Chapter- 8
Power

8.0 General

Power is one of the basic inputs necessary for the industries and socio economic development. Growing energy demand in the country and concern for carbon emission from thermal and gas based power plants is making hydropower development more favorable for India. Development of hydropower wherever feasible in the present scenario taking in to account its renewability and non-polluting nature and relative low cost, is becoming a main source of renewable energy. The possibilities of hydropower generation from the dams envisaged in the Par-Tapi-Narmada link project have been highlighted in the tripartite Memorandum of Understanding (MoU) signed by Hon'ble Chief Ministers of Gujarat and Maharashtra States with Hon'ble Union Minister for Water Resources on 3rd May 2010 for preparation of DPRs of Par – Tapi – Narmada and Damanganga – Pinjal link projects. As such, the power potential studies were carried out through THDCIL, Rishikesh at proposed Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan reservoirs and at the drop on Kelwan Feeder pipe line. The details of quantum of hydropower generation assessed under the link project are furnished in subsequent paragraphs below:

8.1 Present Status of Power Development in Maharashtra and Gujarat States

8.1.1 Available Generating Capacity (MW) in the State/Region from Different Sources with Location, Category Wise.

(a) Power Scenario in Maharashtra

Maharashtra is the largest power generating State in India with installed electricity generation capacity of 30232 MW (as on 31st March, 2013). The energy requirements of the State are supplied from the plants of the Maharashtra State Power Generation Company Ltd. (MAHAGENCO), Independent Power producers (IPPs), Central Sector allocation and renewable energy generators. MAHAGENCO is the major generation utility in the State with a total installed capacity of 10737 MW including a thermal generation capacity of 7480 MW, hydro capacity of 2585 MW and a gas-based capacity of 672 MW. Maharashtra constitutes 13% of the total installed electricity generation capacity in India which is mainly from fossil fuels such as coal and natural gas. However since 2005, Maharashtra's power sector has been unable to meet electricity demand of the State. The State utilities have been re-sorting to load shedding to bridge the gap between supply and demand. Several parts of the State have 8 to 10 hours of load shed. Despite the additional installed capacity, the peak demand deficit in the State has increased from 17% in 2005-06 to 22% in 2011-12. Between 2005-06 and 2011-12, peak electricity demand grew at a compound annual growth rate (CAGR) of 5%, while peak demand met at the CAGR of 4% over the period of 8 years. The capacity has been increased to 26,538 MW in the year 2012 (August 12, CEA). To meet the expanding energy requirement in the State, additions to generating capacity were made both in the private as well as the State sector, expected to lead in reducing deficits. The State of Maharashtra is also forms a major constituent of the western grid of India which now comes under North, East, West and North Eastern (NEWNE) grid of India.

The peak energy demand in Maharashtra is 21,069 MW as against the same only 16,471 MW is met with. Thus presently, Maharashtra is facing energy shortage of 4600 MW. As per 16th Electric Power Survey, the CEA has projected an average growth rate of 5.9 % for the period ending 2017 for Maharashtra and the peak load requirement would be in tune of 29,738 MW. The shortfall is so significant that the State cannot ignore the power supply position from the perspective of development. In order to match the demand, new capacity additions to the tune of about 12,500 MW are slated to come up over the next two Five Year Plans. Overall, the electricity scenario is not good in the State and needs further investment to increase power generation. The State owned Maharashtra State Power Generation Co. Ltd (Mahagenco) has capacity addition programme of 4230 MW capacity of Thermal Power stations and various projects under non-conventional energy sector such as Solar and Wind energy are being considered to mitigate the energy deficit.

Maharashtra State Power Generation Co. Ltd (Mahagenco) has an installed capacity of 10237 MW, of which nearly 75% comprises of Thermal and gas based generation capacity (thermal 7480 MW, and gas based generating capacity 672 MW). The Hydro Electric Projects in the State of

Maharashtra were designed, erected and commissioned through the Water Resource Department (WRD) of GoM. After commissioning, the hydro projects were handed over on long term lease to MAHAGENCO for purpose of Operation and Maintenance. Presently there are 26 Hydel projects having a capacity of 2585 MW. Details are in Table 8.1.

Table 8.1
Installed Capacity of MAHAGENCO

Sl. No.	**Power Station**	**Units and Size (MW)**	**Installed Capacity (MW)**
A	**Thermal Power Stations**		
1	Koradi 5 To 7	1x200 + 2x210	620
2	Nasik 3 To 5	3x210	630
3	Bhusawal 2 and 3	2x210+1x500	920
4	Paras 3 and 4	2x250	500
5	Parli 3 To 7	3x210+ 2x250	1130
6	K'kheda 1 To 5	4x210 + 1x500 Mw	1340
7	Chandrapur 1 To 7	4x210 + 3x500	2340
	Total		**7480**
B	**Gas Turbine Power Station**		
1	Uran G.T.	4x108	432
2	W.H.R. 1and2	2x120	240
	Total		**672**
C	**Hydro Power Stations**		
1	Koyna Hydro	St IandII- 4x70 + 4x80, St III- 4x80, St. IV-4x250 and Koyna Dam Foot-2x18	1956
2	Small Hydro		379
3	Ghatghar Pump Storage	2x125	250
	Total		**2585**
	Grand Total (A+B+C)		**10737**

MAHAGENCO is also implementing capacity additions programmes of about 17040 MW. Project execution works of 4230 MW projects are in full swing and 8850 MW project are in advanced stages of planning. Further MAHAGENCO identified land for 3960 MW projects in various location of Maharashtra. MAHAGENCO is also planned to setup about 650 MW solar power projects in various locations of Maharashtra.

(b) Power Scenario in Gujarat

When Indian power sector is facing challenges despite the significant growth in generation capacity over the past few decades, over the last few years, Gujarat has successfully crossed all these barriers and has become successful in securing its overall energy requirements with installed power generation capacity of 23,824 MW. Gujarat is rich in solar energy, biomass and wind energy. It is also the leading State in terms of overall solar energy installation in India. The details are in Table – 8.2.

Table – 8.2
Gujarat State Installed Capacity as on 31.10.2014

Sl. No.	Units	Type of Fuel	Installed Capacity	Derated Total
I	**Gujarat State Electricity Corporation Ltd (GSECL)**			
	Dhuvaran	Gas	219	219
	Ukai (Thermal)	Coal	1350	1350
	Gandhinagar	Coal	870	870
	Wanakbori	Coal	1470	1470
	Sikka	Coal	240	240
	Kutch Lignite Tanandhrao	Lignite	290	290
	Utran-I	Gas	135	135
	Utran-II	Gas	375	375
	Ukai	Hydro	305	305
	Kadana	Hydro	242	242
	Sub Total		5496	5496
II	**Private Sector**			
	Torrent Power – AE CO	Coal/Gas	522	522
	GIPCL-I	Gas/Naptha	145	145
	GIPCL-II	Gas/Naptha	165	165
	SLPP (GIPCL)	Lignite	500	500
	Gujarat State Energy Generation Ltd (GSEG)/ GSPC	Gas	156	156
	GPEC	Gas	655	655
	ESSAR Power	Coal	515	300
	ESSAR Power	Coal	1200	1000
	Akrimota Thermal Station	Coal	250	250

Sl. No.	Units	Type of Fuel	Installed Capacity	Derated Total
	SUGEN	Gas	1148	1148
	UNOSUGEN	Gas	383	383
	Adani Power Ltd.	Coal	2640	2000
	ACB Ltd	Coal	270	200
	GSPC PIPAVAV	Coal	703	703
	Sub Total		9252	8127
III	**Central Sector**			
	NPC-Kakrapar	Nuclear	440	125
	NPC-Tarapur-I	Nuclear	320	160
	NPC-Tarapur-II	Nuclear	1080	274
	NTPC-Korba	Coal	2100	360
	NTPC-Korba-VII	Coal	500	96
	NTPC-Vindhyachal STPS Stage-I	Coal	1260	230
	NTPC-Vindhyachal STPS Stage-II	Coal	1000	239
	NTPC-Vindhyachal STPS Stage-III	Coal	1000	266
	NTPC-Vindhyachal STPS Stage-IV	Coal	1000	240
	NTPC-Jhanor	Gas	657.4	237
	NTPC-Kawas	Gas	656.2	187
	SIPAT Stage-I	Coal	1980	540
	SIPAT Stage-II	Coal	1000	273
	Sardar Sarovar Project CHPH	Hydro	250	40
	Sardar Sarovar Project-RBPH	Hydro	1200	192
	Kahelgoan	Coal	1500	141
	CGPL, (TATA Power) Mundra	Coal	4150	1971
	MSTPS-I		1000	240
	Sub Total		21093.6	5811
IV	**Other**			
	Wind Installed capacity		3447.9	3447.9
	Solar Installed capacity		892.53	892.53
	Biomass Installed capacity		41.1	41.1
	Madhuban Dam	Hydro	5.56	5.56
	Karjan Dam	Hydro	3	3
	Grand Total		**40232**	**23824**

source: http://www.sldcguj.com

8.1.2 Present Status of Utilisation of Power Produced

Status of power generation and consumption in Maharashtra State during the year 2012-13 is shown in Table: 8.3.

Table: 8.3
Electricity Generation and Consumption
Maharashtra State in 2012-13

Sl. No.	Item	2012-13
A	**Generation (MkWh)**	
	1) Thermal	66075
	2) Oil	-
	3) Hydro	5980
	4) Natural Gas	10242
	5) Renewable Energy andCaptive Power	5842
	Total	**88139**
B	**Consumption (MkWh)**	
	1) Domestic	22831
	2) Commercial	12635
	3) Industrial	38110
	4) Public lighting	1313
	5) Railways	2389
	6) Agriculture	20984
	7) Public Water Works	2263
	8) Miscellaneous	140
	Total	**100665**
C	**Per capita consumption (kWh)**	
	1) Commercial	109.8
	2) Industrial	331.2

Source: Economic Survey of Maharashtra 2013-14, published by Directorate of Economics and Statistics, Government of Maharashtra.

Status of power generation and consumption in Gujarat State during the years 2011-12 to 2013-14 is shown in Table: 8.4 and 8.5:

Table: 8.4
Sector wise Energy Generation (in MUs) in Gujarat

Year	GSECL	Private Sector	Central Sector	Wind Energy	Solar	Biomass	Total MUs
2011-12	28638	37116	8723	3961	167	47	78651
2012-13	23631	42714	14754	5436	1145	43	87723
2013-14	15850	46249	17440	5289	1369	24	86221

Source: http://www.sldcguj.com

Table: 8.5

Category wise Energy Consumption (in MUs) in Gujarat

Sr. No	Type	2011-12	2012-13	2013-14
1	For Jyothi Gram Yojana (JGY)	9508	10304	10511
2	Urban/Town	11236	11757	11958
3	Agriculture	18114	21285	17805
4	Industries	21114	24090	27513
	Total	59972	67436	67787

Source: http://www.sldcguj.com

8.1.3 Shortages/Surpluses and Import/Export of Power from/to the Neighbouring States/Regions

In Maharashtra State during 2012-13, the average peak demand of MAHADISCOM was 14032 MW and the shortfall of 723MW was bridged by resorting to load shedding. MAHADISCOM has purchased 99068 MkWh electricity during 2012-13 costing Rs. 38,858 crore. BEST has purchased 4704 MkWh electricity costing Rs. 2,928 crore during 2012-13.

In Gujarat State the electricity generated during 2013-14 was 86221 MU and whereas, consumption of electric power was 67787 MU. The installed capacity from conventional sources in the State has increased from 14814 MW (as on 31.03.2012) to 18738 MW at the end of the Year 2013-14.

8.1.4 Transmission System and Operation Voltages

The operation voltage details of Maharashtra State and availability of transmission infrastructure as on 28th February, 2014are furnished in Table: 8.6 below:

Table: 8.6

Operation Voltage Details of Maharashtra State and Availability of Transmission Infrastructure as on 28thFebruary, 2014

Voltage level	EHV Substation	Transformation Capacity (MVA)	EHV Lines (CKT KM.)
500kV HVDC	2	3582	1504
400kV	26	22280	7396
220kV	190	43958	14512

132kV	278	24643	13155
110kV	34	2674	1724
100kV	37	2610	697
66kV	34	1144	3270
TOTAL	**601**	**100891**	**42258**

The operation voltage details of Gujarat State and availability of transmission infrastructure as on 31st March, 2014 are furnished in Table: 8.7 below:

Table: 8.7
Operation Voltage Details of Gujarat State and Availability of Transmission Infrastructure as on 31st March, 2014

Voltage Class	Transmission Network	
	No. of Substations	**Transmission Lines (Ckt. Km)**
400 kV	11	3906
220 kV	88	16276
132 kV	51	5003
66/33 kV	1320	24946
TOTAL	**1470**	**50131**

8.2 Power Requirements

8.2.1 Existing

The Electrical energy requirement and availability and Peak demand and Peak met in Maharashtra and Gujarat States during May, 2015 are furnished in Table: 8.8.

Table: 8.8
Electrical Energy Requirement and Availability and Peak Demand and Peak Met (May, 2015*)

State	Electrical Energy (MU)			Electric Power (MW)		
	Requirement	**Availability**	**Surplus / Deficit(-)**	**Peak Demand**	**Peak Met**	**Surplus / Deficit (-)**
Maharashtra	12473	12426	(-)47	19886	19722	(-)164
Gujarat	9193	9192	(-)1	13314	13188	(-)126

Source: CEA, New Delhi. * Provisional.

