend as the installed capacity is increased. However, there is no increase in energy generation for installed capacity beyond 24 MW.
- the incremental energy falls to a low value for installed capacities beyond 18 MW.

iii) In view of the above, installed capacity for Daudhan Power House has been proposed as 18 MW. With the installation as 18 MW, the station would operate at an annual load factor of about 28.3 %.

iv) The month-wise power output pattern in 90% dependable year and on an average basis has been graphically depicted below:



It is observed from the above that there would be either no generation or significantly less generation during a number of months.

v) Low Level Tunnel power house has been proposed to be operated as a base load station since no re-regulating structure is proposed in the downstream of the power house. The unit size for the Power House has been selected as 6 MW based on the pattern of generation.

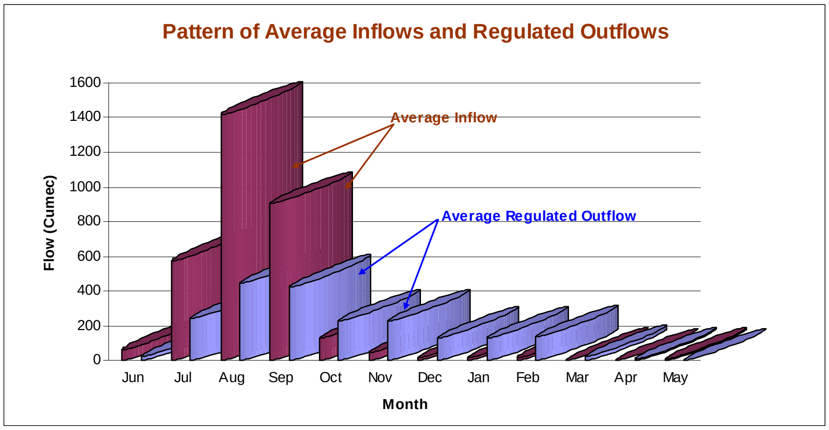
5.5.5.2.3 The annual energy benefits and the power house discharges are summarized in Table:5.5.11 below:

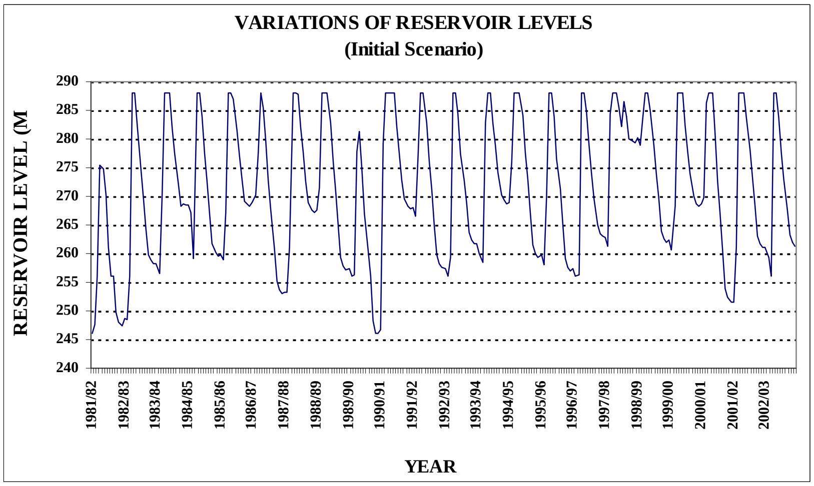
Table:5.5.11

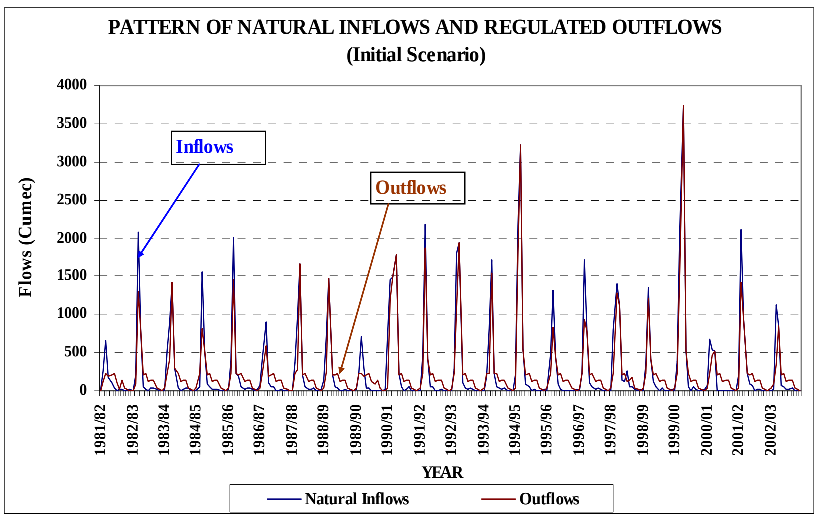
	Daudhan Dam Power House	**Low Level Tunnel Power House**
Installed Capacity	60 MW	18 MW
Unit Size	30 MW	6 MW
Power House Discharge		
At Max. Head	131 cumec	48 cumec
At Min. Head	93 cumec	35 cumec
At Average Head	164 cumec	61 cumec
Annual Energy Benefits	188.5 MU	44.54 MU

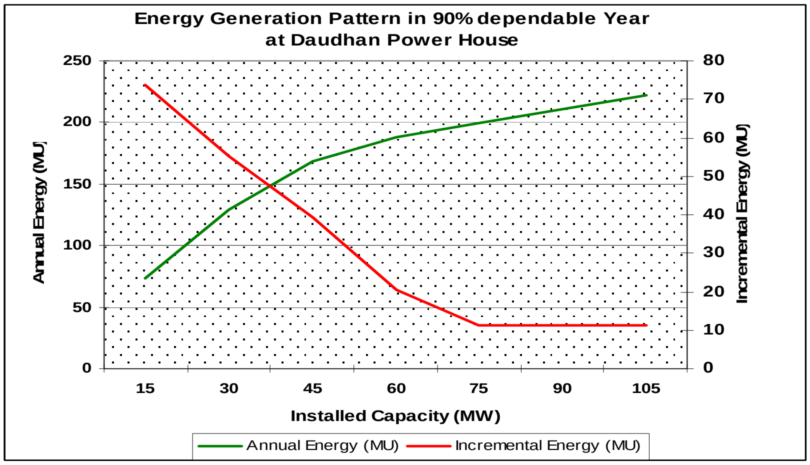
5.5.5.2.4 The detailed month-wise power study for the Initial scenarios of upstream utilizations, corresponding to the installed capacity of 60 MW at Daudhan Dam Power House and 18 MW at Low Level Tunnel Power House is given at Annexure:5.5.1.

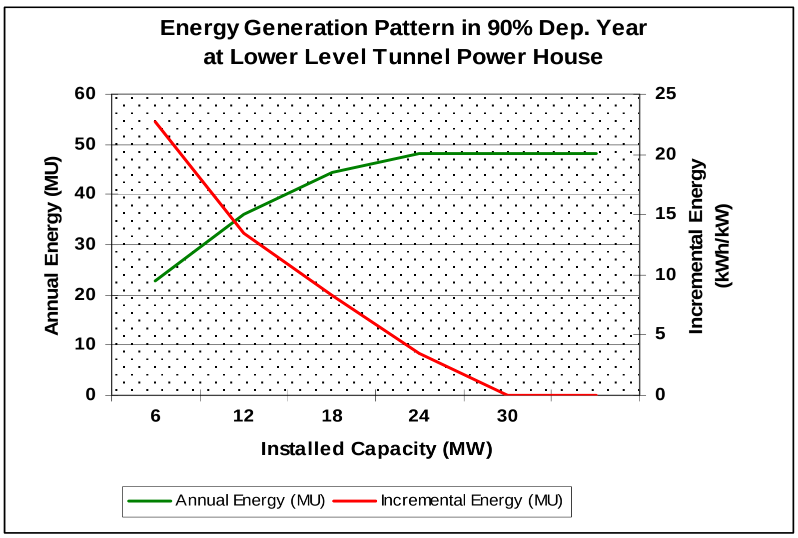
5.5.6 Graphical Analysis of Simulation Study

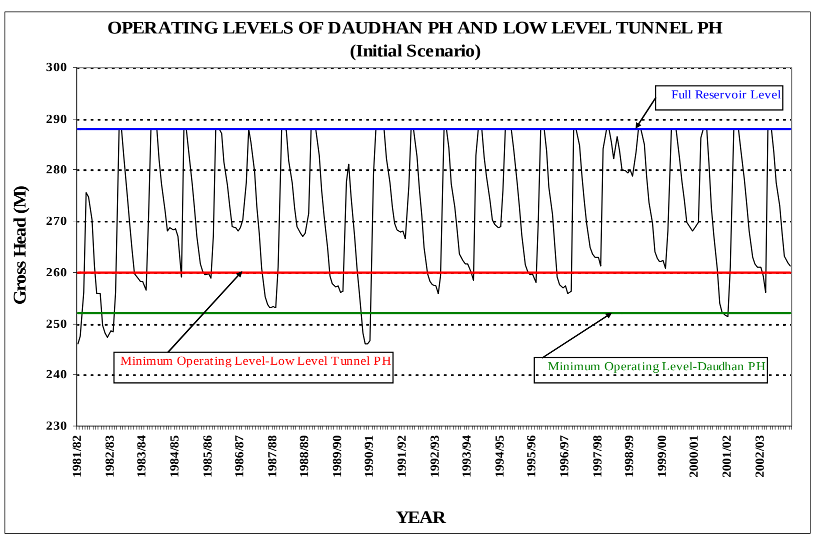

Pattern of Average Inflows and Regulated Outflows
1600
1400
1200
1000
800
600
400
200
0
Flow (Cumec)
Average Inflow
Average Regulated Outflow
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Month