8.2.2 Anticipated Requirements of Energy (MU) and Peak Load (MW)

The 18th Electric Power Survey of India conducted by Central Electricity Authority (CEA), has estimated anticipated Electrical Energy Requirement and Peak Electric Load at Power Station Bus Bars for Maharashtra and Gujarat States for the years 2016-17, 2021-22, 2026-27 and 2031-32. The details are furnished in Table: 8.9.

Table: 8.9
Anticipated Electrical Energy Requirement and Peak Demand

State	Electrical Energy (MU)				Peak Electric Load (MW)			
Year	2016-17	2021-22	2026-27	2031-32	2016-17	2021-22	2026-27	2031-32
Maharashtra	169353	225606	310654	417826	28645	39622	54982	74528
Gujarat	108704	153582	218610	301160	19091	26973	38691	53301

8.3 Future Plans of Power Development

Maharashtra State: Details on the proposed power plants by MAHAGENCO are as furnished below:

Future Power Projects – 6090 MW:

1. Uran Gas Based Combined Cycle Power Plant (1220 MW): (Block-I : 406 MW, Block-II: 814 MW)
2. Bhusawal TPS Unit 6 (1 x 660 MW)
3. Nasik TPS Unit 6 (1 x 660 MW)
4. Paras Thermal Power Project Unit 5 (1 x 250 MW)
5. Dondaicha TPS Unit – 1, 2, 3, 4 and 5 (5 x 660 MW)

Solar power projects (320 MW)

1. Sakri (Dhule) : 25 MW
2. Shirshuphal (Pune): 50 MW
3. Kaudgaon (Osmanabad) Phase I,II: 50 MW each
4. Pokharni(Parbhani): 50 MW
5. Anterveli (Parbhani): 15 MW

6. Mangladevi (Yeotmal): 80 MW

Ongoing Thermal Power Projects – 3230 MW:

1. Chandrapur TPS Unit 8 and 9 (2 x 500 MW)
2. Parli TPS Unit 8 (1 x 250 MW)
3. Koradi TPS Unit 8, 9 and 10 (3 x 660 MW)

Gujarat State

Details regarding capacity addition planned during 2014-17 in Gujarat State are given in Table: 8.10.

Table: 8.10

Capacity Addition Planned during 2014-17 in Gujarat State

S No.	Name of Project	Fuel	Capacity (MW)	Year Wise Addition Planned		
				2014-15	2015-16	2016-17
1	GSECL Wanakbori	Coal	800	-	800	-
2	GIPCL Ext III	Lignite	500	500	-	-
3	Essar Power	Imp Coal	800	-	800	-
4	Shapoorji Pallonji Energy	Imp Coal	800	-	800	-
5	JIPL UMPP Tilaiya	Coal	300	180	120	-
6	NTPC Muvada	Coal	240	-	240	-
7	NTPC Lara	Coal	280	-	140	140
8	NTPC Kakrapar Ext	Atomic	476	-	476	-
9	NTPC Barh	Coal	174	-	-	174
10	NTPC Dhuvaran	Coal	660	-	-	660
11	NTPC Khargone	Coal	220	-	-	220
12	NTPC Gadarwara	Coal	220	-	-	220

	Total	5470	680	3376	1414

Source: Website, Gujarat Energy and Petrochemicals Department

Projects under implementation through private/joint sector participation in Gujarat are as under:

1. 500 MW Pit head Lignite based Power Project at Ghogha in Bhavnagar district by Bhavanagar Energy Company Limited.
2. 700 MW Gas based Power Project at Kovaya in Amreli district in joint venture with GSPC Pipavav Power Company Limited.
3. 1000+ MW Coal based Power Project at Pipavav in joint venture with Torrent Power Limited.
4. 6x1000 MW Nuclear based Power Project at Bhavnagar.
5. Charanka solar park (20 MW) under Jawaharlal Nehru National Solar Mission (JNNSM), Phase-II scheme.

8.4 Assessment of the Power Benefits from Par-Tapi-Narmada Link Project

Par-Tapi-Narmada Link Project has been planned to transfer surplus waters of West flowing Par, Auranga, Ambica and Purna river basins of South Gujarat and neighbouring Maharashtra to provide irrigation facilities to: the areas on its enroute: tribal areas enroute right side of the link canal; tribal dominant districts of Dang and Valsad of Gujarat and Nasik district of Maharashtra; command area of five projects proposed by Government of Gujarat in its initial reaches to caters the water demands for irrigation and drinking purposes in its enroute; and take over the part command area of existing Miyagam Branch Canal of Narmada Canal System. The Narmada waters so saved in Sardar Sarovar Project would be utilized to provide irrigation facilities: in tribal areas of Naswadi, Kavant, Sankheda, Jetpur Pavi, Chhota Udepur talukas of Chhota Udepur district and Halol, Ghogamba and Kalol talukas of Panchmahal district by lift directly from Narmada Main Canal on substitution basis; and in drought affected Saurashtra region of Gujarat on substitution basis through Narmada Canal System to meet irrigation, domestic and other requirements. In addition to this, all possible Panchayat / village tanks coming in the vicinity of the project will be filled up. The project will also provide drinking water to tribal population in the vicinity.This link mainly envisages construction of six dams, two barrages, a 12.7 Km long tunnel, 406.118 km long conveyance system including five tunnels of total 1.150 Km length, 6 power houses and number of Cross-Drainage/Cross Masonry works. Besides providing irrigation benefits to the en-route command and Narmada command, the link will generate annually 102 Million units hydropower with 21 MW Installed Capacity. The reservoirs will also provide flood relief to the people residing in downstream areas.

The six dams proposed in the scheme are Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan. The Jheri and Paikhed dams are proposed across Par and Nar (a tributary of Par) rivers. Chasmandva dam is proposed across river Tan (a tributary of Auranga). Chikkar dam is proposed across river Ambica. Dabdar dam is proposed across Khapri (a tributary of Ambica) and Kelwan dam is proposed across river Purna.

Two barrages are proposed downstream of Paikhed and Chasmandva dams as the hilly terrain does not permit the link canal to take off from the dam sites.

The water from Jheri reservoir will flow through a 12.70 km long tunnel to reach the Paikhed reservoir. The Link Canal will off-take from Paikhed barrage. Water released from the Chasmandva reservoir for diversion into the Link Canal will be tapped at Chasmandva barrage and fed to the Link Canal through a Feeder pipe line of 2.859 km long. A canal of 14.342 km long connects the Chikkar reservoir with Dabdar reservoir. From Dabdar reservoir the combined water will be released into the Link Canal through a 12.258 km long Feeder pipe line. The 7.616 km long Feeder pipe line delivers water from Kelwan reservoir to the Link Canal. A power house is proposed at RD 5.80 km of Kelwan Feeder pipe line where a drop of about 16 m is available.

The first part of the link canal viz. 'Par-Tapi reach' will take off from the right bank of the Paikhed barrage and after inter-connecting the remaining four reservoirs viz. Chasmandva, Chikkar, Dabdar and Kelwan, as detailed above, will finally terminate at the left flank of existing Ukai reservoir on Tapi river.

The second part of the link canal viz. Tapi-Narmada reach will take off from the right bank of Ukai reservoir and after crossing the Narmada river downstream of Sardar Sarovar Project will finally terminate at RD 16.70 km of Miyagam Branch Canal of Narmada Main Canal of Sardar Sarovar Project.

The Link Canal Project is being developed as storage type multipurpose scheme. The Storage Capacities of these reservoirs are proposed for diversion of water to the link canal scheme for fulfilling the Domestic, Industrial, irrigation and downstream environmental requirements. The Environmental releases and link requirement are considered to be diverted through Paikhed and Chasmandva Power houses. Whenever there is surplus water available as spillage, same can be released through these two power houses by running the machines on 20% overload. The power releases of the remaining four power houses controlled by Link canal water demands.

Accordingly, the power potential studies were carried out through THDCIL, Rishikesh at the proposed Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan reservoirs and at the drop on Kelwan Feeder pipe line and assessed the potential of hydropower generation under the link project. The Power Potential study reports of Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan reservoirs and Power House at the drop available on Kelwan Feeder pipe line at Appendix – 8.1 to 8.6 respectively in Volume – V and the EandM report of these Powerhouses are at Appendix 8.7 to 8.12 respectively in Volume - V. The details of the studies are furnished in the following paragraphs. The details of generating units, installed capacity and annual energy generation in the 90% dependable year and at 95 % plant availability are given in Table – 8.11:

Table – 8.11

Details of Installed Capacities of Various Power Houses

S No.	Powerhouse	Installed Capacity (MW)			Annual Energy Generation (MU)
		Number of Units	Installed Capacity of each Unit (MW)	Total	
1	Paikhed dam PH	3	3.00	9.00	45.53
2	Chasmandva dam PH	2	1.00	2.00	5.67
3	Chikkar dam PH	2	1.00	2.00	8.35
4	Dabdar dam PH	2	1.60	3.20	16.60
5	Kelwan dam PH	2	1.25	2.50	13.09
6	Kelwan feeder pipe line PH	2	1.00	2.00	12.48
			Total	**20.70**	**101.70**
			Say	**21.00**	**102.00**

8.4.1 Paikhed Dam Power House

8.4.1.1 Power Potential Study

8.4.1.1.1 Type of Project

The project is planned as storage type multipurpose scheme. The Storage Capacity of the reservoir is proposed for diversion of water for link canal scheme and committed downstream release for environmental requirements including fulfilling the Domestic, Industrial and irrigation requirements of local people. The Environmental releases and link diversion are considered to be diverted through Power house. Whenever there is surplus water available for spillage, same can be released through the power house by running the machines on 20% overload. The committed downstream releases for environmental purpose and spills are proposed to be released back in to Nar River through power house. The present power potential study is carried out keeping the following factors into consideration.

8.4.1.1.2 Hydrology, Sedimentation Studies and Criteria for Fixing up Reservoir Levels

Water Availability

The water availability studies of Par, Auranga, Ambica and Purna river basins and at Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan dam sites have been carried out by the Hydrological Studies Organisation, CWC, New Delhi as a part of “Hydrological Studies of Par-Tapi-Narmada Link Project”. The monsoon monthly net yields and non-monsoon net yield series have been developed by CWC for the period from 1975 to 2006 at Paikhed dam site using rainfall runoff models developed at Nanivahiyal GandD site on Par River. The non-monsoon yield is distributed in to non-monsoon monthly yields in the proportion of the observed flow at the GandD site. This net yield is considered as inflow into the Paikhed reservoir along with the diversion from Jheri reservoir into Paikhed reservoir and utilized for power potential studies. The planned utilizations under Paikhed reservoir considered for the studies are: i) Local domestic and industrial water demand, ii) Environmental and ecological requirements downstream of proposed dam site, and iii) Downstream releases for further transfer to Par-Tapi-Narmada Link Canal. The details of monthly inflows in to Paikhed reservoir for the period from 1975 to 2006 are given in Annexure: 1 of Appendix – 8.1 of Volume-V.

Parameters used in Power Potential Study

Full Reservoir Level: FRL of the Reservoir has been kept at 248.00 m.
Minimum Draw Down Level (MDDL): The MDDL level has been considered at Elevation 190.00 m. The MDDL shall be kept as to satisfy the submergence requirement of the proposed power intake of generating plant.

Tail Water Level: The average Tail Water Level (TWL) has been considered at an elevation of 172.0 m for power potential studies.

Water Conductor Losses: The power house has been proposed to be constructed at the toe of the dam hence, keeping in view the entire length of water conductor system, the water conductor losses have been considered as 0.20 m in the present study.

Design Net Head = Gross head – Water Conductor losses.

Efficiencies: The efficiencies applicable for most of the small hydro turbines and generator units, considered for the purpose of calculation of annual energy are given below:

Efficiency of Turbine	:	95%
Efficiency of Generator	:	98%
Overall efficiency of turbine- generator	:	93%

8.4.1.1.3 Reservoir Operation

Operation of the reservoir has been kept in such a way that maximum level shall be achieved during monsoon period and during non- monsoon season reservoir shall be depleted up to minimum reservoir level to the extent possible.

8.4.1.1.4 Simulation Studies

Simulation Studies have been done based on net yield series generated at Paikhed dam site for 32 year i.e. from the year 1975-76 to 2006-07.The parameters involved in the simulation studies include monthly inflows into the reservoir, various demands, evaporation losses, elevation-area- capacity relationship of the reservoir after 50 years of the sedimentation. The details of simulation study carried out for the assessment of power potential are at Appendix 8.1 (Power Potential study of Paikhed reservoir) in volume – V.

8.4.1.1.5 Firm Power

The firm annual energy that could be generated at Paikhed Power plant in the 90% dependable year (1986-87) with an installed capacity of 9.0 MW is 45.53 MU.