VARIATIONS OF RESERVOIR LEVELS
(Initial Scenario)
RESERVOIR LEVEL (M
290
285
280
275
270
265
260
255
250
245
240
1981/82
1982/83
1983/84
1984/85
1985/86
1986/87
1987/88
1988/89
1989/90
1990/91
1991/92
1992/93
1993/94
1994/95
1995/96
1996/97
1997/98
1998/99
1999/00
2000/01
2001/02
2002/03
YEAR


PATTERN OF NATURAL INFLOWS AND REGULATED OUTFLOWS
(Initial Scenario)
Flows (Cumec)
4000
3500
3000
2500
2000
1500
1000
500
0
Inflows
Outflows
1981/82
1982/83
1983/84
1984/85
1985/86
1986/87
1987/88
1988/89
1989/90
1990/91
1991/92
1992/93
1993/94
1994/95
1995/96
1996/97
1997/98
1998/99
1999/00
2000/01
2001/02
2002/03
YEAR
Natural Inflows
Outflows







5.5.7 Adequacy of Pondage at Gangau Weir

5.5.7.1 The area-capacity characteristics of Gangau Weir, as per the DPR prepared earlier, are given in Table:5.5.12 below :

Table:5.5.12

Elevation (m)	Capacity (MCM)	Elevation (m)	Capacity (MCM)
211.0	0.000	**226.0**	3.003
214.0	0.077	**229.0**	5.236
217.0	0.231	**232.0**	8.624
220.0	0.539	**235.0**	14.630
223.0	1.386		

From the above, it is observed that, a pondage of about 5.0 MCM is available at Gangau Weir between the maximum and the minimum pond levels of 234.9 m (14.430 MCM) and of 232.4 m (9.425 MCM) respectively as per the Feasibility Report prepared by NWDA in 1995.

5.5.7.2 The maximum discharge required for peaking at average head conditions would be 164 cumec. As such, diurnal Pondage requirements for about 4 hours of peaking would be 2.36 MCM. Therefore, the Pondage available at Gangau Weir would be adequate to re-regulate the peak releases from the Daudhan Power House.

5.5.8. Impact of Flows in the Final Scenario

5.5.8.1 Simulation studies have been carried out for the Final Scenario of upstream utilizations and the power generation at Daudhan power house and the low level tunnel power house in the above scenario is given in Annexure:5.5.2.

5.5.8.2 Based on the simulation studies carried out for the Initial and the Final Scenario, the following observations are made :

Table:5.5.13

Sl. No.	Parameter	Initial Scenario	Final Scenario
1.	**Average Inflows (Cumec)**		
	Annual	270.68	258.20
	Nov.-May	17.04	1.80
2.	**Average Annual Utilisation (Cumec)**	169.6 (63.2%)	162.40 (62.9%)
3.	**Average Annual Spills (Cumec)**	96.8 (33.1%)	93.4 (36.2%)
4.	**Annual Energy Generation in 90% Dep. Year (MU)**		
	Daudhan PH	188.51	158.32 MU
	Low Level Tunnel PH	50.14	41.10 MU

5.5.9 Pumping Requirement for Ken-Betwa Link Canal

5.5.9.1 As already brought out above, it is proposed to have the three outlets from Daudhan Reservoir to cater to the irrigation and drinking water requirements etc. While the outlets for releasing water to Bariarpur through Ken river and for KMPP command through lower level tunnel are located much below the Draw Down Level of 246 m, the outlet for conveying waters to Barwa Sagar by means of Upper level tunnel/ Ken-Betwa Link Canal is located at a much higher level viz. 262 m.

5.5.9.2 As discussed above, during Initial Scenario of upstream utilizations, the reservoir shall be so operated as to obviate the need of pumping waters into Ken-Betwa link Canal. It is, however, observed from the results of the simulation study for the Initial Scenario of upstream utilizations that the reservoir would fail to cater to irrigation and other requirements in some of the months.

5.5.9.3 Pumping is, therefore, not be envisaged during the Initial Scenario of upstream utilizations. The same may be reviewed subsequently during Final Scenario of upstream utilizations.

5.5.10 Summary of the Study

5.5.10.1 Based on the studies carried out and the results of the Power Potential Study for Ken-Betwa Link Project are summarized in Table:5.5.14 below:

Table:5.5.14

Location & River	-	Across the Ken River near Daudhan Village in M.P., about 19 km from Chattarpur-Panna State Highway
Ht. of dam	-	about 77 m
Full Reservoir Level (FRL)	-	288 m
Gross Storage at FRL (Daudhan)	-	2853 MCM
Draw Down Level for Power generation		
Daudhan Dam Power House	-	252 m
Low Level Tunnel Power House	-	260 m
Draw Down Level Irrigation		
For releasing water to Bariarpur through Daudhan Dam PH	-	246 m
through Low Level Tunnel PH for KMPP Command	-	246 m

Through Ken-Betwa Link for Barwa Sagar	-	262 m	
Annual Average Inflow Data	-	1981-82 to 2002-03	
(Initial Scenario) Maximum	-	18113 MCM (year 1999-2000)	
Minimum	-	3443 MCM (year 1981-82)	
Average	-	8536 MCM	
Average Flows during July-Oct.	-	94.5 %	
Annual Average Inflow Data	-	1981-82 to 2002-03	
(Final Scenario) Maximum	-	17525 MCM (year 1999-2000)	
Minimum	-	2950 MCM (year 1981-82)	
Average	-	8142 MCM	
Average Flows during July-Oct.	-	98.3 %	
Tailrace Water Level (TWL)			
Daudhan Dam Power House	-	234 m	
Low Level Tunnel Power House	-	246 m	
Operation of Power Station			
Daudhan Dam Power House	-	Peaking Operation	
Low Level Tunnel Power House	-	Base Load Operation	
Gross Head		**Max.**	**Min.**
Daudhan Dam Power House	-	54 m	18 m
Low Level Tunnel Power House	-	42 m	14 m
Power House Discharge	-	**Daudhan Dam Power House**	**Low Level Tunnel Power House**
At Max. Head	-	131 cumec	48 cumec
At Min. Head	-	93 cumec	35 cumec
At Average Head		164 cumec	61 cumec
Pondage Availability at Gangau Weir	-	About 5 MCM	
Unit Size & Installed Capacity	-		
Daudhan Dam Power House	-	2 x 30= 60 MW	
Low Level Tunnel Power House		3 x 6 = 18 MW	
Annual Energy Generation		**Initial**	**Final**

in 90% Dependable Year		**Scenario**	**Scenario**
Daudhan Dam Power House	-	188.5 MU	158.32 MU
Low Level Tunnel Power House	-	50.14 MU	41.10 MU

5.6 Electrical & Mechanical Works

5.6.1 Introduction

5.6.1.1 The project is proposed to be located in the Panna and Chhatarpur districts of Madhya Pradesh. The dam site is situated in the Chhatarpur district near the Daudhan village having latitude 24°36′51″ N and longitude 79°50′30″ E and is about 2.5 km upstream of the age old Gangau weir.

5.6.1.2 The climate in project area is semi-arid to dry sub-humid. It is generally tolerable except during the months of January, May and June. The air being mostly dry except during south west monsoon season. Summer is hot and winter is generally mild. About 90% of the annual rainfall is received during the monsoon period i.e. from June to October. The average maximum and minimum temperatures are 44.2^0C and 6.7^0C respectively.

5.6.1.3 The dam proposed at Daudhan is an earthen cum concrete dam with a side channel spillway with FRL & MWL as 288m. The analysis of hydrology indicates that the annual runoff during the study period vary from a maximum of 18113 MCM (year 1999-2000) to a minimum of 3443 MCM (year 1981-82) with the average being 8536 MCM.

5.6.1.4 The Power House-I is proposed to be located at the foot of the dam on the left bank of Ken river to the right of spill way whereas the Power House-II is proposed to be located at the end of a 1.1 km long lower level tunnel on the left bank of Daudhan dam axis. The installed capacities of Power House-I and II are 2 x30MW and 3 x6MW respectively.

5.6.1.5 From Power house-II, a canal of length about 2.1 km is proposed to be connected to LBC of KMPP for providing irrigation to Ken command of Madhya Pradesh. An upper level tunnel of length about 2.0 km is also proposed from left bank of Daudhan dam itself and from the exit of it the Ken Betwa link canal of length about 118.0 km is proposed to run through Chhatarpur and Tikamgarh districts of Madhya Pradesh and part of Jhansi and Mahoba districts of Uttar Pradesh to provide irrigation and drinking water facility to the major towns/ villages in the enroute of the link.