8.4.1.1.6 Installed Capacity

One of the most commonly used criterion for optimization of the installed capacity is based on the analysis of incremental energy that is generated with a unit increase in the installed capacity. In the present optimization studies, energy generation has been analyzed with different installed capacities, ranging from 2.0 MW to 16.00 MW. The energy computations are done for 50% and 90% dependable years and for all the 32 years flow data available. The installed capacity is increased in steps of 1.00 MW. In each case, unrestricted energy and the firm energy have been computed, with and without spill. The results for 90% dependable year are summarized in Table 8.9:

Table 8.9

Incremental Energy Benefits in a 90% Dependable Year (1986-87)

Sl. No.	Installed Capacity	Annual Energy Gen.	95% Energy (MU)	Annual PLF	Incremental Power	Incremental Capacity	Variation in incremental Annual Energy
	MW	MU	MU	%	d(KWh)	d(kW)	d(kWh)/ d(kW)
1	2	16.032	15.230	86.932			
2	3	22.392	21.272	80.945	6042	1000	6.042
3	4	26.895	25.550	72.917	4278	1000	4.278
4	5	30.834	29.293	66.878	3742	1000	3.742
5	6	34.506	32.781	62.369	3488	1000	3.488
6	7	38.048	36.145	58.946	3364	1000	3.364
7	8	40.856	38.813	55.384	2668	1000	2.668
8	9	41.690	39.605	50.235	792	1000	0.792
9	10	42.434	40.312	46.018	707	1000	0.707
10	11	43.178	41.019	42.568	707	1000	0.707
11	12	43.922	41.725	39.693	707	1000	0.707
12	13	44.666	42.432	37.260	707	1000	0.707
13	14	44.984	42.735	34.846	303	1000	0.303
14	15	44.984	42.735	32.523	0	1000	0.000
15	16	44.984	42.735	30.490	0	1000	0.000

The ratio of incremental energy to incremental installed capacity (d(kWh)/ d(kW) for 90% dependable year is plotted against the installed capacity in Figure 8.1.

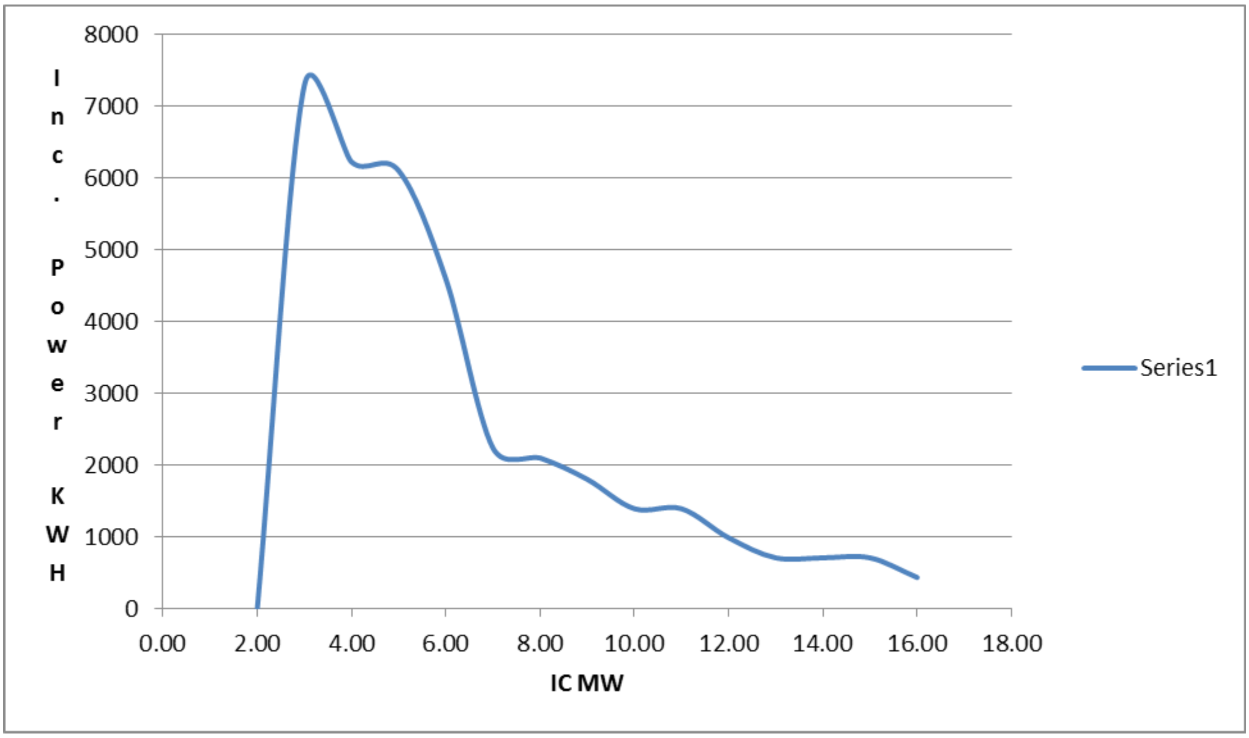

Fig 8.1: Installed Capacity vs. Incremental Energy (90% Dependable year)

Based on incremental consideration, the optimum installed capacity at Paikhed Dam is of the order of 8.00 MW for 90% dependable year. Keeping in view the power potential analysis for 90% dependable year, it has been observed that installed capacity is varying from 7.00 MW to 9.00 MW, hence, in order to maximum utilization of releases, a plant of 9 MW installed capacity with 3 units of 3.00 MW each has been proposed.

Annual Plant load factor for 9.00 MW installed capacity is 50.235% with annual generation of 45.53 MU.

8.4.1.1.7 Scope for Seasonal/Secondary Power Generation

The design energy in 90% dependable year has been calculated as 45.53 MU. Reviewing the energy calculated for the year 1975 to year 2006, it is seen that additional energy i.e. secondary energy can be generated in many years. Thefollowing table summaries the distribution of no. of years in which secondary energy is available. The details are furnished in Table – 8.10:

Table – 8.10

Assessment of Secondary Energy

No. of Months with Secondary Energy	No. of years in the Hydrological Series	%age of Time	Cumulative %age	Secondary Energy (MU)	95% Secondary Energy (MU)
0	9	28.125	100.00	0.00	0.00
1	6	18.750	71.875	6.48	6.156
2	10	31.250	53.125	12.96	12.312
3	4	12.500	21.875	19.44	18.468
4	3	9.375	9.375	25.92	24.624
Total	**32**	**100.000**			

For economic viability of the project, only design energy has been considered. Sale of secondary energy will increase the revenue and improve the viability of the project.

8.4.1.1.8 Size and Type of Generating Units

The proposed 9.0 MW Paikhed Hydro-Electric Project would have a surface power station located on the right bank of Nar River at toe of the Paikhed Dam. The installed capacity of 9.0 MW would be provided by 3 number Francis turbine driven generating units of 3.00 MW each. The units would operate under a gross head range of 76.0 m to 18.20 m. The rated design net head has been worked out as 56.53 m.

8.4.1.1.9 Number of Generating Units

Keeping in view the power potentinal analysis for 50%, 90% dependable years and average annual energy from the year 2001-02 to 2006-07 and in order to maximum utilization of releases, a plant of 9 MW with 3 units of 3.00 MW each has been proposed.

8.4.1.2 Electrical and Mechanical Works

The proposed 9000 kW Paikhed Hydro-Electric Project would have a surface power station located on the left bank of the Nar river at toe of the Paikhed Dam, proposed across river Nar near village Paikhed in Dharampur taluka of Valsad district in Gujarat State. The installed capacity (9.0 MW) would be provided by 3 number Francis turbine driven generating units of 3.00 MW each. The units would operate under a gross head range of 76.00 m to 18.20 m. The rated net head has been worked out as 56.53 m. The step-up 3.3kV/33 kV three phase Transformers would be at the unloading bay level on the downstream side, the power house service bay also being at EL 167.80 m. From the transformers, power would be taken to the switchyard by short overhead lines. Power would be transmitted from switchyard by 33 kV outgoing transmission lines.

This project is being developed as storage type water supply scheme with a dam toe type power station. The average tail water level has been taken as 172.00 m. The selection criteria for electro-mechanical works including turbine, generator, transformer, controls and protections and all other associated works for the power plant including Power evacuation and its transmission to sub-station for Paikhed HEP are discussed below:

8.4.1.2.1 Turbine

i) Selection of Type of Turbine: As per the power potential studies described under Para 8.4.1.1, three turbines - each of 3000 kW capacity have been proposed. The selection of type of turbine for a Hydro Power Project is a function of its specific speed. As per IS: 12800 (Part 3):1991, head variation has been considered from 125% to 65% and accordingly trial speed has been calculated. Based on the calculation, rotational speed has been taken as 750 rpm with Horizontal Francis Turbine. Details of design parameters for Paikhed Hydro Electric Project are given at Appendix – 8.7 of Volume-V.

For the given head condition, Francis turbines are recommended. Each turbine shall be capable of running at 120 % of rated capacity. Each turbine shall be horizontal shaft type suitable for coupling directly to horizontal shaft synchronous generator of 3000 kW plus 20% overload i.e., 3600 kW rating.

ii) Turbine Setting: Setting of Francis runner has been calculated to eliminate any chance of development of cavitations as per Thoma's criteria (ref: IS: 12800 (Part 3):1991).

iii) Runner Diameter: As per IS: 12800 (Part 3):1991), runner dia D_3 is computed. The manufacturer has provided runner dia. as 900 mm. All other turbine and casing dimensions have been computed with respect to above value of D_3 as adopted by the manufacturer viz. 900 mm. Details are given at Appendix 8.7 of Volume-V.

8.4.1.2.2 Francis Turbine and Associated Equipments

i) Type: The Turbine shall be of the Horizontal Shaft Francis suitable for coupling directly to horizontal shaft synchronous generator. The direction of rotation shall be anti-clock wise when viewed from coupling end. The turbine shall be capable of giving outputs higher than rated outputs to match the over load capability of generator.

ii) Spiral Casing: The Turbine shall be of spiral casing type so constructed as to allow all the removable parts to be dismantled conveniently. The design shall also permit removal of rotating parts without disturbing the guide apparatus. The design shall also permit horizontal/vertical movement of runner shaft by an amount sufficient for adjustment of bearing and for clearing the joint at the coupling between the turbine and the generator.

iii) Runner: The Runner shall be of 13/4 chromium-nickel steel. The runner shall be cast integrally of stainless steel. The runner will have adequate number of blades which shall be polished and ground smooth and shall be free from roughness, cracks, high spots etc. The finished machine and ground runner shall be dynamically balanced.

iv) Shaft and Coupling: The turbine shaft, if required, shall be forged carbon steel or alloy steel confirming to IS or other equivalent international standards. Wherever the flanges are integral with the shaft, the same should be conform to American standard ANSI-49.1, 1967. The turbine shaft shall be connected to the runner at one side and to the gear box / flywheel generator shaft on the other side. It shall be of ample size to transmit torque at rated speed without excessive vibration or any distortion. However, the turbine shaft is not applicable, as Turbine Runner will be mounted on the extended shaft of Generator.

v) Turbine Guide and Thrust Bearings: The turbine will be provided with an oil-lubricated guide bearing with suitable Babbitt lining for the shaft. The bearing shall be designed for the turbine radial and axial loads. The bearing will be split to facilitate dismantling. Bearing shall be provided with suitable instrumentation for monitoring the temperature and oil level.

vi) Draft Tube Each turbine shall be provided with a draft tube liner/suction bend of welded construction of structural steel. The design of the draft tube shall be such as to ensure the best overall efficiency for the turbine and stable and pulsation –free operation of the machines.

vii) Wicket–Gate Mechanism with Gate Operating Mechanism: The generator side and draft tube side head cover shall be of suitable construction of steel, to accommodate guide bearings, casings, labyrinth rings, shaft sealing, guide vane bearings etc. The head covers will be suitably designed to resist the superimposed hydraulic load, such that any consequential deflections / slopes of the head cover would not hamper the -functioning of the wicket-gate operating mechanism.

Guide Vanes: Each guide vane and its stem will be an integral casting in Stainless steel. The contacting surface of gates and the gate stems will be smooth and finish machined. All guide vane bearings (Axial/radial) shall be maintenance free, with appropriate sealing against water flow channel by ‘O’ rings.

The angular movement of the gates will be so limited and the mechanism so designed that the bedding faces of the guide vanes close, with no gap, with the servomotor at its closed position.

Levers/Links: The guide vane links/levers to be clamped to the guide vane stem and locked in position during assembly. A suitably designed frictional clutch mechanism to prevent possible damage to the wicket gates in case of trapped foreign bodies between the gates will be provided.

Gate Operating Ring: A suitably designed gate operating ring will be operated by a servo-motor. The operating ring will be provided with maintenance free bushes.
Servomotor: Double Acting servomotors operated by governor oil pressure shall be mounted on the generator side head-cover. The servo-motor shall be supplied with a feedback transmitter. Servo-motor will be of sufficient capacity to operate the gates, when supplied with oil at minimum pressure.

8.4.1.2.3 Inlet Valves

Three Nos. Flat disc type butterfly valves, each of 1300 mm dia and operated by hydraulic pressure are proposed to be provided upstream of each turbine inlet to isolate any one of the machines in case of emergency and to afford flexibility of operation of the power plant. The valve will be opened by using an oil servomotor and closed by counter weight under all operating conditions. The counter weight shall be provided as a fail-safe feature, so that it will have a closing bias in case of fault condition. The body shall be welded construction, with its operating feet to take all Horizontal loads at foundations. The body to house door trunions complete with self lubricated PTFE/chevron type bushes for bearings.

The disc shall be fabricated from steel plates. The valve disc will have a peripheral sealing ring of rubber. The disk shall be optimally designed to provide minimum resistance to flow. Oil operated servomotors shall be mounted on a mounting frame for opening under balanced conditions, so that separate foundations for oil servomotor are avoided.

The oil pressure system for operating the valve shall be common with the governor oil, pressure system. The bypass valve with hydraulically operated main valve shall be provided for opening the valve under balanced conditions.

An inlet pipe of suitable bore shall be flanged u/s of the valve, about 500mm long for welding to the penstock at site. A dismantling joint of telescopic type shall be located d/s of the valve.

8.4.1.2.4 Governing Equipment

The turbine shall be equipped with suitable electronic governor conforming to IEC No. 308/Hydro-Mechanical governor complete with all accessories. Standard protections like over speed device, brake control, emergency shut down and alarm etc., shall be provided in the governing system.