5.6.2 Transportation Constraints

5.6.2.1 The nearest rail head to the Daudhan project site is Khajuraho from where well maintained National and State Highways are connected upto

Bamitha which is about 28 km from the project site. In this reach, no low level bridges/bridges with travel restrictions exist. However, from Bamitha to the actual project site, the existing single lane roads/forest roads are to be suitably remodeled/ reconstructed to facilitate transportation of required heavy machineries. Alternate road connection from Chhatarpur to the project site via. Deogaon mod, Jhamtuli and Salaiya to the project site could also be used for transportation of the machineries by remodeling the road from Deogaon mod (on NH–76) to the project site. For both these alternatives, necessary provision has been made in the project estimates for remodeling /reconstruction.

5.6.3 Broad Scope of Works

5.6.3.1 Power House-I (2x30=60 MW)

Power House-I envisages an installation of 2 units, each of 30 MW in a surface power house. The scope of Electro Mechanical (E&M) works includes design, Engineering, Manufacture, Testing at Works, Supply, Transportation, Insurance, Handling, Storage at site, Erection, Service as broadly detailed below for commissioning of 2x30 MW generating units. The main equipment comprises of :-

- 2 (Two) Nos. of Vertical Shaft Kaplan Turbines & Main Inlet Valves of butterfly type complete with all unit auxiliaries like Governing System, Pressure oil System, High pressure and low pressure compressed air system, Grease Lubrication System, Oil Leakage Unit. Drainage & dewatering system etc.

- 2 (Two) Nos. of Hydro Generators, complete with Static Excitation System, Brake System, Brake Dust Collection, Lubrication Oil System, cooling water system, CO_2 System for fire protection of generator, etc.

- 11/132/√3 kV, 36.67 MVA, 3 phase, ONAF (Oil Natural air forced) cooled Generator Step-up Transformers; 11/0.415 kV, 630 kVA, 3 phase, ONAN (Oil natural air natural) cooled Station Auxiliary Transformers; 11/0.415 kV, 630 kVA, 3 phase, ONAN (Oil natural air natural) cooled Station Service Transformers and 11/0.415 kV, 500 kVA, 3 phase dry type Unit Auxiliary Transformers complete with all the accessories.

- 11 kV Isolated Phase Bus ducts for interconnection between Generator phase terminals & Generator Transformers along with terminal equipment for phase as well as for neutral side.

- SCADA system comprising of Computerized Control & Monitoring for the Main Plant, Electrical System & Plant Auxiliaries.

- 132 kV high voltage switchgear for outdoor switchyard
- Common Station Auxiliaries
- Relay & Protection System
- 415 V Station & Unit Auxiliary Supply System
- Station D.C. System comprising of 220 V DC batteries, Battery charging equipment and DC Distribution board
- Power, Control & Instrumentation Cables, Cables Trays, cable supporting racks, Hardware & fittings etc.
- Electric Overhead Traveling Crane for power house
- Elevator
- PLCC Equipment and Plant Communication System
- Earthing System
- Workshop Equipment (Common for both the power houses)
- Laboratory & Testing Equipment (Common for both the power houses)
- 500 kVA Diesel Generating Set for emergency supply

5.6.3.2 Power House -II (3x6=18 MW)

Power House-II envisages an installation of 3 units, each of 6 MW in a surface power house. The scope of EM works includes design, Engineering, Manufacture, Testing at Works, Supply, Transportation, Insurance, Handling, Storage at site, Erection, Service as broadly detailed below for commissioning of 3x6 MW generating units. The main equipment comprises of :-

- 3 (three) Nos. of Vertical Shaft Kaplan Turbines & Main Inlet Valves of butterfly type complete with all unit auxiliaries like Governing System, Pressure oil System, High pressure and low pressure compressed air system, Grease Lubrication System, Oil Leakage Unit. Drainage & dewatering system etc.
- 3 (three) Nos. of Hydro Generators, complete with Brushless Excitation System and AVR, Brake System, Brake Dust Collection, Lubrication Oil System, cooling water system, CO2 System for fire protection of generator etc.

- 11/33 kV, 7.5 MVA, 3 phase, ONAF (Oil Natural Air forced) cooled Generator Step-up Transformers; 33/11 kV, 1600 kVA, 3 phase, ONAN (Oil natural, air natural) cooled step down Transformers; 11/0.415 kV, 630 KVA, 3 phase, ONAN cooled (dry type) station service transformer and 11/0.415 kV, 250 kVA, 3 phase dry type Unit Auxiliary Transformers complete with all the accessories.

- 11 kV segregated Phase Bus ducts for interconnection between Generator phase terminals & Generator Transformers along with terminal equipment for phase as well as for neutral side.

- SCADA system comprising of Computerized Control & Monitoring for the Main Plant, Electrical System & Plant Auxiliaries.

- 11 kV high voltage switchgear

- Common Station Auxiliaries

- Relay & Protection System

- 415 V Station & Unit Auxiliary Supply System

- Station D.C. System comprising of 220 V DC batteries, Battery charging equipment and DC Distribution board

- Power, Control & Instrumentation Cables, Cables Trays, cable supporting racks, Hardware & fittings etc.

- Electric Overhead Traveling Crane for power house

- Elevator

- PLCC and Plant Communication System

- Earthing System

- 250 KVA Diesel Generating Set for emergency supply

5.6.4 Selection of Parameters of Main Generating Units & Associated Equipment

5.6.4.1 Considering the reservoir and the tail water levels, the gross and net heads as assessed are as given below:-

a) Working Head Range:

Table:5.6.1

	POWER HOUSE -I (2x30=60 MW)		POWER HOUSE -II (3x6=18 MW)	
	Gross	Net	Gross	Net
Maximum	54.00 m	52.92 m	42.00 m	39.90 m
Minimum	18.00 m	17.28 m	14.00 m	12.88 m
Design	42.00 m	41.00 m	32.67 m	30.50 m

5.6.4.2 Kaplan type of turbine has been considered to be most suitable for operation over the above head range for both the powerhouses. The turbines shall be designed to develop continuous over load of 10% at design/ rated head and at higher heads.

5.6.4.3 The details of the hydraulic system of the generating units and basic data for design of turbines are given in Table:5.6.2 below: -

Table:5.6.2

		POWER HOUSE -I	POWER HOUSE -II
	Installed Capacity	**2x30=60MW**	**3x6=18 MW**
	Reservoir Levels:		
a)	Full Reservoir Level (FRL)	288.00 m	288.00 m
b)	Minimum Draw Down Level (MDDL)	252.00 m	260.00 m
	Tail water levels:-		
c)	Minimum tail water level	234.00 m	246.00 m
d)	Maximum tail water level	234.00 m	246.00 m
e)	Maximum flood water level	240.89 m	240.89 m
	Turbine operating range:-		
a)	Maximum gross head	54.00 m	42.00 m
b)	Minimum gross head	18.00 m	14.00 m
c)	Average gross head	36.00 m	28.00 m
d)	Maximum net head	52.92 m	32.67 m
e)	Minimum net head	17.28 m	12.88 m
f)	Design head	41.00 m	30.50 m
	Turbine Discharge		
a)	One unit discharge	82.75 m^3/sec.	22.30 m^3/sec
b)	Total discharge	165.50 m^3/sec	66.90 m^3/sec
	Turbine Basic Data		

a)	Generator Unit Rating	30 MW	6 MW
b)	Turbine Rating	30612 KW	6122 KW
c)	Overload capacity	33 MW	6.6 MW
d)	Rated / Design head	41.00 m	30.50 m
e)	Rated speed	214.29 rpm	300 rpm
f)	Run-away speed	396.43 rpm	555 rpm
g)	Specific speed	421.125	381.644
h)	Discharge diameter (D3)	3.40 m	2.00 m
i)	Inlet diameter (D1)	3.40 m	2.00 m
j)	Spiral casing inlet diameter	4.0 m	2.40 m
k)	Turbine setting	(-) 12.00 m	(-) 6 m
l)	Turbine efficiency	0.92	0.92
m)	Generator efficiency	0.98	0.98
n)	Overall TG Efficiency	0.9016	0.9016
o)	Centerline of the spiral casing	EL 222.00 m	EL 240 .00 m

<u>Mechanical Characteristics</u>

i) Maximum speed rise on rated load rejection
50% by all units
simultaneously

ii) Maximum penstock pressure rise at
rated load 30%
rejection by all units simultaneously

iii) Maximum cooling water temperature
20^0 C

iv) Seismic forces
Corresponding to Zone-II

5.6.5 Electro-Mechanical Equipment

5.6.5.1 Turbines -Construction Aspects

The runner and other critical components of the turbine shall be of 13:4 stainless steel with high resistance to abrasion. For normal silt conditions and low heads i.e. heads less than 100 m, no special hard coating on the runner surface is considered necessary. However to attend to normal silt erosion and cavitations, pitting phenomenon, arrangement shall be provided for bottom removal of runner for easy maintenance and less time consuming operations for disassembly and reassembly.

The lower cone of the draft tube shall not be embedded in concrete to allow its dismantling for removal of runner and other components downwards for maintenance and replacement. Adequate head room and space will be provided around draft tube for purpose of handling of the components. The dismantling part of the draft tube shall have the telescopic arrangement.

The turbine shaft shall be of forged carbon steel or alloy steel, which shall be connected to the runner on one side & to the generator on the other side. Suitable shaft gland of suitable material capable of sustaining of abrasive effect of silt for prevention of water leakage along the shaft shall be provided.

The spiral casing shall be fabricated from welded steel plates & shall have suitable sections for ease of transportation. The discharge through each turbine shall be regulated by set of guide vanes individually connected to the regulating ring through suitable levers and links. Shear pins shall be provided on each guide vanes to protect them against breaking during closing operation due to foreign body getting wedged in between the guide vanes. The guide vanes shall be operated by two double acting oil operated servomotors of adequate capacity.

A common system for Station Drainage & Draft Tube Dewatering shall be provided.

Turbine shall be provided with all standard set of instruments, gauges and safety devices.

5.6.5.2 Governing Equipment

Each Turbine shall be equipped with a digital speed governing system conforming to IEC 60308 to ensure control of speed under all conditions of loading. All the basic functions of the governor will have specific software. The console unit housing governor forward and feed-back command controls will be located at machine hall floor level alongwith unit control board panels. The governing system shall be complete with speed responsive temporary and permanent droop settings, load limiting devices, pressure systems etc. Each turbine will have separate oil pressure system with oil pumps, sump tank, pressure tank etc.

The governor shall regulate the Turbine Generator unit to a uniform speed free from hunting and instability and shall provide for stable operation in all stages or conditions of operation of the generating units.

High pressure oil hydraulic system with nitrogen filled piston type accumulator for turbine and MIV control shall be provided for Power House-I only. The nitrogen filled piston type accumulator shall be provided with suitable number of N2 bottles, safety relief and charging valve sufficient to operate the servomotors of turbine when the oil pumps are not operating. The accumulator capacity shall be sufficient to cater the emergency shut down requirement.

Compressed air system will be used for governing system of power house –II.

5.6.5.3 Main Inlet Valve (MIV)

The Main Intel Valve (Butterfly Type) having 4000 mm diameter for Power house-I and 2400 mm diameter for Power house –II is proposed to be provided for each turbine for shutting off pressure water supply from the Penstock to the Turbine, complete with necessary piping, control cabinet, upstream and downstream connecting pipes with companion flanges, dismantling joint, bypass, air valve, operating mechanism etc. The seals will be made of a material that has high resistance to silt erosion. The valve shall be so designed and constructed as to enable assembly of components at works and at the same time to permit easy transportation. The weights and sizes of the components/packages shall be within the permissible transport limits for the project site.

The Valve body and disc will be made of cast steel or fabricated from cast or fabricated steel components. The valve body will have a suitable base for mounting and supporting the Valve on a concrete foundation. The valve will be of Lattice Door Type.

The valve will be provided with upstream and downstream companion flanges of the full face bearing type along with necessary connecting pipe (valve inlet pipe) to match with the corresponding penstock at upstream and suitable pipe for connecting with the turbine spiral casing downstream of the valve. A dismantling cum-expansion joint will be provided with the butterfly valve on the downstream end to facilitate installation and dismantling of the valve. Necessary reducer piece of required length will be used for connecting penstock to the butterfly valve on the upstream side.

The Valve is operable by oil pressure from the OPU (common for Governing System and Butterfly Valve). The closing operation of the Valve will be by means of a counter weight and supplemented by oil pressure as an additional measure of safety.

5.6.5.4 Oil Pressure System for Governor and Turbine Inlet Valves

Each turbine shall be provided with a pressure oil system for operation of turbine wicket gates, servomotors through governors and the opening of MIV. The pressure oil system shall consist of oil sumps tank, oil pumping unit, oil pressure accumulator (OPU), piping valve, fittings and switchgear for manual and automatic operation. The oil pressure unit shall have sufficient oil volume to meet all requirements of the governor guide vanes servomotors and Main Inlet Valve (MIV) servomotors.

5.6.6 GENERATOR

i) The generator shall be vertical shaft synchronous machine with rated continuous output of 30 MW for Powerhouse-I and 6 MW for powerhouse-II having the same rotational speed to match with that of the respective turbine.

The generator will have the following parameters:

Table:5.6.3

			POWER HOUSE - I	POWER HOUSE - II
a)	Rated capacity/output	:	30 MW	6 MW
b)	Overload Capacity	:	33 MW	6.6 MW
c)	Power factor	:	0.9 (lag)	0.9 (lag)
d)	Frequency	:	50 Hz	50 Hz
e)	Phases	:	Three	Three
f)	Rated speed	:	214.29 rpm	300 rpm
g)	Rated terminal voltage	:	11kV	11kV
h)	Range of Terminal voltage	:	(±)5%	(±)5%
i)	Range of Frequency	:	-5% to + 3%	-5% to + 3%
j)	Combined voltage and Frequency variations	:	± 5%	± 5%
k)	Bearing arrangement	:	Umbrella type	Umbrella type

ii) The generators will have an overload rating of about 10% of the name plate rating. Provision of this overload capacity is as per convention and will be useful during planned and forced outage of any of the units to complete partially as the capacity loss due to such outage.

iii) It is proposed to provide a three phase, 0.9 power factor salient pole type vertical shaft Synchronous Generator. The generator shall be provided with 10% continuous overload capacity to match the maximum turbine output. The generation voltage shall be 11 kV.

iv) The Generator stator & rotor windings shall be provided with Class F insulations but temperature rise at rated outputs shall be limited to that corresponding to class B insulation. The generator shall be provided with cooling system based on closed circuit air circulation principle. Generator phase terminals shall be brought out of barrel for connection to 11 kV Bus ducts. Generator neutral terminals shall also be brought out for formation of neutral. The neutral of the Generator shall be grounded through a distribution type transformer with secondary resistor.

v) For the rated as well as overload generator output, within the permissible operating conditions, the temperature rise limits of the stator and rotor windings will be restricted to correspond to Class

'B' insulation and the temperature limits will be as per prescribed Standards BIS/IEC.

vi) The combined thrust bearing and lower guide bearing shall be located below the rotor and with no upper guide bearing. The thrust bearing and its bracket shall be capable of carrying in addition to Generator loads, the maximum hydraulic thrust loads and weights of rotating parts of turbine.

vii) The Generator shall be capable of safely withstanding maximum stresses during normal operation, runway speed conditions, two phase and three phase short circuit conditions, single phase earth fault, out-of-phase synchronization, magnetic unbalance etc.

viii) The Generator shaft provided shall be made of the best quality forged carbon or alloy steel properly heat treated. The shaft shall be of ample size to operate at all speeds.

ix) The Generator coolers shall be frame mounted type with air coolers tubes made of Cupro-Nickel alloy. Each Generator shall be provided with pneumatically operated brakes of sufficient capacity.

x) Creep detector devices, vibration detectors, monitoring of moisture in bearing oil reservoir, dynamic monitoring of air gap etc. shall also be provided in addition to other required instruments.

xi) Water sprinkler system complete with water distribution mains, headers, detecting instruments, control instruments as required shall be provided for extinguishing the fire within the Generator.

xii) The generator shall be provided with twin circuit cooling water system. The primary cooling circuit shall be single pass and secondary cooling circuit shall be multi pass. The water for primary cooling circuit shall be pumped from tail race. The cooling system shall be having additional capacity to meet the cooling water requirements of the generator transformers.

xiii) Each generator shall be complete with ancillary items like lubrication oil system, heater, brake, brake dust collection system, CO_2 equipment for Fire fighting etc. Generator shall be provided with RTDs, thermostats & sensors, dial type thermometers for temperature monitoring of core, windings, pads, lubrication and cooling water system. Transducers for on-line condition monitoring, vibration monitoring, shaft current monitoring, stator winding, partial discharge monitoring and rotor air gap monitoring system shall be provided.

Main parameters of generator have been calculated as per IS: 12800 (part 1) and result are given below:-.

Table:5.6.4

			POWER HOUSE - I	POWER HOUSE - II
a)	Air Gap Diameter (Dg)	:	6600 mm	3300 mm
b)	Outer Core Diameter (Do)	:	7400 mm	3800 mm
c)	Stator Frame Diameter (Df)	:	8600 mm	5000 mm
d)	Inner Diameter of Generator Barrel	:	10600 mm	7000 mm
e)	Outer Diameter of Generator Barrel	:	11600 mm	8000 mm
f)	Core Length of Stator	:	600 mm	350 mm
g)	Length of Stator Frame	:	2200 mm	2000 mm
h)	Weight of Generator Rotor	:	90 ton	27 ton
i)	Proposed EOT crane capacity	:	100/30 ton	30/10 ton
	Power House Dimensions	:		
a)	Unit spacing	:	20 m	16 m
b)	Power House Width (B Line to D Line)	:	22 m	19 m
c)	Length of Service Bay	:	20 m	24 m

5.6.7 Excitation System for Generator

5.6.7.1 For Power house-I :

i) The generators will be provided with static excitation system which shall have micro process based controls. The excitation equipment/system shall comprise of rectifier, excitation transformer, thyristors, field breaker with discharge resistor, field flashing circuit, automatic voltage regulator and protection and control devices along with accessories to make it a complete system. It will have features like rotor current limiter, stator current limiter, follow-up circuits, etc. for the entire range of operation.

ii) The excitation system shall be capable of operation at ceiling voltage for duration of one minute without damage. The ceiling voltage shall not be less than 1.8 times the rated load field voltage under the condition of rated load, rated voltage, rated frequency and rated power factor at 90^0C of field winding temperature. The forward gain and characteristics of frequency response shall be adjustable.

iii) The excitation system shall be capable of continuously supplying the maximum excitation power required to produce 110% of rated output, at rated generator voltage, Rated Power factor and 47.5 Hz to 51.5 Hz frequency etc. The short circuit ratio shall be greater than 1.0. The rating of the exciter shall be sufficient to maintain the nominal voltage even at 1.25 times rated current and rated power factor during short time duty.

iv) The excitation system shall be of a high initial response type. The excitation system voltage response time shall not exceed 0.5 seconds.

v) The Excitation System will by complete with Digital Voltage Regulator, a complete system for both manual and automatic Voltage Regulating, Excitation Control and Indication. All electronic devices such as amplifies and logic circuits shall be of solid state design, using integrated circuits. The AVR shall have fast response and anti hunting features. The AVR shall be provided with cross compensating devices for parallel operation of generators. The AVR shall initiate corrective action without hunting. The AVR shall be sensitive to the changes of +/-0.5% of normal voltage of the generator when operating under steady load conditions for any load or excitation within operating range.