8.4.1.2.5 Pressure Oil System

Each unit will be provided Oil pressure units systems comprise a sump tank and a pressure tank separate for each generating unit. Two numbers of electrically operated governor oil pumps will be provided, one for normal running and the other acting as standby for each unit. Provision of emergency shutdown of the unit without any oil pump shall be made.

8.4.1.2.6 Generator

i) General: There are two types of generators namely:

1. Synchronous, and
2. Induction.

Induction generators are generally about 20% cheaper than the synchronous generators of same output. Whereas synchronous generators are self contained in developing its own excitation power, induction generators require an external source for providing it with the magnetization power. The induction generator uses excitation power supplied from an external source, which is normally the grid. However, in case of grid failure, black start of machines will be difficult. Since Paikhed HEP is not a very small project, dependability on grid could result in loss of power due to standstill generator. Hence it has been proposed to use synchronous generators.

ii) Speed Rise and Runaway Speed: Each generator shall be designed and constructed so as to be capable of running for a period of 15 minutes at a maximum runway speed. The runaway speed test shall be considered successful if after undergoing the test, 'no injury' is apparent. The runaway speed test may be carried out at a site and at works.

iii) Cooling System: Generator shall be of open type construction with IP: 23 /IC: 01 enclosure

iv) Stator: The stator frame shall be manufactured of cast iron/fabricated steel construction. The frame shall be designed to withstand the bending stresses and deflections due to its self weight and the weight of the core supported by it. The stator core shall be built up by segmental punching made of low loss silicon sheet steel non-oriented type and end plates. Each punching shall be properly debarred and applied with insulating varnish on both the sides.

The stator winding shall be star connected. The terminal leads of each phase are brought out to a separate terminal box. Six Nos. (Two resistance element per phase) embedded temperature detectors for each generator of resistance type shall be provided for stator winding located symmetrically. The connections on the resistor elements shall be well insulated and extended to a box on the outside of stator frame. The generator stator windings will be provided with epoxy insulation of class “F” type.

v) Rotor: The design and construction of the rotor shall as per latest practice and also in accordance with the best modern practice. The factor of safety at minimum runaway speed based on yield point of material shall not be less than 1.5.

Necessary flywheel effect shall be determined, in case required moment of inertia is not available from rotor, separate flywheel shall be provided to furnish additional flywheel effect. A mechanical over speed device with electrical contacts (two sets) one for alarm and other for trip shall be mounted on non-driving end of the generator and in case of shorting of diodes there shall be trip command.

vi) Shaft: The generator shaft shall be made of the best quality carbon steel properly heat-treated. The shaft shall be of adequate size to operate at all speeds including maximum runway speed and shall be able to withstand short circuit stresses without excessive vibrations or distortion.

The shaft shall be accurately machined all over and polished where it passes through the bearings and accessible points for alignment check.

vii) Bearings: The generator bearings shall be Antifriction ball / roller type / Tilting Pad. One No. of bearing shall be mounted on DE and NDE. These bearing shall be guaranteed for minimum continuous working for 100,000 (one hundred thousand) hours and shall be of proven design and performance and have minimum maintenance.

Bearings shall be adequately insulated to prevent any harmful circulating currents. The bearings shall be designed to withstand operation of runaway speed for a period of 15 minutes.

Dial type thermometer with two NO contacts shall be provided one Number on each DE and NDE bearings. At each bearing one no. duplex RTD shall be provided for indication/recording and alarm as well as for tripping the unit in case of high temperature.

The guaranteed operating temperature of the bearing at rated output and overload condition shall be indicated. However the bearing temperature for "alarm" and "unit trip" shall not be higher than 75^{0} C and 80^{0} C respectively.

viii) Heaters: The heater suitable for 240 volts, single-phase AC supply shall be provided

ix) Brakes: For stopping the generating units quickly, each generator shall be provided with pneumatically operated brakes, which will be operated automatically or manually. The generator brake would consist of a suitable number of brake shoes, which will operate against a polished segmental steel brake track bolted to rotor or to any other component such as fly wheel, if any.

x) Terminal Box: Separate terminal boxes shall be provided for the following:

- Phase terminals of the generator.
- Neutral terminals of the generator.
- Space heater.
- Temperature detectors.

The phase and neutral terminal boxes shall be of phase segregated type.
Terminal boxes shall be of weatherproof construction to eliminate entry of dust, vermin and water with a degree of protection IP: 54.

xi) Noise Level

The generator shall be designed to have a noise level not exceeding 90 db at a distance of one meter from the equipment.

xii) Insulation and Temperature rise

Insulation shall be provided as follows:

(i) Stator winding material corresponding to class F.
(ii) Rotor winding material corresponding to class F.

For the rated and 120% overload generator output within the permissible operating conditions, the temperature rise limits of the stator windings would be restricted and the limit would be as per latest Bureau of Indian Standards over the ambient air temperature prevailing at site. The generator manufacturer shall coordinate with the turbine manufacturer to match the speed, runaway speed, moment of inertia, overload capacity and coupling arrangements etc.

8.4.1.2.7 Electrical Control And Protection Equipments

i) General

Digital Electronic governor with Oil Pressure Unit (OPU) is proposed to be housed in one of the corners of the powerhouse. This system will serve the following four purposes:

- Indication
- Metering
- Protection
- Control

All the indications such as butterfly valve on/off status, breaker on / off status etc. will be indicated on the unit control board incorporated in the Electronic Governor. 110 Volt D.C. lamps of different colour codes will be used for this purpose.

ii) Metering

All the necessary parameters like voltage, frequency, power factor, current, power, energy, unit hour running etc. will be measured through suitably scaled meters mounted on the unit control board of the Governor.

iii) Controls

All Controls like control for closing the butterfly valves and motor operated circuit breakers for load switching will be incorporated in the Digital Electronic Governor. Thus, the electronic unit control shall have a complete and coordinated set of instruments, controls and safety devices for indication, metering and protection related to all conditions of running of the plant including activating / de-activating various protection devices during emergency operating conditions for the plant.

iv) D.C. System

Float cum boost charger 110 Volt, 400 AH capacity and tubular batteries will be provided for feeding power to indication lamps, protection relay coils, and initial impulse to the self excitation system by means of field flashing and to operate few emergency lights.

Central Board of Irrigation and Power (CBIP) Technical report no. 79 (Manual on Sub-Station, Chapter 1 on substation battery charging equipment and D.C. switch gear) will be followed for detailed designing.

v) Fire Protection

Latest techniques available for control of fire using fire-fighting equipments, smoke detectors etc. will be used. Automatic system with manual override is recommended.

8.4.1.2.8 Material Handling in the Power House

It is proposed to provide a girder type electric operated crane with a capacity of 40/10T. The hoisting operation shall be done by electric motor operated hoist, which can be operated from the generator floor level. The EOT crane would facilitate a small group of erection and maintenance personnel to handle both erection and maintenance activities.

8.4.1.2.9 Auxiliary Power Supply

Three Phase, 33 kV / 415 V Star / Delta 125 kVA capacity step-down transformer will be used for feeding the station lighting and heating load for power house, illumination for approach road and switch yard. Emergency lights on important places will be operated by D.C. battery provided in the powerhouse. 62.5 kVA diesel generator set will also be provided for illumination in powerhouse, staff colony, streetlights and switchyard during shut down of machines.

8.4.1.2.10 Cables and Boxes

Heat shrink type cable and boxes shall be provided for HT cable connecting generator to control panel, neutral grounding and relays.

8.4.1.2.11 Station Drainage System

Two nos. horizontal centrifugal / submersible drainage pumps of adequate capacity to remove normal seepage and drainage water along with necessary piping, valves and fittings shall be provided. A drainage sump shall be provided on the inlet valve floor.

The motors shall be of ample rating suitable for continuous duty and mounted at the pit. The automatic control of the pump units shall be arranged through float switches to start the pumps automatically when the water level in pit rises up to the pre-determined level. The pump motors shall be suitable for operation on 415 $\pm$ 10% volt, 3 phase, 50 Hz.

8.4.1.2.12 Dewatering System

One turbine dewatering system shall be provided for dewatering all the hydraulic portion i.e. from penstock gate to draft tube gate. The draft tube shall be connected to the dewatering sump by gate valve provided with each unit through a pipe directly from where water shall be pumped out into tailrace. Two portable submersible pump motor sets of adequate capacity shall be provided for dewatering all the hydraulic paths. The pump motor shall be suitable for operation on 415 V + 10%, volt, 3 phase, 50 Hz. For lowering these pump in sump a suitable monorail above sump is to be provided in the civil works.

For dewatering the penstock, spiral isolating valves shall be provided on the inlet and outlet pipes to dewater to tail race through the draft tube up to the tail water level and rest of the water shall be pumped after closing the draft tube gates and pumping from the sump.

8.4.1.2.13 Ventilation System

It is proposed to install six (06) nos. of exhaust fans of 300 mm size, 1000 RPM mounted at a suitable elevation facing towards the tail race.

8.4.1.2.14 Draft Tube Gate

Three nos. Slide type gates have been envisaged at the draft tube structure on the tailrace side. The clear opening is 4.02 m wide x 2.30 m high. The gates shall be designed for a head corresponding to average tail water level of 172.0 m and checked for water level corresponding to maximum flood level 174.0 m (sill EL 159.40 m).

The gate shall be lifted under balanced head conditions created by filling valve. The gate shall be operated by means of independent rope drum hoist of 15 t capacity (tentative) mounted on trestle at deck level of EL 167.80 m.

8.4.1.2.15 Tailrace Channel

The tail race channel will connect the draft tubes of the power house with the Nar river.

8.4.1.2.16 Switchyard

A comparatively flat terrace exists near powerhouse at EL + 174.00 m where the switchyard has been proposed with 33 kV Outdoor Switchyard Equipments comprising of Vacuum Circuit Breakers, CT's, PT's, LA's, Isolators, Jumpers, and Structure etc. In this location one no. three phase power transformer will be kept on plinth. Earth mat will be laid underground. Proper fuse sets, switches etc. will be mounted on M.S. poles. The total area will be strongly fenced as per Indian electrical safety rules. High voltage cable will be laid underground in cable trenches. The power cable will connect low voltage side of the step-up transformer.

8.4.1.2.17 Grounding Systems

i) General

The following equipments / systems are required to be earthed:

- Neutral points of different voltages
- Equipment frame work and other metallic parts
- Boundary fence, steel structures etc.
- Lightning arrestor

ii) Design

The grounding system shall conform to IS 3043-1987 or latest edition and Indian Electricity Rules 1956 along with latest amendments. Power house and switch yard areas shall be protected against electric shocks by providing electrodes and earthing mat for the power house and switchyard areas as per computed/measured electrical resistivity values. Earthing electrodes shall be uniformly distributed and located adjacent to fencing of switchyard and powerhouse.

8.4.1.2.18 Transmission and Distribution Works

i) General

Paikhed Small Hydro Power Project is proposed to be a grid-connected scheme. However, it is proposed to evacuate the power to the existing 33 kV sub-station of SEB located in Wilson hill (Piprol) town. The distance of sub-station from Paikhed Small switchyard is approximately 7.5 km.

ii) Power Evacuation

It is proposed that the electricity shall be generated at 3.3 kV level and evacuated at 33 kV level.

Two numbers Step-up transformer, of 6500 kVA rating and 3.3 kV / 33 kV voltage level for these machines shall be provided at switchyard near the powerhouse. The electricity at 33 kV voltage level will be transmitted to the 33 kV SEB sub-station. Appropriate arrangements for protection of the transmission line shall be made.

iii) Step-up Transformers for the Switchyard

As mentioned earlier, two transformers are proposed to be provided in the switchyard adjacent to the powerhouse. These transformers shall be of 6500 kVA rating, outdoor type, oil filled, 50 Hz, 3 Phase, vector group Y n d 11, natural air cooled. The windings shall be of copper. The connections at HV winding side shall be star and LV winding side shall be delta. Off-load taps on HV side shall be (+) 2.5% to (-) 7.5% in steps of 2.5%. The LV side shall be suitable for cable box whereas HV side shall be suitable for the selected conductor.

The temperature rise on any part of the transformer shall not exceed 40^0 C by oil thermometer and 60^0 C in winding by resistance methods (RTDs) under full load conditions. The cover of the tank of the transformer shall be bolted to the tank for easy maintenance. C.B.I.P. manual and IS code 2026 – 1977 will be followed for detailed design of transformers.

iv) Transmission Lines

It is proposed to provide single circuit 33 kV transmission line supported on tubular steel poles for evacuation of the same. The 33 kV transmission line from Powerhouse to SEB sub-station located at Wilson hill town shall be supported on steel poles- SP-55 with ACSR Dog conductor and insulators etc. as per the prevailing practice. Total length of the transmission line from switchyard to SEB substation is assessed to be 7.5 Km. Necessary arrangements with control panels and metering panels shall be made at Sub-Station end for 33 kV incomer line.

8.4.1.2.19 Drawings

The general arrangement drawing with Plan view and Section view of Powerhouse has been prepared and appended as Appendix 8.7 in Volume- V.

8.4.1.2.20 Cost Estimate (S-Power Plant)

The cost of Electro-Mechanical Works has been computed by utilizing the quotations obtained from leading E and M equipment manufacturers of the various Quotations obtained from the reputed equipment manufacturers, the price quoted by one of the reputed manufacturer was found to be most realistic and hence the same has been adopted in formulating the cost estimate for EandM works. The cost of the Transmission line from Powerhouse to SEB has been computed based on the prevailing rates of the State's power transmission organizations.