5.6.7.2 For Power house-II :

i) The generators will be provided with static excitation system (brushless type).The excitation system will be used to supply DC power to the field winding of the generator. Excitation system of the generator shall be provided by a brushless system. The excitation system shall be composed of rotating AC exciter, rotating diode bridge, excitation transformer and excitation control system etc. The system shall be complete with along with surge suppressor, automatic voltage regulator of solid state type with thyristor bridge and field suppression equipment etc.

ii) The number of Rectifier Bridge shall be so chosen that one bridge is always available as spare. The protection against voltage spikes shall be provided.

iii) The exciter shall be a synchronous generator with stationary poles and rotating armature. The voltage induced in the armature winding shall be rectified by semiconductor diodes rotating with the armature, and led to the field winding on the rotor of the main synchronous machine.

iv) The excitation system shall be of a high initial response type. The excitation system voltage response time shall not exceed 0.5 seconds.

v) The excitation system shall be capable of operation at ceiling voltage for a duration of one minute without damage. The ceiling voltage shall not be less than 1.8 times the rated load field voltage under the condition of rated load, rated voltage, rated frequency and rated power factor at 90^0C of field winding temperature. The forward gain and characteristics of frequency response shall be adjustable.

vi) Supply for initial excitation for Field Flashing will be obtained through 415V, 50Hz, 3-Phase Supply, or alternatively through 220V DC Supply.

vii) The Excitation System will be capable of continuously supplying the Maximum Excitation Power required to produce 110% of Rated Output, at Rated Generator Voltage, Rated Power Factor and 47.5 Hz Frequency, etc. The rating of the exciter shall be sufficient to maintain the nominal voltage even at 1.25 times rated current and rated power factor during short time duty.

viii) Power will be obtained through a 3-Phase, Self-cooled, Indoor, Metal-enclosed, Cast Dry Type Transformer connected to 11 kV Panels.

ix) The Excitation System will by complete with Digital Voltage Regulator, a complete system for both manual and automatic Voltage Regulating, Excitation Control and Indication. All electronic devices such as amplifies and logic circuits shall be of solid state design, using integrated circuits. The AVR shall have fast response and anti hunting features. The AVR shall be provided with cross compensating devices for parallel operation of generators. The AVR shall initiate corrective action without hunting. The AVR shall be sensitive to the changes of +/-0.5% of normal voltage of the generator when operating under steady load conditions for any load or excitation within operating range.

5.6.8. Control & Monitoring System

i) SCADA system comprising of Distributed Digital Control, Monitoring & Information System for the entire power plant & associated electro mechanical services covering the total functional requirement of control, sequence, interlocks & equipment protection, monitoring, feedbacks, system disturbance feedback etc. shall be incorporated.

ii) The control system shall be configured in mainly three control levels. The first level shall be station control level which comprises a number of functional systems for supervisory control and man-machine communication. The second level shall be the local control level which comprises a number of functional groups such as units, switchyard, station service etc. The third level shall be the equipments such as governor, AVR etc. and mainly used for testing and adjustment.

iii) The station control level shall include functions for overall and centralised control of the station. Typical functions shall be supervision and monitoring of the machine conditions, recording the operation/faults and providing logs & operational information to assist the operators.

iv) The local control level shall be unit control board which shall be local control centre for overall sequence of operation. At startup or shutdown, it will execute a set of sequence programmes. Based on process criteria, it shall generate commands for drive control of functional group for execution of programme. It shall check for presence of all required criteria before it shall issue a particular command. The execution time will also be monitored and if execution time exceeds the stipulated time limit, a trip or an alarm command shall be issued. It shall be possible to control the unit from unit control board in fully automatic mode, step by step mode and manual mode.

v) Equipment, control level shall have local control board/cubicle to control the equipment directly.

vi) The data transmission between station control level and local control level shall be accomplished by means of LAN with high speed large capacity data bus of optical fiber cables.

vii) A mimic bus diagram board shall be provided to depict the status and operational information of transmission lines, bus, generating units and station service circuits in real time and to operate equipment with functional switches. Dam water level indicators and recorders shall be furnished on this board.

viii) Whole system shall have a total redundancy in the main CPUs, programmable controllers of local control units, LAN system and power supply units. Even if one group has a severe failure, another back up group shall instantly succeed the operation without stoppage.

5.6.9 11 KV Bus Duct

i) 11 kV Isolated Phase Bus ducts for Power house-I and segregated phase Bus Ducts for powerhouse –II conforming to IS: 8084 shall be provided with continuous current rating of 2000 Amperes for Phase-I and 400 Amperes for Phase-II respectively for the main Bus ducts connecting Generator Phase terminals to LV terminal of Generator Transformer. Bus duct shall be complete with continuous type Aluminium alloy enclosure, conductor supported on support insulator with self-aligning arrangement, wall frame assembly, seal off bushing, flexible connections at termination points, Tap-off bus duct for connecting to Excitation Transformer, Unit-Auxiliary Transformer & LAVT cubicle. The normal current rating of the tap-off bus duct shall be 10% of the main bus ducts.

ii) The bus duct assembly shall be designed to withstand rated continuous current and required short circuit current without injury or permanent deformation of any part of the bus structure.

iii) Provision shall be made in each set of bus ducts for shorting links which shall be used for drying out of the equipment before commissioning or for carrying out the short circuit test on the equipment.

iv) Provision shall be made for removable links in the main run of neutral side of bus duct, at each tap-off connection i.e., LAVT cubicle, Excitation Transformer, Unit Auxiliary Transformer (UAT) etc.

v) Neutral Grounding Cubicle with Grounding Transformers & secondary resistor, LAVT Cubicle, and various CTs in the run off bus ducts as required for Metering & Protection of Generating unit shall be included in the scope.

5.6.10 Generator, Transformer & Other Transformers

The rating and other parameters are as given below:

Table:5.6.5

			POWER HOUSE -I	**POWER HOUSE -II**
a)	Type	**:**	three phase, core or shell type	three phase, core or shell type
b)	No. of transformers	**:**	2 Nos.	3 Nos.

c)	Rated output on all tappings (including 10% over load capacity)	:	36.67 MVA	7.5 MVA
d)	Voltage	:	H.V.Side 132 KV; LV Side 11 kV	H.V.Side 33 KV; LV Side 11 kV
e)	Rated frequency	:	50 Hz, -5% to + 3%	50 Hz, -5% to + 3%
f)	Type of cooling	:	ONAF	ONAF
g)	Cooling medium	:	Mineral oil	Mineral oil
h)	Tapping	:	Off Load Type	Off Load Type
i)	Earthing	:	HV neutral solidly earthed	HV neutral solidly earthed
j)	Installation	:	Outdoor on rails	Outdoor on rails

i) 2 (Two) Nos. 36.67 MVA, 11/132 kV, Three Phase; Ynd11 Generator Transformers shall be installed for stepping up of generation voltage to 132 kV level for synchronization with the grid for Powerhouse No-I.

ii) 3 (Two) Nos. 7.5 MVA, 11/33 kV, Three Phase; Ynd11 Generator Transformers shall be installed for stepping up of generation voltage to 33 kV level for synchronization with the grid for Powerhouse No-II.

iii) The transformers shall be suitable for parallel operation. Off-Circuit Tap Changer shall be provided to correct the voltage imbalance in generation and grid voltage conditions. The transformers will be provided with necessary protective and monitoring devices including Buchholtz relay, oil temperature & winding temperature indicators, safety valve etc. The transformer shall conform to IS: 2026. The transformers shall be provided with EHV grade insulating oil conforming to IS : 335.

iv) Dry Type Indoor Transformers conforming to the IS : 11171 shall be fed through tap-off ducts from the Main Bus duct for meeting the power requirements of unit auxiliaries of each generating unit.

v) Provisions of 0.415 kV switchgear have been kept for catering the common Station Auxiliary Loads.

vi) 630 KVA, 11/0.415 kV, ONAN cooled Station service Transformer one each for powerhouse-I and II shall be provided to meet the power requirement of station auxiliaries as well as unit auxiliaries at the time of starting of the unit.

vii) 630 KVA, 11/0.415 kV, ONAN cooled, Station Auxiliary Transformer for powerhouse-I tap-off from the 11kV IPBD shall be provided to meet the power requirement of station auxiliaries as well as unit auxiliaries.