Total cost of S-Power Plant which includes prices for Manufacture, Supply, and Transportation up to Project Site of EandM Equipments, Erection and Commissioning of EandM Equipments and Transmission cost up to SEB is Rs 21.46 Crores.

Schedule of requirements for supply of Electro-mechanical equipments has been annexed as Annexure – I in Appendix 8.7 of Volume- V. Details of Cost estimate have been appended as Annexure – II in Appendix 8.7 in Volume- V.

8.4.2 Chasmandva Dam Power House

8.4.2.1 Power Potential Study

8.4.2.1.1 Type of Project

The Chasmandva reservoir is planned as storage type multipurpose project. The Storage Capacity of the reservoir is proposed for diversion of water for link canal scheme and committed downstream release for environmental requirements including fulfilling the Domestic, Industrial and irrigation requirements of local people. The Environmental releases and link diversion are considered to be diverted through Power house. Whenever there is surplus water available for spillage, same can be released through the power house by running the machines on 20% overload. The committed downstream releases for environmental purpose and spills are proposed to be released back in to Tan River through power house. The present power potential study is carried out keeping the following factors into consideration.

8.4.2.1.2 Hydrology, Sedimentation Studies and Criteria for Fixing up Reservoir Levels

Water Availability

The water availability studies of Par, Auranga, Ambica and Purna river basins and at Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan dam sites have been carried out by the Hydrological Studies Organisation, CWC, New Delhi as a part of "Hydrological Studies of Par-Tapi-Narmada Link Project". The monsoon monthly net yields and non-monsoon net yield series have been developed by CWC for the period from 1975 to 2006 at Chasmandva dam site using rainfall runoff models developed at Amba GandD site on Tan River. The non-monsoon yield is distributed in to non-monsoon monthly yields in the proportion of the observed flow at the GandD site. This net yield is considered for power potential studies. The planned utilizations under Chasmandva reservoir considered for the studies are: i) Local domestic and industrial water demand, ii) Environmental and ecological requirements downstream of proposed dam site, and iii) Downstream releases for further transfer to Par-Tapi-Narmada Link Canal. The details of monthly inflows in to Chasmandva reservoir for the period from 1975 to 2006 are given in Annexure: 1 of Appendix – 8.2 of Volume-V.

Parameters Used in Power Potential Study

Full Reservoir Level: FRL of the Reservoir has been kept at 214.00 m.

Minimum Draw Down Level (MDDL): The MDDL level has been considered at Elevation 190.00 m. The MDDL shall be kept as to satisfy the submergence requirement of the proposed power intake of generating plant.

Tail Water Level: As per topographical map of the D/s of Chasmandva dam, average Tail Water Level (TWL) has been considered at an elevation of 173.02m for power potential studies.

Water Conductor Losses: The power house has been proposed to be constructed at the toe of the dam hence, keeping in view the entire length of water conductor system, the water conductor losses have been considered as 0.20 m in the present study.

Design Net Head = Gross head – Water Conductor losses.

Efficiencies: The efficiencies applicable for most of the small hydro turbines and generator units, considered for the purpose of calculation of annual energy are given below:

Efficiency of Turbine	:	95%
Efficiency of Generator	:	98%
Overall efficiency of turbine- generator	:	93%

8.4.2.1.3 Reservoir Operation

Operation of the reservoir has been kept in such a way that maximum level shall be achieved during monsoon period and during non- monsoon season reservoir shall be depleted up to minimum reservoir level to the extent possible.

8.4.2.1.4 Simulation Studies

Simulation Studies have been done based on net yield series generated at Chasmandva dam site for 32 year i.e. from the year 1975-76 to 2006-07.The parameters involved in the simulation studies include monthly inflows into the reservoir, various demands, evaporation losses and elevation-area- capacity relationship of the reservoir after 50 years of the sedimentation. The details of simulation study carried out for the assessment of power potential are at Appendix 8.2 (Power Potential study of Chasmandva reservoir) in Volume –V.

8.4.2.1.5 Firm Power

The firm annual energy that could be generated at Chasmandva Power plant in the 90% dependable year (1986-87) with an installed capacity of 2 MW is 5.67 MU.

8.4.2.1.6 Installed Capacity

One of the most commonly used criterion for optimization of the installed capacity is based on the analysis of incremental energy that is generated with a unit increase in the installed capacity. In the present optimization studies, energy generation has been analyzed with different installed capacities, ranging from 0.25 MW to 3.0 MW. The energy computations are done for 50% and 90% dependable years and for all the 32 years flow data available. The installed capacity is increased in steps of 0.25 MW. In each case, unrestricted energy and the firm energy have been computed, with and without spill. The results for 90% dependable year are summarized in Table 8.11.

Table 8.11
Incremental Energy Benefits in a 90% Dependable Year (1986-87)

Sl. No.	Installed Capacity	Annual Energy Gen.	95% Energy (MU)	Annual PLF	Incremental Power	Incremental Capacity	Variation in incremental Annual Energy
	MW	MU	MU	%	d(KWh)	d(kW)	d(kWh)/ d(kW)
1	0.250	0.628	0.597	27.251			
2	0.500	1.174	1.115	25.468	518.700	250	2.075
3	0.750	1.720	1.634	24.873	518.700	250	2.075
4	1.000	2.266	2.153	24.576	518.700	250	2.075
5	1.250	2.618	2.487	22.714	334.250	250	1.337
6	1.500	2.804	2.664	20.273	176.700	250	0.707
7	1.750	2.990	2.841	18.529	176.700	250	0.707
8	2.000	3.176	3.017	17.222	176.700	250	0.707
9	2.250	3.362	3.194	16.205	176.700	250	0.707
10	2.500	3.401	3.231	14.755	37.403	250	0.150
11	2.750	3.401	3.231	13.414	0.000	250	0.000
12	3.000	3.401	3.231	12.296	0.000	250	0.000

The ratio of incremental energy to incremental installed capacity d (kWh)/ d(kW) for 90% dependable year is plotted against the installed capacity in Figure 8.2 :

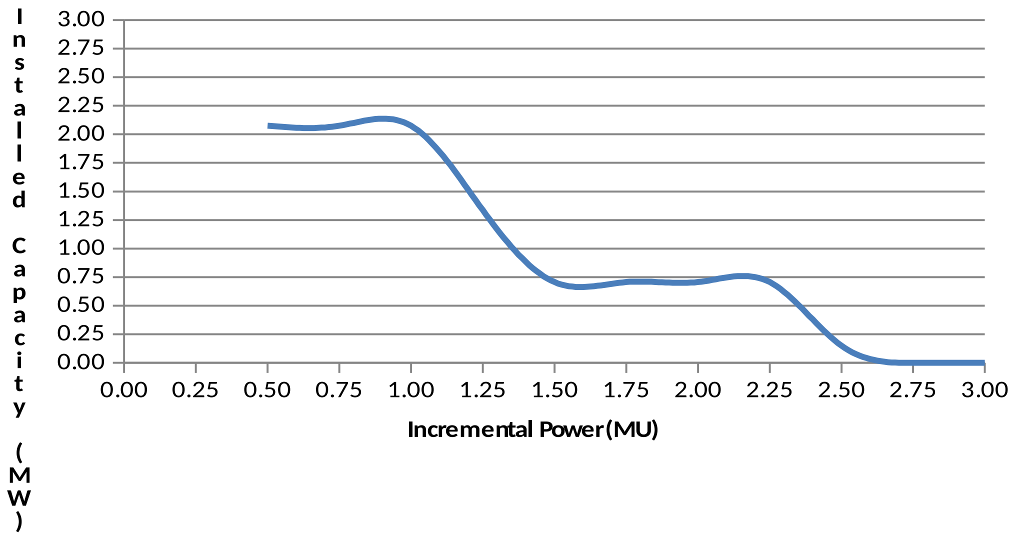

Fig 8.2: Incremental Power vs. Installed Capacity (90% Dependable year)

In view of higly variable nature of inflow data and results generated from the 50% depandable year and 90% depandable year , average energy generation, PLF and No. of days machines can be operated on full capacity from the year 2001-02 to 2006-07, for 2 MW and 20% overload i.e. 2.40 MW are also calculated to optimize the installed capacity and max. energy generation with and without spill.

The installed capcity of Chasmandva Hydroelectric Project is recommended as 2 MW with two units of 1.0 MW each. The average annual energy generation from the plant is estimated as 5.67 MU with a PLF of 32.37 without using the spill, machines can be operated on full load about 96 days.

8.4.2.1.7 Scope for Seasonal/Secondary Power Generation

The average annual energy generation has been calculated as 5.67 MU. Reviewing the energy calculated for the year 1975 to year 2006, it is seen that additional energy i.e. secondary energy can be generated in many years. The following table summaries the distribution of no. of years in which secondary energy is available. The details are furnished in Table – 8.12:

Table – 8.12
Assessment of Secondary Energy

No. of Months with Secondary Energy	No. of Years in the Hydrological Series	%age of Time	Cumulative %age	Secondary Energy (MU)	95% Secondary Energy (MU)
0	21	65.625	100.00	0.00	0.00
1	5	15.625	34.375	1.44	1.368
2	4	12.500	18.750	2.88	2.736
3	2	6.250	6.250	4.32	4.104
Total	**32**	**100.000**			

For economic viability of the project, only design energy has been considered. Sale of secondary energy will increase the revenue and improve the viability of the project.

8.4.2.1.8 Size and Type of Generating Units

The proposed 2 MW Chasmandva Hydro-Electric Project would have a surface power station located on the left bank of Tan River at toe of the Chasmandva Dam. The installed capacity of 2 MW would be provided by two Francis turbine driven generating units of 1.0 MW each. The units would operate under a gross head range of 40.98 m to 16.98 m. The rated net head has been worked out as 32.78 m.

8.4.2.1.9 Number of Generating Units

Keeping in view the power potentinal analysis for 50%, 90% dependable years and average annual energy from the year 2001-02 to 2006-07 and in order to maximum utilization of releases, a plant with 2 units of 1.00 MW each has been proposed.

8.4.2.2 Electrical and Mechanical Works

The proposed 2000 kW Chasmandva Hydro-Electric Project would have a surface power station located on the right bank of the Tan river at toe of the Chasmandva Dam, proposed across river Tan near village Chasmandva in Dharampur taluka of Valsad district in Gujarat State. The installed capacity (2.00 MW) would be provided by 2 number Francis turbine driven generating units of 1.0 MW each. The units would operate under a gross head range of 40.98 m to 16.98 m. The rated net head has been worked out as 32.78 m. The step-up 3.3kV/33 kV three phase Transformers would be at the unloading bay level on the downstream side, the power house service bay also being at EL 175.12 m. From the transformers, power would be taken to the switchyard by short overhead lines. Power would be transmitted from switchyard by 33 kV outgoing transmission lines.

This project is being developed as storage type multipurpose scheme with a dam toe type power station. The gross head range would be about 40.98 m to 16.98 m. The average tail water level has been taken as 173.02 m. The selection criteria for electro-mechanical works including turbine, generator, transformer, controls and protections and all other associated works for the power plant including Power evacuation and its transmission to sub-station for Chasmandva HEP are discussed below:

8.4.2.2.1 Turbine

i) Selection of Type of Turbine: As per the power potential studies described under Para 8.4.2.1, two turbines - each of 1000 kW capacity have been proposed. The selection of type of turbine for a Hydro Power Project is a function of its specific speed. As per IS: 12800 (Part 3):1991, head variation has been considered from 125% to 65% and accordingly trial speed has been calculated. Based on the calculation, rotational speed has been taken as 750 rpm with Horizontal Francis Turbine. Details of design parameters for Chasmandva Hydro Electric Project are given at Appendix – 8.8 of Volume – V of report.

For the given head condition, Francis turbines are recommended. Each turbine shall be capable of running at 120 % of rated capacity. Each turbine shall be horizontal shaft type suitable for coupling directly to horizontal shaft synchronous generator of 1000 kW plus 20% overload i.e., 1200 kW rating.

ii) Turbine Setting: Setting of Francis runner has been calculated to eliminate any chance of development of cavitations as per Thoma's criteria (ref: IS: 12800 (Part 3):1991).

iii) Runner Diameter:, Runner dia D_3 computed as per IS: 12800 (Part 3):1991 is 700 mm. The manufacturer has provided runner dia. as 730 mm. All other turbine and casing dimensions have been computed with respect to above value of D_3 as adopted by the manufacturer viz. 730 mm. Details are given at Appendix – 8.8 of Volume-V.