5.6.11 132 kV Switchyard (Power House No. I)

i) Generator power stepped up to 132 kV through generator step-up transformers shall be controlled at 132 kV switchyard comprising of circuit breakers, isolators, current transformers, post insulators, potential transformers and lightning arrestors etc. 132 kV incoming feeders from generator transformers in power house and outgoing feeders to transmission lines shall be connected to the 132 kV double bus with controlling switchgear elements for control and protection system

ii) Continuous and short circuit current rating of 132 kV system shall be 800 Amperes and 40 kA respectively. 132 kV switchyard package shall also include insulators and hardware, 132 kV conductors for bus and feeders, earth wire, galvanized steel structure for in-take and off-take gantries and equipment for switchyard like bay marshalling kiosks, cables and cable trays, lighting, switchyard equipment grounding etc shall also be included in the switchyard equipment package.

iii) The switchyard shall have provision for the following bays:

Incoming Feeders
2 Bays
Outgoing Feeders
2 Bays
Bus Coupler
1 Bay

Total no. of bays
5 Bays

iv) The switchyard is located adjoining to power house on the right hand side while looking towards downstream side. The 132 kV D/C lines are proposed to be constructed upto Khajurao from the switchyard.

v) The space requirement for 132 kV switchyard is assessed to be 70x85.5m. The required space for switchyard is available at the identified location of switchyard.

5.6.12 33 kV Switchyard – (Power House No. II)

i) Generator power stepped up to 33 kV through generator step-up transformers shall be controlled at 33 kV switchyard comprising of circuit breakers, isolators, current transformers, post insulators, potential transformers and lightning arrestors etc. 33 kV incoming feeders from generator transformers in power house and outgoing feeders to transmission lines shall be connected to the 33 kV Double bus with controlling switchgear elements for control and protection system.

ii) Continuous and short circuit current rating of the 33 kV system shall be 400 Amperes and 40 kA respectively. 33 kV switchyard package shall also include insulators and hardware, 33 kV conductors for bus and feeders, earth wire, galvanized steel structure for in-take and off-take gantries and equipment for switchyard like bay marshalling kiosks, cables and cable trays, lighting, switchyard equipment grounding etc shall also be included in the switchyard equipment package.

iii) The switchyard shall have provision for the following bays:

Incoming Feeders
3 Bays
Outgoing Feeders
3 Bays
Bus Coupler
1 Bay

Total no. of bays
7 Bays

iv) The switchyard is located adjoining to power house on the right hand side while looking towards downstream side.

v) The space requirement for 33 kV switchyard is assessed to be 60mx63m. The required space for switchyard is available at the identified location of switchyard.

5.6.13 Fencing

The station fence properly grounded, covering the entire switchyard area with necessary warning, protection, gates and security shall be provided in the switch yard.

5.6.14 Power Evacuation

Power Evacuation from powerhouse-I will be evacuated through 132 kV double circuit line from switchyard to proposed 132 kV S/Stn. at Khajuraho about 32 km from the project site.

Power Evacuation from powerhouse-II will be evacuated through 33 kV double circuit line from switchyard to proposed 132/33 kV intermediate sub-station at Bamitha about 25 km from the project site.

The proposed power stations of this project are falling in dense forest area, therefore detail survey will be required including approval from concerned competent authority so that project can be connected to near by sub station by utilizing minimum/ escaping dense forest area.

5.6.15 Relay & Protection System (Power House-I & II)

The electrical protection system for Generator, Generator Transformers, Bus bars and feeders shall be provided with numeric type integrated protection relays, with 100 % redundancy. The electrical protection shall be of modular design complete with software & MMI. It shall have facility to programme all settings on line & off-line. It shall have built in testing facility. The protection system shall be highly reliable & fully redundant. The protection system shall be designed and used for a fast and selective protection of generators, generator transformers and outgoing feeders with fast separation of faulted parts. Protection shall be covered by two completely independent current transformers, especially for Generator, Generator step up transformer, Bus bars and Transmission line feeders.

5.6.15.1 For Power house-I

i) **The following protection shall be provided for generating unit and step up transformers:**

- 21G Generator phase fault impedance with timer
- Generator transformer winding temperature alarm and trip
- 26 T Generator transformer oil temperature alarm and trip
- Reverse power protection (37 a)
- Generator & turbine bearings temperature alarm and trip
- Generator Vibration alarm and trip
- Loss of field protection
- Negative phase sequence protection (46 a)
- 50/51 Generator over current instantaneous and time delay protection
- Over voltage protection instantaneous and time delay
- 27 Under voltage protection
- 59F Field over voltage protection
- Voltage transformer fuse protection
- Transformer Buchholz type gas protection
- 64 F Field ground fault protection
- 64 N1 100% stator ground fault protection (Time delay)

- 64 N2 90% stator ground fault protection
- 64 R Step up transformer restricted ground fault protection
- Bearing oil level alarm and trip
- 71 A Transformer oil level alarm and trip
- Transformer oil pressure protection
- 81 Frequency protection
- 87 G Generator differential protection
- 87 GT generator transformer differential protection
- Rotor excitation over current protection
- Shaft current protection
- Generator PT fuse failure protection (95 FF)
- Over fluxing cover excitation protection (97)
- Local breaker backup protection (50z)
- Inverse time over current protection (51 GT)

ii) **The Following protection shall be provided for Unit Auxiliary Transformer:**

- 50/51 Instantaneous and time over current protection
- 64 Earth fault protection
- 27 Under voltage protection
- 49 Transformer winding temperature alarm protection

iii) **The Following protection shall be provided for Excitation Transformer:**

- 50/51 Instantaneous and time over current protection
- 64 Earth fault protection
- 49 Transformer winding temperature alarm protection

iv) **The Following protection shall be provided for 132 kV switchyard feeders- Generator feeders, Bus coupler and out going line feeders.**

Generator feeders

- 50/51 over current protection
- 50 Z Local breaker failure protection

Bus Coupler bay

- 87 BB Bus bar differential protection
- 67/67 N Directional over current and earth protection
- 50 Z Local breaker failure protection
- CT wire supervision

Out going feeders

- 21 Distance relay protection for short lines
- Directional over current and earth fault protection
- 50 Z Local breaker failure protection
- Out of step blocking protection
- 59 Over voltage protection instantaneous and time delay
- Auto reclose single phase and three phase protection
- Fault locators
- Fuse failure protection
- Bus PT selection scheme
- Any other protection as required.

Electrical transducers for conversion to digital signals of important electrical parameters like voltage, current, frequency, active power, reactive power etc. of generating units, station auxiliaries and outgoing feeders shall be provided.

5.6.15.2 For Power house-II

i) **The following protection shall be provided for generating unit and step up transformers:**

- 21G Generator phase fault impedance with timer
- Loss of field protection
- Negative phase sequence protection (46 a)
- 50/51 Generator over current instantaneous and time delay protection
- Over voltage protection instantaneous and time delay
- 27 Under voltage protection
- 64 F Field ground fault protection
- 64 R Step up transformer restricted ground fault protection
- 81 Frequency protection
- 87 G Generator differential protection
- 87 GT generator transformer differential protection
- Generator PT fuse failure protection (95 FF)
- Over fluxing cover excitation protection (97)
- Local breaker backup protection (50z)
- Inverse time over current protection (51 GT)

ii) **The Following protection shall be provided for Unit Auxiliary Transformer:**

- 50/51 Instantaneous and time over current protection
- 64 Earth fault protection
- 27 Under voltage protection

- 49 Transformer winding temperature alarm protection

iii) **The Following protection shall be provided for Excitation Transformer:**

- 50/51 Instantaneous and time over current protection
- 64 Earth fault protection
- 49 Transformer winding temperature alarm protection

iv) **The Following protection shall be provided 33 kV switchyard feeders- Generator feeders, Step down transformer feeders, Bus coupler and out going line feeders.**

Generator feeders

- 50/51 over current protection
- 50 Z Local breaker failure protection

Step Down Transformer feeder

- 87 ST Transformer differential
- 50/51 over current protection
- 50Z Local breaker failure protection

Bus Coupler bay

- 87 BB Bus bar differential protection
- 67/67 N Directional over current and earth protection
- 50 Z Local breaker failure protection
- CT wire supervision

Out going feeders

- 21 Distance relay protection for short lines
- Out of step blocking protection
- 59 Over voltage protection instantaneous and time delay
- Fuse failure protection
- Bus PT selection scheme
- Any other protection as required.

Electrical transducers for conversion to digital signals of important electrical parameters like voltage, current, frequency, active power, reactive power etc. of generating units, station auxiliaries and outgoing feeders shall be provided.

The electrical protection shall be grouped under following groups.

(i) **Non-electrical lock-out faults, controlled action shutdown**

The mechanical faults like turbine & generator bearing temperature "high", originating from turbine & generator side are covered under this group. It will be ensured that tripping of 132 kV breakers of affected generator feeders is delayed till the turbine wicket gates reach no load opening position.

(ii) **Urgent electrical lockout faults.**

All urgent electrical faults shall initiate simultaneous tripping of 132 kV and 33 kV circuit breakers along with shutdown of the turbine. Faults like differential protection, stator earth fault protection overall differential protection, generator transformer HV restricted earth fault, transformer buchholz protection etc. are covered under this group.

The governor failure faults and machine over speed faults originating from unit side are also covered under this group.

The manual emergency shutdown of the machine shall be also be effected under this group.

(iii) **Electrical non lockout failure**

The faults like negative phase sequence, generator impedance back up etc., shall be covered under like group and shall trip 132 kV and 33 kV breaker and UAB breaker without shutdown of turbine/generator.

5.6.16 Auxiliary Equipment / System

5.6.16.1 Electrical Auxiliaries

i) Station Service & Unit Auxiliary Supply (LT System)

<u>For Power house-I</u>

415 V Switchboards with adequate no of feeders complete with Air / moulded case Circuit Breakers, Bus bars etc shall be installed in the power house for feeding the unit and station auxiliaries without any interruption under conditions. It shall conform to the requirement of IS: 13947.

630 kVA, 11/0.415 kV Station auxiliary Transformer shall be provided to feed station auxiliaries. This transformer shall be fed from 11 kV bus-ducts. The power requirement for start up of the generating units as well

as essential station service requirement shall be met from either outside source available at 11 kV in the Power house-II through one no. 11/0.433 kV, 630 KVA step down station service transformer or by 500 KVA DG set in the 132 kV switchyard.

Two numbers Unit auxiliary transformer, each of 500 kVA, 11/.433 kV, shall be provided to feed unit auxiliaries. During start up of unit, unit auxiliaries shall be initially supplied from station service board. After build up of voltage at generator terminals, supply of unit auxiliary board from station service source shall be disconnected and supply to unit auxiliary board shall be started from unit auxiliary transformers. The scheme of change over of supply to unit auxiliary board shall be completely automatic and various interlocks in the schemes shall be provided to prevent change over during fault conditions. Also paralleling supplies shall be avoided.

The unit auxiliary and station service distribution boards shall have draw out type Air breakers as incomer breakers and MCCBs for outgoing feeder breakers. The short circuit rating of all breakers shall be 50 kA.

For Power house-II

415 V Switchboards with adequate no of feeders complete with Air / moulded case Circuit Breakers, Bus bars etc shall be installed in the power house for feeding the unit and station auxiliaries without any interruption under conditions. It shall conform to the requirement of IS : 13947.

630 kVA, 11/0.415 kV shall be provided to feed station auxiliaries and unit auxiliaries as well as during start up of generating unit. These transformers shall be fed from 11 kV bus which shall be fed from 1600 KVA, 33/11 kV step down transformer or through an outside source at 1kV bus. The supplies from 33/11 kV step down transformer and from out side source shall be suitably inter locked..

Three numbers Unit auxiliary transformer, each of 500 kVA, 11/.433 kV, shall be provided to feed unit auxiliaries. During start up of unit, unit auxiliaries shall be initially supplied from station service board. After build up of voltage at generator terminals, supply of unit auxiliary board from station service source shall be disconnected and supply to unit auxiliary board shall be started from unit auxiliary transformers. The scheme of change over of supply to unit auxiliary board shall be completely automatic and various interlocks in the schemes shall be provided to prevent change over during fault conditions. Also paralleling supplies shall be avoided.

The unit auxiliary and station service distribution boards shall have draw out type Air breakers as incomer breakers and MCCBs for outgoing feeder breakers. The short circuit rating of all breakers shall be 50 kA.

ii) DC Supply System

The D.C. supply system comprise of two sets of 800 AH, 220 V DC batteries for powerhouse-I and two sets of 400 AH, 220 V DC batteries for powerhouse-II. Each set having provision of main and standby chargers, other control equipment, and independent DC distribution boards. These two sets of batteries shall be used for control/protection functions and also field flashing/emergency functions. There will be a separate 48 V, DC system for communication requirement etc. for both the powerhouses.

iii) Emergency Diesel Generator Supply System

500 kVA Diesel Generating Set for powerhouse-I and 250 kVA Diesel Generating Set for powerhouse-II capable of continuously delivering net output under site conditions at 0.8 lagging power factor, 415V, 3 phase, 50 Hz shall be installed in the switchyard for emergency in the event of failure of station A.C. supply. The diesel generating set shall be complete with 4 stroke Diesel Engine, Alternator complete with accessories like flywheel, lubrication oil system, governor, air clearances, AVR, AMF panel & all electro mechanical protection & metering equipped with following machine tools. This power shall also be used to operate station drainage pumps under normal and emergency conditions.

iv) Grounding Mat

The grounding system of the power house shall be provided to establish a common low resistance reference with respect to ground for all parts of the project. The resistance with respect to earth shall be as low as practicable. The configuration and extent shall be such as to provide safe step and touch potentials within each area and to avoid harmful differences in potentials between one location and another, within the project area. The earth mat system shall extend to the penstock/ tailrace area, if required.

The powerhouse and switchyard areas would be provided with separate main ground mats and both the mats will be inter-connected by grounding strips to lower the earth resistance. All non-current carrying equipment in the powerhouse and switchyard shall be grounded separately and connected to main ground mats.

All the independent ground mats shall be of mild steel flat conductor having suitable cross section. M.S. grounding electrode rods of suitable size will also be required to be driven into the ground and connected to the ground mats. Grounding leads (risers) will be taken to each of the power house floors for earthing of various electrical equipments.

The grounding system shall be designed with the following objective:-

(i) To provide low impedance path of fault currents to ensure prompt and consistent operation of protective devices during ground faults.

(ii) To keep the maximum voltage gradient along the surface inside and around the project complex with in safe limits during ground faults.

(iii) To protect the life and property from over voltage.

(iv) Safe touch and step voltages

(v) Short Circuit, Earth Fault and Double Earth Fault Currents will flow through the Earthing System and not through other conducting parts to a hazardous extent.

v) Illumination of Plant

The illumination system would comprise interior and exterior lights as appropriate for the entire power house area, switchyard area and at dam site. A separate emergency lighting system fed from the station battery system would be provided for all essential locations of the power house and switchyard.

All the fitting, luminaries, conduits, wires fixture etc. shall be of reputed make conforming to relevant IS codes. Indoor illumination scheme shall have mainly twin tube light fitting and high pressure mercury vapour lamps. Emergency D.C. lamps shall also be provided in machine hall, control room and areas of strategic importance.

Outdoor illumination shall be accomplished through sodium vapour lamps, mercury vapour lamps and fluorescent tubes. Power & light convenience outlets shall be provided at various locations in power house, service bay, control room, auxiliary floors. Industrial type, 3 phase convenience outlets shall also be provided at various locations.

vi) PLCC and Plant Communication Equipment

PLCC equipment for the power house will provide line protection, communication, telemetry and remote control. Independent carrier channels will be provided for relaying, voice communication, computer communication and telemetry functions. Matching equipment to cater to these functions shall also to be provided at the receiving end substation. Communication system for power house, switchyard area and dam site will consist of internal telephone system and paging system. Paging system includes public address system and visual display unit (VDU).

vii) Electrical laboratory Testing Equipment

A testing laboratory shall be maintained in the power house for testing of various electrical & mechanical equipment and installations. The Laboratory shall be equipped with testing & measuring instruments like Megger, HV Test kit, Kelvin bridges current Injection set, oil testing kit etc. This laboratory is located at power house No.-I and utilized by both the power houses.

viii) Power, Control & Instrumentation Cables & Cable Trays ETC

1.1 kV Grade PVC insulated un-armoured Aluminum Power Cables shall be used inside the power house while for control cables 1.1 kV Grade PVC insulated unarmoured copper cables conforming to IS : 1554 shall be employed. The control and 220V DC cables shall be fire retardant low smoke (FRLS) type having copper conductor. The power cables to be used outdoor shall be of armoured type. Instrumentation Cables including Fiber Optic Cables immune to electromagnetic interference shall be included in the scope. All the accessories like Cable glands, Ferrules, Cables Trays, Conduits of adequate sizes as required for the installation of Cables shall be include.

5.6.16.2 Mechanical Auxiliaries

i) EOT Cranes

The heaviest equipment/assembly required to be lifted in the power house by the EOT crane will be the assembled generator rotor. For the 30 MW generating unit, the assembled rotor weight is expected to be of the order of 90 tonnes. To lift this weight one crane with a capacity of 100/30 tonns has been considered.

For the 6 MW generating unit, the assembled rotor weight is expected to be of the order of 25 tonnes. To lift this weight, one crane with a capacity of 30/10 tonnes has been considered

All the crane shall be cabin controlled. The crane shall provide with all accessories including runway rails, down shop leads, bumpers etc. The crane shall conform to IS: 3177. The inching operation shall be provided for the motions of the crane.

Separate trolley type gantry crane of 15 T capacity shall be provided to operate all the draft tube gates at tail race side for both the powerhouses.

The capacities of all the cranes will be reviewed during detailed engineering stage.

ii) Elevator

The power house -I shall be equipped with 1 (one) number elevator with sufficient capacity to transport 13 persons and/or material between various floors of the power house. The elevator shall be driven by an electric hoisting machine to the traction type complete with motor, brake, gearing, drive sheave and driving shaft etc. the elevator shall be provided with smooth speed control. One number elevator of the same capacity shall be provided at dam site also.

iii) Cooling Water Scheme

Cooling water system shall be provided for cooling of each generating unit. The cooling water system shall supply the water to turbine guide bearings, turbine shaft seal, governor/MIV oil sump tanks, generators, generator air coolers, generator thrust bearings, generator guide bearings, generator-transformers, ventilation and air conditioning system etc. Clear water for turbine shaft seal to be provided separately.