8.4.2.2.2 Francis Turbine and Associated Equipments

i) Type: The Turbine shall be of the Horizontal Shaft Francis suitable for coupling directly to horizontal shaft synchronous generator. The direction of rotation shall be anti-clock wise when viewed from coupling end. The turbine shall be capable of giving outputs higher than rated outputs to match the over load capability of generator.

ii) Spiral Casing: The Turbine shall be of spiral casing type so constructed as to allow all the removable parts to be dismantled conveniently. The design shall also permit removal of rotating parts without disturbing the guide apparatus. The design shall also permit horizontal/vertical movement of runner shaft by an amount sufficient for adjustment of bearing and for clearing the joint at the coupling between the turbine and the generator.

iii) Runner: The Runner shall be of 13/4 chromium-nickel steel. The runner shall be cast integrally of stainless steel. The runner will have adequate number of blades which shall be polished and ground smooth and shall be free from roughness, cracks, high spots etc. The finished machine and ground runner shall be dynamically balanced.

iv) Shaft and Coupling: The turbine shaft is not applicable, as Turbine Runner is proposed to be mounted on the extended shaft of Generator.

v) Turbine Guide and Thrust Bearings: The turbine will be provided with an oil-lubricated guide bearing with suitable Babbitt lining for the shaft. The bearing shall be designed for the turbine radial and axial loads. The bearing will be split to facilitate dismantling. Bearing shall be provided with suitable instrumentation for monitoring the temperature and oil level.

vi) Draft Tube Each turbine shall be provided with a draft tube liner/suction bend of welded construction of structural steel. The design of the draft tube shall be such as to ensure the best overall efficiency for the turbine and stable and pulsation –free operation of the machines.

vii) Wicket–Gate Mechanism with Gate Operating Mechanism:
(a) The generator side and draft tube side head cover shall be of suitable construction of steel, to accommodate guide bearings, casings, labyrinth rings, shaft sealing, guide vane bearings etc. The head covers will be suitably designed to resist the superimposed hydraulic load, such that any consequential deflections / slopes of the head cover would not hamper the -functioning of the wicket-gate operating mechanism.
Guide Vanes: Each guide vane and its stem will be an integral casting in Stainless steel. The contacting surface of gates and the gate stems will be smooth and finish machined. All guide vane bearings (Axial/radial) shall be maintenance free, with appropriate sealing against water flow channel by 'O' rings.
The angular movement of the gates will be so limited and the mechanism so designed that the bedding faces of the guide vanes close, with no gap, with the servomotor at its closed position.
Levers/Links: The guide vane links/levers to be clamped to the guide vane stem and locked in position during assembly. A suitably designed frictional clutch mechanism to prevent possible damage to the wicket gates in case of trapped foreign bodies between the gates will be provided.
Gate Operating Ring: A suitably designed gate operating ring will be operated by a servo-motor. The operating ring will be provided with maintenance free bushes.
Servomotor: Double Acting servomotors operated by governor oil pressure shall be mounted on the generator side head-cover. The servo-motor shall be supplied with a feedback transmitter. Servo-motor will be of sufficient capacity to operate the gates, when supplied with oil at minimum pressure.

8.4.2.2.3 Inlet Valves

Two Nos. Flat disc type butterfly valves, each of 950 mm dia and operated by hydraulic pressure are proposed to be provided upstream of each turbine inlet to isolate any one of the machines in case of emergency and to afford flexibility of operation of the power plant. The valve will be opened by using an oil servomotor and closed by counter weight under all operating conditions. The counter weight shall be provided as a fail-safe feature, so that it will have a closing bias in case of fault condition. The body shall be welded construction, with its operating feet to take all Horizontal loads at foundations. The body to house door trunions complete with self lubricated PTFE/chevron type bushes for bearings.

The disc shall be fabricated from steel plates. The valve disc will have a peripheral sealing ring of rubber. The disk shall be optimally designed to provide minimum resistance to flow. Oil operated servomotors shall be mounted on a mounting frame for opening under balanced conditions, so that separate foundations for oil servomotor are avoided.

The oil pressure system for operating the valve shall be common with the governor oil, pressure system. The bypass valve with hydraulically operated main valve shall be provided for opening the valve under balanced conditions.

An inlet pipe of suitable bore shall be flanged u/s of the valve, about 500mm long for welding to the penstock at site. A dismantling joint of telescopic type shall be located d/s of the valve.

8.4.2.2.4 Governing Equipment

The turbine shall be equipped with suitable electronic governor conforming to IEC No. 308/Hydro-Mechanical governor complete with all accessories. Standard protections like over speed device, brake control, emergency shut down and alarm etc., shall be provided in the governing system.

8.4.2.2.5 Pressure Oil System

Each unit will be provided Oil pressure units systems comprise a sump tank and a pressure tank separate for each generating unit. Two numbers of electrically operated governor oil pumps will be provided, one for normal running and the other acting as standby for each unit. Provision of emergency shutdown of the unit without any oil pump shall be made.

8.4.2.2.6 Generator

i) General: There are two types of generators namely:

1. Synchronous, and
2. Induction.

Induction generators are generally about 20% cheaper than the synchronous generators of same output. Whereas synchronous generators are self contained in developing its own excitation power, induction generators require an external source for providing it with the magnetization power. The induction generator uses excitation power supplied from an external source, which is normally the grid. However, in case of grid failure, black start of machines will be difficult. Since Chasmandva HEP is not a very small project, dependability on grid could result in loss of power due to standstill generator. Hence it has been proposed to use synchronous generators.

ii) Speed Rise and Runaway Speed: Each generator shall be designed and constructed so as to be capable of running for a period of 15 minutes at a maximum runway speed. The runaway speed test shall be considered successful if after undergoing the test, 'no injury' is apparent. The runaway speed test may be carried out at a site and at works.

iii) Cooling System: Generator shall be of open type construction with IP: 23 /IC: 01 enclosure

iv) Stator: The stator frame shall be manufactured of cast iron/fabricated steel construction. The frame shall be designed to withstand the bending stresses and deflections due to its self weight and the weight of the core supported by it. The stator core shall be built up by segmental punching made of low loss silicon sheet steel non-oriented type and end plates. Each punching shall be properly debarred and applied with insulating varnish on both the sides.

The stator winding shall be star connected. The terminal leads of each phase are brought out to a separate terminal box. Six Nos. (Two resistance element per phase) embedded temperature detectors for each generator of resistance type shall be provided for stator winding located symmetrically. The connections on the resistor elements shall be well insulated and extended to a box on the outside of stator frame. The generator stator windings will be provided with epoxy insulation of class “F” type.

v) Rotor: The design and construction of the rotor shall as per latest practice and also in accordance with the best modern practice. The factor of safety at minimum runaway speed based on yield point of material shall not be less than 1.5.

Necessary flywheel effect shall be determined, in case required moment of inertia is not available from rotor, separate flywheel shall be provided to furnish additional flywheel effect. A mechanical over speed device with electrical contacts (two sets) one for alarm and other for trip shall be mounted on non-driving end of the generator and in case of shorting of diodes there shall be trip command.

vi) Shaft The generator shaft shall be made of the best quality carbon steel properly heat-treated. The shaft shall be of adequate size to operate at all speeds including maximum runway speed and shall be able to withstand short circuit stresses without excessive vibrations or distortion.
The shaft shall be accurately machined all over and polished where it passes through the bearings and accessible points for alignment check.

vii) Bearings: The generator bearings shall be Antifriction ball / roller type / Tilting Pad. One No. of bearing shall be mounted on DE and NDE. These bearing shall be guaranteed for minimum continuous working for 100,000 (one hundred thousand) hours and shall be of proven design and performance and have minimum maintenance.

Bearings shall be adequately insulated to prevent any harmful circulating currents. The bearings shall be designed to withstand operation of runaway speed for a period of 15 minutes.

Dial type thermometer with two NO contacts shall be provided one Number on each DE and NDE bearings. At each bearing one no. duplex RTD shall be provided for indication/recording and alarm as well as for tripping the unit in case of high temperature.

The guaranteed operating temperature of the bearing at rated output and overload condition shall be indicated. However the bearing temperature for "alarm" and "unit trip" shall not be higher than 75^{0} C and 80^{0} C respectively.

viii) Heaters: The heater suitable for 240 volts, single-phase AC supply shall be provided

ix) Brakes For stopping the generating units quickly, each generator shall be provided with pneumatically operated brakes, which will be operated automatically or manually. The generator brake would consist of a suitable number of brake shoes, which will operate against a polished segmental steel brake track bolted to rotor or to any other component such as fly wheel, if any.

x) Terminal Box: Separate terminal boxes shall be provided for the following:

- Phase terminals of the generator.
- Neutral terminals of the generator.
- Space heater.
- Temperature detectors.

The phase and neutral terminal boxes shall be of phase segregated type.

Terminal boxes shall be of weatherproof construction to eliminate entry of dust, vermin and water with a degree of protection IP: 54.

8.4.2.2.7 Electrical Control And Protection Equipments

a) General

Digital Electronic governor with Oil Pressure Unit (OPU) is proposed to be housed in one of the corners of the powerhouse. This system will serve the following four purposes:

- Indication
- Metering
- Protection
- Control

All the indications such as butterfly valve on/off status, breaker on / off status etc. will be indicated on the unit control board incorporated in the Electronic Governor. 110 Volt D.C. lamps of different colour codes will be used for this purpose.

b) Metering

All the necessary parameters like voltage, frequency, power factor, current, power, energy, unit hour running etc. will be measured through suitably scaled meters mounted on the unit control board of the Governor.

c) Controls

All Controls like control for closing the butterfly valves and motor operated circuit breakers for load switching will be incorporated in the Digital Electronic Governor. Thus, the electronic unit control shall have a complete and coordinated set of instruments, controls and safety devices for indication, metering and protection related to all conditions of running of the plant including activating / de-activating various protection devices during emergency operating conditions for the plant.

d) D.C. System

Float cum boost charger 110 Volt, 150 AH capacity and tubular batteries will be provided for feeding power to indication lamps, protection relay coils, and initial impulse to the self excitation system by means of field flashing and to operate few emergency lights.

Central Board of Irrigation and Power (CBIP) Technical report no. 79 (Manual on Sub-Station, Chapter 1 on substation battery charging equipment and D.C. switch gear) will be followed for detailed designing.

e) Fire Protection

Latest techniques available for control of fire using fire-fighting equipments, smoke detectors etc. will be used. Automatic system with manual override is recommended.

8.4.2.2.8 Material Handling in the Power House

It is proposed to provide a girder type electric operated crane with a capacity of 10T. The hoisting operation shall be done by electric motor operated hoist, which can be operated from the generator floor level. The EOT crane would facilitate a small group of erection and maintenance personnel to handle both erection and maintenance activities.

8.4.2.2.9 Auxiliary Power Supply

3 Phase, 33 kV / 415 V Star / Delta 150 kVA capacity step-down transformer will be used for feeding the station lighting and heating load for power house, illumination for approach road and switch yard.

Emergency lights on important places will be operated by D.C. battery provided in the powerhouse. 150 kVA diesel generator set will also be provided for illumination in powerhouse, staff colony, streetlights and switchyard during shut down of machines.

8.4.2.2.10 Cables and Boxes

Heat shrink type cable and boxes shall be provided for HT cable connecting generator to control panel, neutral grounding and relays.

8.4.2.2.11 Station Drainage System

Adequate provision will be made for collection of any leakage water around the turbine and its delivery to a lowest point of the station drain. A drain connector at lowest point of scroll case for drawing into the draft tube will be provided.

8.4.2.2.12 Ventilation System

It is proposed to install six (06) nos. of exhaust fans of 300 mm size, 1000 RPM mounted at a suitable elevation facing towards the tail race.

8.4.2.2.13 Draft Tube Gate

Two nos. Slide type gates have been envisaged at the draft tube structure on the tailrace side. The clear opening is 3.40 m wide x 2.34 m high. The gates shall be designed for a head corresponding to average tail water level of 173.02 m (sill EL166.51 m) and checked for water level corresponding to maximum flood level 175.12 m.

The gate shall be lifted under balanced head conditions created by filling valve. The gate shall be operated by means of independent rope drum hoist of 15t capacity (Tentative) mounted on trestle at deck level of EL 175.12 m.

8.4.2.2.14 Tailrace Channel

The tail race channel will connect the draft tubes of the power house with the Tan river.

8.4.2.2.15 Switchyard

A comparatively flat terrace exists near powerhouse at EL + 175.00 m where the switchyard has been proposed with 33 kV Outdoor Switchyard Equipments comprising of Vacuum Circuit Breakers, CT’s, PT’s, LA’s, Isolators, Jumpers, and Structure etc. In this location one no. three phase power transformer will be kept on plinth. Earth mat will be laid underground. Proper fuse sets, switches etc. will be mounted on M.S. poles. The total area will be strongly fenced as per Indian electrical safety rules. High voltage cable will be laid underground in cable trenches. The power cable will connect low voltage side of the step-up transformer.

8.4.2.2.16 Grounding Systems

i) General

The following equipments / systems are required to be earthed:

- Neutral points of different voltages
- Equipment frame work and other metallic parts
- Boundary fence, steel structures etc.
- Lightning arrestor

ii) Design

The grounding system shall conform to IS 3043-1987 or latest edition and Indian Electricity Rules 1956 along with latest amendments. Power house and switch yard areas shall be protected against electric shocks by providing electrodes and earthing mat for the power house and switchyard areas as per computed/measured electrical resistivity values. Earthing electrodes shall be uniformly distributed and located adjacent to fencing of switchyard and powerhouse.

8.4.2.2.17 Transmission and Distribution Works

i) General

Chasmandva Hydro Electric Power Project is proposed to be a grid-connected scheme. However, it is proposed to evacuate the power to the existing 66 kV sub-station of SEB located in Anklach village. The distance of sub-station from Chasmandva switchyard is approximately 11.25 km.

ii) Power evacuation

It is proposed that the electricity shall be generated at 3.3 kV level and evacuated at 33 kV level.

One number Step-up transformer, of 2850 kVA rating and 3.3 kV / 33 kV voltage level for these machines shall be provided at switchyard near the powerhouse. The electricity at 33 kV voltage level will be transmitted to the 66 kV SEB sub-station. Appropriate arrangements for protection of the transmission line shall be made.

iii) Step-up Transformers for the Switchyard

As mentioned earlier, Single transformer is proposed to be provided in the switchyard adjacent to the powerhouse. These transformers shall be of 2850 kVA rating, outdoor type, oil filled, 50 Hz, 3 Phase, vector group Y n d 11, natural air cooled. The windings shall be of copper. The connections at HV winding side shall be star and LV winding side shall be delta. Off-load taps on HV side shall be (+) 2.5% to (-) 7.5% in steps of 2.5%. The LV side shall be suitable for cable box whereas HV side shall be suitable for the selected conductor.

The temperature rise on any part of the transformer shall not exceed 40^0 C by oil thermometer and 60^0 C in winding by resistance methods (RTDs) under full load conditions. The cover of the tank of the transformer shall be bolted to the tank for easy maintenance. C.B.I.P. manual and IS code 2026 – 1977 will be followed for detailed design of transformers.

iv) Transmission Lines

Chasmandva Dam is located in Gujarat State and it is proposed to evacuate the power from this HEP to nearby substation in Gujarat State. The nearest Substation with a capacity of 66 kV is situated at Anklachh town of Valsad District of Gujarat State. Total length of the transmission line from switchyard to GETCO's 66kV sub-station is assessed to be approx. 11.25 Km. Necessary arrangement with 33/66kV step up transformer, LA, PT's, CT's and Breaker with control panels and metering panels shall be made at Sub-Station end for 33 kV incomer line.

8.4.2.2.18 Drawings

The general arrangement drawing with Plan view and Section view of Powerhouse has been prepared and appended as Appendix-8.8 in Volume-V.

8.4.2.2.19 Cost Estimate (S-Power Plant)

The cost of Electro-Mechanical Works has been computed by utilizing the quotations obtained from leading E and M equipment manufacturers. of the various Quotations obtained from the reputed equipment manufacturers, the price quoted by one of the reputed manufacturer was found to be most realistic and hence the same has been adopted in formulating the cost estimate for EandM works. The cost of the Transmission line from Powerhouse to SEB has been computed based on the prevailing rates of the State's power transmission organizations.

Total cost of S-Power Plant which includes prices for Manufacture, Supply, and Transportation up to Project Site of EandM Equipments, Erection and Commissioning of EandM Equipments and Transmission cost up to 66 Kv SEB situated at Anklachh town of Valsad District is Rs.10.01 Crores.

Schedule of requirements for supply of Electro-mechanical equipments has been given Appendix-8.8 in Volume-V.

Details of cost estimate have been annexed as Annexure-IV in Appendix-8.8 of Volume-V.

8.4.3 Chikkar Dam Power House

8.4.3.1 Power Potential Study

8.4.3.1.1 Type of Project

The Chikkar reservoir is planned as storage type multipurpose project. The Storage Capacity of the reservoir is proposed for diversion of water for link canal scheme and committed downstream release for environmental requirements including fulfilling the Domestic, Industrial and irrigation requirements of local people. The link demands which are to be diverted to Dabdar reservoir through Chikkar-Dabdar Inter-connecting pipe line will be released. The present power potential study is carried out keeping the following factors into consideration.

8.4.3.1.2 Hydrology, Sedimentation Studies and Criteria for Fixing up Reservoir Levels

Water Availability

The water availability studies of Par, Auranga, Ambica and Purna river basins and at Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan dam sites have been carried out by the Hydrological Studies

Organisation, CWC, New Delhi as a part of "Hydrological Studies of Par-Tapi-Narmada Link Project". The monsoon monthly net yields and non-monsoon net yield series have been developed by CWC for the period from 1975 to 2006 at Chikkar dam site using rainfall runoff models developed at Kudkas GandD site on Kapri River (tributary of Ambica River). The non-monsoon yield is distributed in to non-monsoon monthly yields in the proportion of the observed flow at the GandD site. This net yield is considered for power potential studies. The planned utilizations under Chikkar reservoir considered for the studies are: i) Local domestic and industrial water demand, ii) Environmental and ecological requirements downstream of proposed dam site, and iii) diversion to Dabdar reservoir through Feeder pipe line for further transfer to Par-Tapi-Narmada Link Canal. The details of monthly inflows in to Chikkar reservoir for the period from 1975 to 2006 are given in Annexure: 1 of Appendix – 8.3 of Volume-V.

Parameters Used in Power Potential Study

Full Reservoir Level: FRL of the Reservoir has been kept at 210.00 m.

Minimum Draw Down Level (MDDL): The MDDL level has been considered at Elevation 179.00 m. The MDDL shall be kept as to satisfy the submergence requirement of the proposed power intake of generating plant.

Tail Water Level: The off-take level of Feeder pipe line from Chikkar reservoir to Dabadar reservoir i.e. 172.00 m has been considered as Tail Water Level for power potential studies.

Water Conductor Losses: The power house has been proposed to be constructed at the toe of the dam hence, keeping in view the entire length of water conductor system, the water conductor losses have been considered as 0.20 m in the present study.

Design Net Head = Gross head – Water Conductor losses.

Efficiencies: The efficiencies applicable for most of the small hydro turbines and generator units, considered for the purpose of calculation of annual energy are given below:

Efficiency of Turbine	:	95%
Efficiency of Generator	:	98%
Overall efficiency of turbine- generator	:	93%

8.4.3.1.3 Reservoir Operation

Operation of the reservoir has been kept in such a way that maximum level shall be achieved during monsoon period and during non- monsoon season reservoir shall be depleted up to minimum reservoir level to the extent possible.

8.4.3.1.4 Simulation Studies

Simulation Studies have been done based on net yield series generated at Chikkar dam site for 32 year i.e. from the year 1975-76 to 2006-07.The parameters involved in the simulation studies include monthly inflows into the reservoir, various demands, evaporation losses and elevation-area- capacity relationship of the reservoir after 50 years of the sedimentation. The details of simulation study carried out for the assessment of power potential are at Appendix 8.3 (Power Potential study of Chikkar reservoir) in Volume – V.

8.4.3.1.5 Firm Power

The firm annual energy that could be generated at Chikkar Power plant in the 90% dependable year (2002-03) with an installed capacity of 2.0 MW is 8.35 MU.

8.4.3.1.6 Installed Capacity

One of the most commonly used criterion for optimization of the installed capacity is based on the analysis of incremental energy that is generated with a unit increase in the installed capacity. In the present optimization studies, energy generation has been analyzed with different installed capacities, ranging from 0.25 MW to 2.25 MW. The energy computations are done for 50% and 90% dependable years and for all the 32 years flow data available. The installed capacity is increased in steps of 0.25 MW. In each case, unrestricted energy and the firm energy have been computed, with and without spill. The results for 90% dependable year are summarized in Table 8.13.

Table 8.13

Incremental Energy Benefits in a 90% Dependable Year (2002-03)

S. No.	Installed Capacity	Annual Energy Gen.	95% Energy	Annual PLF	Incremental Power	Incremental Capacity	Variation in incremental Annual Energy
	MW	MU	MU	%	d(KWh)	d(kW)	d(kWh)/ d(kW)
1	0.250	1.284	1.220	55.699			
2	0.500	2.467	2.344	53.506	1123.777	250	4.495
3	0.750	3.571	3.392	51.634	1048.800	250	4.195
4	1.000	4.675	4.441	50.698	1048.800	250	4.195
5	1.250	5.779	5.490	50.137	1048.800	250	4.195
6	1.500	6.883	6.539	49.762	1048.800	250	4.195
7	1.750	7.847	7.454	48.627	915.691	250	3.663
8	2.000	8.266	7.853	44.821	398.085	250	1.592
9	2.250	8.266	7.853	39.840	0.000	250	0.000

The ratio of incremental energy to incremental installed capacity d (kWh)/ d(kW) for 90% dependable year is plotted against the installed capacity in Figure 8.3:

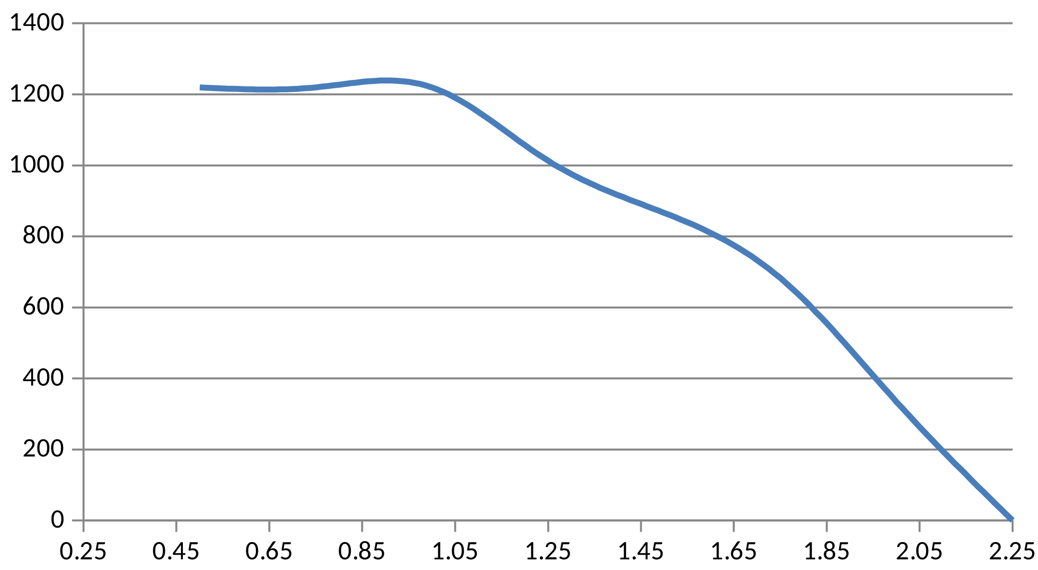

Fig 8.3: Incremental Power vs. Installed Capacity (90% Dependable year)

8.4.3.1.7 Scope for Seasonal/Secondary Power Generation

The power releases are dependent on requirement of inter-connecting canal between Chikkar and Dabdar reservoirs which in turn are dependent on Link canal monthly demands which are constant in each month. Therefore, there is no scope for secondary power generation.

8.4.3.1.8 Size and Type of Generating Units

The proposed 2 MW Chikkar Hydro-Electric Project would have a surface power station located on the right bank of Ambica River at toe of the Chikkar Dam. The installed capacity of 2 MW would be provided by 2 number Francis turbine driven generating units of 1 MW each. The units would operate under a gross head range of 38.00 m to 7.00 m. The rated net head has been worked out as 27.47 m.

8.4.3.1.9 Number of Generating Units

Keeping in view the power potentinal analysis for 50%, 90% dependable years and average annual energy from the year 2001-02 to 2006-07 and in order to maximum utilization of releases, a plant with 2 units of 1.0 MW each has been proposed.

8.4.3.2 Electrical and Mechanical Works

The proposed 2000 kW Chikkar Hydro-Electric Project would have a surface power station located on the right bank of the Ambica river at toe of the Chikkar Dam, proposed across river Ambica near village Chikkar in Dharampur taluka of Valsad district in Gujarat State. The installed capacity (2 MW) would be provided by 2 number Francis turbine driven generating units of 1 MW each. The units would operate under a gross head range of 38.00 m to 7.00 m. The rated net head has been worked out as 27.47 m. The step-up 3.3kV/33 kV three phase Transformers would be at the unloading bay level on the downstream side, the power house service bay also being at EL 171.90 m. From the transformers, power would be taken to the switchyard by short overhead lines. Power would be transmitted from switchyard by 33 kV outgoing transmission lines.

This project is being developed as storage type multipurpose scheme with a dam toe type power station. The gross head range would be about 38.00 m to 7.00 m. The average tail water level has been taken as 172 m. The selection criteria for electro-mechanical works including turbine, generator, transformer, controls and protections and all other associated works for the power plant including Power evacuation and its transmission to sub-station for Chikkar HEP are discussed below.

8.4.3.2.1 Turbine

i) Selection of Type of Turbine: As per the power potential studies, two turbines of 1000 kW Installed Capacity each have been proposed. The selection of type of turbine for a Hydro Power Project is a function of its specific speed. As per IS: 12800 (Part 3):1991, head variation has been considered from 125% to 65% and accordingly trial speed has been calculated. Based on the calculation, rotational speed has been taken as 600 rpm with Horizontal Francis Turbine. Details of design parameters for Chikkar Hydro Electric Project are given at Appendix – 8.9 of Volume-V of report.

For the given head condition, Francis turbines are recommended. Each turbine shall be capable of running at 110 % of rated capacity. Each turbine shall be horizontal shaft type suitable for coupling directly to horizontal shaft synchronous generator of 1000 kW plus 10% overload i.e., 1100 kW rating.

ii) Turbine Setting: Setting of Francis runner has been calculated to eliminate any chance of development of cavitations as per Thoma's criteria (ref: IS: 12800 (Part 3):1991).

iii) Runner Diameter: Runner dia D_3 computed as per IS: 12800 (Part 3):1991) is 807. The manufacturer has provided runner dia. as 800 mm. All other turbine and casing dimensions have been computed with respect to above value of D_3 as adopted by the manufacturer viz. 800 mm. The details are given at Appendix – 8.9 of Volume – V.