The water requirement for cooling water system to be tapped from the each unit of the draft tube by employing three number of pumps (Two pumps as main and other as stand by) having a common header. The pumps shall be suitable to install either in wet pit or in the dry pit (amphibious installation). The pumps shall have sufficient capacity for circulating the water in the cooling water system of the Generating Unit and Generator Transformer and the return water from the various coolers will be discharged into the tailrace above flood water level. Necessary strainers, valves, pressure gauges and pressure switches, temperature switches shall be provided. Alternately, tapping of penstocks may also be considered during detailed engineering.

iv) Compressed Air System

Power House-I

The compressed air system shall consist of a low pressure compressed air system. The low pressure compressed air system shall meet the requirement of the complete power house for intermittent supply of air to cater the needs of generator brakes, bus ducts and other station service requirements. Two numbers of compressors (one main + one standby) have been proposed to cater to the requirements of the units. The capacity of the compressor shall be adequate to cater the above needs of complete power house. All necessary piping, fittings, pipe supports, adequate number of isolating valves, non-return valve, etc. shall be provided.

Power house-II

The compressed air system shall consist of a low pressure compressed air system. The low pressure compressed air system shall meet the requirement of the complete power house for intermittent supply of air to cater the needs of generator brakes, bus ducts and other station service requirements. Three numbers of compressors (two main + one standby) have been proposed to cater to the requirements of all the three units. The capacity of each compressor shall be adequate to cater the above needs of complete power house including the requirement for governing system of turbine and MIVs. All necessary piping, fittings, pipe supports, adequate number of isolating valves, non-return valve, etc. shall be provided.

v) Station Drainage System and Dewatering System.

For dewatering of any unit (penstock and draft tube), to access for inspection and maintenance, a separate common dewatering sump with two numbers submersible slurry pumps (one main & other standby) have been provided. In the first instance, the water from the penstock will be drained down by gravity into the tail pool via the draft tube up to the tail water level. The remaining water will be drained into the sump through dewatering pipes and header (complete with control valves) and simultaneously pumped out to tail race under manual control/ auto control etc.

Station drainage system will be provided to cater to any water leakages/drains from plant and equipments such as turbine top covers, shaft seals (glands) outlet water, leakages from compressors (cooling water), pump glands, seepages into power house from surroundings, discharges from sinks, wash basins etc. All such water will be led to drain through pipes and surface drain (by gravity) into the drainage/dewatering gallery below the draft tube level. From there, the water will be led to the station drainage sump and regularly pumped out by submersible pumps to the tailrace. The equipment will comprise of two nos. submersible pumps (one main & other standby) complete with the valves, piping controls & annunciation etc.

Both the pits are inter-connected with all necessary pipes, valves and fittings.

vi) Ventilation & Air Conditioning System

The ventilation system shall be sized and configured to provide sufficient air circulation as well as temperature and humidity control throughout the main power house for the satisfactory operation of the equipment and personnel. Temperature shall be controlled by means of air to water heat exchangers. Smoke evacuation system shall be provided. Control room and shift engineer rooms will be air conditioned with suitable package type air conditioning units. No centralized air conditioning is envisaged. Air handing units will play main role in the system. The water requirement will be fulfilled through the overhead water tank.

vii) Fire detection and Fire Protection Systems

Fire protection system for power house shall be planned to timely detect the occurrence of fire & quick extinguishing of fire when it breaks and to prevent the spread of fire so as to minimize the extent of damage.

A microprocessor based Fire Alarm/Detection System completes with all accessories shall be provided for audio/visual annunciation of fire.

A storage tank of adequate capacity shall be provided at a higher elevation at out side the powerhouse for storage of Fire protection water which shall be supplied by gravity on occurrence of fire. Water can be tapped from the river or any other source of water available there and pumped to overhead tank by amphibious type pumps through automatic strainers.

Automatic High Velocity Water Spray System for Generator and Station Transformers, low and medium pressure fire hydrant system for Power Station, fire hydrants etc including piping systems with hydrant valves and fire hose cabinets at number of strategic points at all the floors. Necessary isolating and non return valves, pressure gauges, pressure switches and temperature sensors shall be provided.

Portable fire extinguishers shall also be provided at strategic points at all the floors of the power house/transformers area to control the fire in initial stage such as hand portable CO_2 extinguisher and portable foam type chemical extinguisher. Wheeled portable foam type chemical extinguisher shall be provided where ever necessary.

Separate fire protection system shall be provided for 132 kV and 33 kV outdoor switchyard.

viii) Mechanical work shop and Workshop Equipment

A Mechanical workshop shall be provided in the machine hall floor of power house-I with all latest equipments, lathe machines and machine tools etc., as required, to carry out normal repair and O&M of various electro- mechanical equipments. The work shop shall be common for the both the power houses. The workshop shall be equipped with following machine tools. This workshop is located at power house No.-I and utilized by both the power houses.

(a) Lathe Machine
(b) Welding sets
(c) Grinding sets
(d) Power Hacksaw
(e) Drilling machine etc.

ix) Oil Handling System for lubricating & insulation oil

It is proposed not to provide full capacity oil storage and pumping system for lubrication and insulation oils in the power house. This is to eliminate any potential fire hazards. Only a portable oil purifier will be kept in service bay for treating lubricating and insulation oils. The spare oil shall be stocked in drums at stores located away from power house.

x) Potable Water System

Potable and sanitation service water will be provided for the power house. The system will comprise of pumps, pressure filters, chemical treatment units, storage and distribution piping.

5.6.17 Construction Power

The construction power for this project can be taken from 11kV Ranguwan feeder radiated from 33/11 kV Bamitha sub station which is 7 km from Bhusour Village. The project site from Bamitha sub station is about 25 km.

5.6.18 Estimates for Electrical and Mechanical works

The estimates for electrical and mechanical works of Ken-Betwa H.E. Project (2x30 MW + 3x6 MW) have been worked out on the basis of prevailing rates of similar equipment and works are given separately for both the powerhouses as Annexures:5.6.1&5.6.2.

5.6.19 Drawings

The following drawings forming part of the DPR and pertaining to general layout plan, cross-section of power house incorporating layout details of major equipments, power house layout plans at various floors, switchyard layout and single line diagram are appended as plate no 5.1 to 5.23 in drawing volume-III

Table:5.6.6

	Ken-Betwa H.E. Project, 2x30 MW

Sl.No.	**Description of Drawing**	**Drawing Nos.**	**Plate nos**
1.	General Layout plan.	1252-CEA-HE&RM-KB- DPR-01	5.1
2.	Power House Cross Section	1252-CEA-HE&RM- KB -DPR-02	5.2
3.	Power House Generator floor layout at EL 229.00 m	1252-CEA-HE&RM- KB -DPR-03	5.3
4.	Power House Turbine floor layout at EL 225.00 m	1252-CEA-HE&RM- KB -DPR-04	5.4
5.	Power House MIV floor layout at EL 218.00 m	1252-CEA-HE&RM- KB -DPR-05	5.5
6.	Power house Machine Hall & Service bay layout at EL 233.00 m	1252-CEA-HE&RM- KB -DPR-06	5.6
7.	Power House Control room layout at EL 238.00 m	1252-CEA-HE&RM- KB -DPR-07	5.7
8.	Power House Auxiliary Bay and Transformer deck layout at EL 243.00 m	1252-CEA-HE&RM- KB -DPR-08	5.8
9.	Power House L-Section through Center line of the Units	1252-CEA-HE&RM- KB -DPR-09	5.9
10.	Single Line Diagram (for PH-I and PH-II)	1252-CEA-HE&RM- KB -DPR-10	5.10
11.	Layout Plan of 132 kV Switchyard & Sections	1252-CEA-HE&RM- KB -DPR-11	5.11
12.	Layout Plan of 33 kV Switchyard & Sections	1252-CEA-HE&RM- KB -DPR	5.12

Table:5.6.7

	Ken-Betwa H.E. Project, 3x6 MW		
Sl.No.	Description of Drawing	Drawing Nos.	Plate nos
1.	General Layout plan.	1252-CEA-HE&RM-KB- DPR-01	5.13
2.	Power House Cross Section	1252-CEA-HE&RM-KB -DPR-02	5.14
3.	Layout Plan at Generator floor	1252-CEA-HE&RM-KB -DPR-03	5.15
4.	Layout Plan at Turbine Floor	1252-CEA-HE&RM-KB -DPR-04	5.16
5.	Layout Plan at MIV Floor	1252-CEA-HE&RM-KB -DPR-05	5.17
6.	Layout Plan at auxiliary bay	1252-CEA-HE&RM-KB -DPR-06	5.18

7.	Layout Plan at control room	1252-CEA-HE&RM-KB -DPR-07	5.19
8.	Layout Plan at Transformer deck	1252-CEA-HE&RM-KB -DPR-08	5.20
9.	L-Section of the power house	1252-CEA-HE&RM-KB -DPR-09	5.21
10.	Single Line Diagram	1252-CEA-HE&RM-KB -DPR-10	5.22
11.	Layout Plan of 33 kV Switchyard	1252-CEA-HE&RM-KB -DPR-11	5.23

These drawings are placed in Drawing Volume.

Note: The description for common system for both the power houses have been given and wherever the system requires independently, the same is described separately for both the power houses**.**