8.4.3.2.2 Francis Turbine and Associated Equipments

i) Type: The Turbine shall be of the Horizontal Shaft Francis suitable for coupling directly to horizontal shaft synchronous generator. The direction of rotation shall be anti-clock wise when viewed from coupling end. The turbine shall be capable of giving outputs higher than rated outputs to match the over load capability of generator.

ii) Spiral Casing: The Turbine shall be of spiral casing type so constructed as to allow all the removable parts to be dismantled conveniently. The design shall also permit removal of rotating parts without disturbing the guide apparatus. The design shall also permit horizontal/vertical movement of runner shaft by an amount sufficient for adjustment of bearing and for clearing the joint at the coupling between the turbine and the generator.

iii) Runner: The Runner shall be of 13/4 chromium-nickel steel. The runner shall be cast integrally of stainless steel. The runner will have adequate number of blades which shall be polished and ground smooth and shall be free from roughness, cracks, high spots etc. The finished machine and ground runner shall be dynamically balanced.

iv) Shaft and Coupling: The turbine shaft is not applicable, as Turbine Runner is proposed to be mounted on the extended shaft of Generator.

v) Turbine Guide and Thrust Bearings: The turbine will be provided with an oil-lubricated guide bearing with suitable Babbitt lining for the shaft. The bearing shall be designed for the turbine radial and axial loads. The bearing will be split to facilitate dismantling. Bearing shall be provided with suitable instrumentation for monitoring the temperature and oil level.

vi) Draft Tube Each turbine shall be provided with a draft tube liner/suction bend of welded construction of structural steel. The design of the draft tube shall be such as to ensure the best overall efficiency for the turbine and stable and pulsation –free operation of the machines.

vii) Wicket–Gate Mechanism with Gate Operating Mechanism:
The generator side and draft tube side head cover shall be of suitable construction of steel, to accommodate guide bearings, casings, labyrinth rings, shaft sealing, guide vane bearings etc. The head covers will be suitably designed to resist the superimposed hydraulic load, such that any consequential deflections / slopes of the head cover would not hamper the -functioning of the wicket-gate operating mechanism.

viii) Guide Vanes: Each guide vane and its stem will be an integral casting in Stainless steel. The contacting surface of gates and the gate stems will be smooth and finish machined. All guide vane bearings (Axial/radial) shall be maintenance free, with appropriate sealing against water flow channel by 'O' rings.

The angular movement of the gates will be so limited and the mechanism so designed that the bedding faces of the guide vanes close, with no gap, with the servomotor at its closed position.

ix) Levers/Links: The guide vane links/levers to be clamped to the guide vane stem and locked in position during assembly. A suitably designed frictional clutch mechanism to prevent possible damage to the wicket gates in case of trapped foreign bodies between the gates will be provided.

x) Gate Operating Ring: A suitably designed gate operating ring will be operated by a servo-motor. The operating ring will be provided with maintenance free bushes.

xi) Servomotor: Double Acting servomotors operated by governor oil pressure shall be mounted on the generator side head-cover. The servo-motor shall be supplied with a feedback transmitter. Servo-motor will be of sufficient capacity to operate the gates, when supplied with oil at minimum pressure.

8.4.3.2.3 Inlet Valves

Two Nos. Flat disc type butterfly valves, each of 950 mm dia and operated by hydraulic pressure are proposed to be provided upstream of each turbine inlet to isolate any one of the machines in case of emergency and to afford flexibility of operation of the power plant. The valve will be opened by using an oil servomotor and closed by counter weight under all operating conditions. The counter weight shall be provided as a fail-safe feature, so that it will have a closing bias in case of fault condition. The body shall be welded construction, with its operating feet to take all Horizontal loads at foundations. The body to house door trunions complete with self lubricated PTFE/chevron type bushes for bearings.

The disc shall be fabricated from steel plates. The valve disc will have a peripheral sealing ring of rubber. The disk shall be optimally designed to provide minimum resistance to flow. Oil operated servomotors shall be mounted on a mounting frame for opening under balanced conditions, so that separate foundations for oil servomotor are avoided.

The oil pressure system for operating the valve shall be common with the governor oil, pressure system. The bypass valve with hydraulically operated main valve shall be provided for opening the valve under balanced conditions.

An inlet pipe of suitable bore shall be flanged u/s of the valve, about 500mm long for welding to the penstock at site. A dismantling joint of telescopic type shall be located d/s of the valve.

8.4.3.2.4 Governing Equipment

The turbine shall be equipped with suitable electronic governor conforming to IEC No. 308/Hydro-Mechanical governor complete with all accessories. Standard protections like over speed device, brake control, emergency shut down and alarm etc., shall be provided in the governing system.

8.4.3.2.5 Pressure Oil System

Each unit will be provided Oil pressure units systems comprise a sump tank and a pressure tank separate for each generating unit. Two numbers of electrically operated governor oil pumps will be provided, one for normal running and the other acting as standby for each unit. Provision of emergency shutdown of the unit shall without any oil pump shall be made.

8.4.3.2.6 Generator

i) General: There are two types of generators namely:

1. Synchronous, and
2. Induction.

Induction generators are generally about 20% cheaper than the synchronous generators of same output. Whereas synchronous generators are self contained in developing its own excitation power, induction generators require an external source for providing it with the magnetization power. The induction generator uses excitation power supplied from an external source, which is normally the grid. However, in case of grid failure, black start of machines will be difficult. Since Chikkar HEP is not a very small project, dependability on grid could result in loss of power due to standstill generator. Hence it has been proposed to use synchronous generators.

ii) Speed Rise and Runaway Speed: Each generator shall be designed and constructed so as to be capable of running for a period of 15 minutes at a maximum runway speed. The runaway speed test shall be considered successful if after undergoing the test, 'no injury' is apparent. The runaway speed test may be carried out at a site and at works.

iii) Cooling System: Generator shall be of open type construction with IP: 23 /IC: 01 enclosure

iv) Stator: The stator frame shall be manufactured of cast iron/fabricated steel construction. The frame shall be designed to withstand the bending stresses and deflections due to its self weight and the weight of the core supported by it. The stator core shall be built up by segmental punching made of low loss silicon sheet steel non-oriented type and end plates. Each punching shall be properly debarred and applied with insulating varnish on both the sides.

The stator winding shall be star connected. The terminal leads of each phase are brought out to a separate terminal box. Six Nos. (Two resistance element per phase) embedded temperature detectors for each generator of resistance type shall be provided for stator winding located symmetrically. The connections on the resistor elements shall be well insulated and extended to a box on the outside of stator frame. The generator stator windings will be provided with epoxy insulation of class “F” type.

v) Rotor: The design and construction of the rotor shall as per latest practice and also in accordance with the best modern practice. The factor of safety at minimum runaway speed based on yield point of material shall not be less than 1.5.

Necessary flywheel effect shall be determined, in case required moment of inertia is not available from rotor, separate flywheel shall be provided to furnish additional flywheel effect. A mechanical over speed device with electrical contacts (two sets) one for alarm and other for trip shall be mounted on non-driving end of the generator and in case of shorting of diodes there shall be trip command.

vi) Shaft The generator shaft shall be made of the best quality carbon steel properly heat-treated. The shaft shall be of adequate size to operate at all speeds including maximum runway speed and shall be able to withstand short circuit stresses without excessive vibrations or distortion. The shaft shall be accurately machined all over and polished where it passes through the bearings and accessible points for alignment check.

vii) Bearings: The generator bearings shall be Antifriction ball / roller type / Tilting Pad. One No. of bearing shall be mounted on DE and NDE. These bearing shall be guaranteed for minimum continuous working for 100,000 (one hundred thousand) hours and shall be of proven design and performance and have minimum maintenance.

Bearings shall be adequately insulated to prevent any harmful circulating currents. The bearings shall be designed to withstand operation of runaway speed for a period of 15 minutes.

Dial type thermometer with two NO contacts shall be provided one Number on each DE and NDE bearings. At each bearing one no. duplex RTD shall be provided for indication/recording and alarm as well as for tripping the unit in case of high temperature.

The guaranteed operating temperature of the bearing at rated output and overload condition shall be indicated. However the bearing temperature for "alarm" and "unit trip" shall not be higher than 75^{0} C and 80^{0} C respectively.

viii) Heaters: The heater suitable for 240 volts, single-phase AC supply shall be provided.

ix) Brakes For stopping the generating units quickly, each generator shall be provided with pneumatically operated brakes, which will be operated automatically or manually. The generator brake would consist of a suitable number of brake shoes, which will operate against a polished segmental steel brake track bolted to rotor or to any other component such as fly wheel, if any.

x) Terminal Box: Separate terminal boxes shall be provided for the following:

- Phase terminals of the generator.
- Neutral terminals of the generator.
- Space heater.
- Temperature detectors.

The phase and neutral terminal boxes shall be of phase segregated type.

Terminal boxes shall be of weatherproof construction to eliminate entry of dust, vermin and water with a degree of protection IP: 54.

8.4.3.2.7 Electrical Control And Protection Equipments

a) General

Digital Electronic governor with Oil Pressure Unit (OPU) is proposed to be housed in one of the corners of the powerhouse. This system will serve the following four purposes:

- Indication
- Metering
- Protection
- Control
-

All the indications such as butterfly valve on/off status, breaker on / off status etc. will be indicated on the unit control board incorporated in the Electronic Governor. 110 Volt D.C. lamps of different colour codes will be used for this purpose.

b) Metering

All the necessary parameters like voltage, frequency, power factor, current, power, energy, unit hour running etc. will be measured through suitably scaled meters mounted on the unit control board of the Governor.

c) Controls

All Controls like control for closing the butterfly valves and motor operated circuit breakers for load switching will be incorporated in the Digital Electronic Governor. Thus, the electronic unit control shall have a complete and coordinated set of instruments, controls and safety devices for indication, metering and protection related to all conditions of running of the plant including activating / de-activating various protection devices during emergency operating conditions for the plant.

d) D.C. System

Float cum boost charger 110 Volt, 150 AH capacity and tubular batteries will be provided for feeding power to indication lamps, protection relay coils, and initial impulse to the self excitation system by means of field flashing and to operate few emergency lights.

Central Board of Irrigation and Power (CBIP) Technical report no. 79 (Manual on Sub-Station, Chapter 1 on substation battery charging equipment and D.C. switch gear) will be followed for detailed designing.

e) Fire Protection

Latest techniques available for control of fire using fire-fighting equipments, smoke detectors etc. will be used. Automatic system with manual override is recommended.

8.4.3.2.8 Material Handling in the Power House

It is proposed to provide a girder type electric operated crane with a capacity of 10T. The hoisting operation shall be done by electric motor operated hoist, which can be operated from the generator floor level. The EOT crane would facilitate a small group of erection and maintenance personnel to handle both erection and maintenance activities.

8.4.3.2.9 Auxiliary Power Supply

Three Phase, 33 kV / 415 V Star / Delta 150 kVA capacity step-down transformer will be used for feeding the station lighting and heating load for power house, illumination for approach road and switch yard. Emergency lights on important places will be operated by D.C. battery provided in the powerhouse. 150 kVA diesel generator set will also be provided for illumination in powerhouse, staff colony, streetlights and switchyard during shut down of machines.

8.4.3.2.10 Cables and Boxes

Heat shrink type cable and boxes shall be provided for HT cable connecting generator to control panel, neutral grounding and relays.

8.4.3.2.11 Station Drainage System

Adequate provision will be made for collection of any leakage water around the turbine and its delivery to a lowest point of the station drain. A drain connector at lowest point of scroll case for drawing into the draft tube will be provided.

8.4.3.2.12 Ventilation System

It is proposed to install six (06) nos. of exhaust fans of 300 mm size, 1000 RPM mounted at a suitable elevation facing towards the tail race.

8.4.3.2.13 Draft Tube Gate

Two Slide type gates have been envisaged at the draft tube structure on the tailrace side. The clear opening is 3.4 m wide x 2.34 m high. The gates shall be designed for a head corresponding to average tail water level of 171.50 m (sill EL 164.28 m).

The gate shall be lifted under balanced head conditions created by filling valve. The gate shall be operated by means of independent rope drum hoist of 15t capacity (Tentative) mounted on trestle at deck level of EL 171.80 m.

8.4.3.2.14 Tailrace Channel

The tail race channel will connect the draft tubes of the power house with the Feeder pipe line Inter-connecting Chikkar and Dabdar reservoirs.

8.4.3.2.15 Switchyard

A comparatively flat terrace exists near powerhouse at EL + 176.00 m where the switchyard has been proposed with 33 kV Outdoor Switchyard Equipments comprising of Vacuum Circuit Breakers, CT's, PT's, LA's, Isolators, Jumpers, and Structure etc. In this location one no. three phase power transformer will be kept on plinth. Earth mat will be laid underground. Proper fuse sets, switches etc. will be mounted on M.S. poles. The total area will be strongly fenced as per Indian electrical safety rules. High voltage cable will be laid underground in cable trenches. The power cable will connect low voltage side of the step-up transformer.

8.4.3.2.16 Grounding Systems

a) General

The following equipments / systems are required to be earthed:

- Neutral points of different voltages

- Equipment frame work and other metallic parts
- Boundary fence, steel structures etc.
- Lightning arrestor

b) Design

The grounding system shall conform to IS 3043-1987 or latest edition and Indian Electricity Rules 1956 along with latest amendments. Power house and switch yard areas shall be protected against electric shocks by providing electrodes and earthing mat for the power house and switchyard areas as per computed/measured electrical resistivity values. Earthing electrodes shall be uniformly distributed and located adjacent to fencing of switchyard and powerhouse.

8.4.3.2.17 Transmission and Distribution Works

a) General

Chikkar Hydro Power Project is proposed to be a grid-connected scheme. However, it is proposed to evacuate the power to the existing 66 kV sub-station of SEB located in -Waghai town. The distance of sub-station from Chikkar switchyard is approximately 7.00 km.

b) Power Evacuation

It is proposed that the electricity shall be generated at 3.3 kV level and evacuated at 33 kV level.

One number Step-up transformer, of 2850 kVA rating and 3.3 kV / 33 kV voltage level for these machines shall be provided at switchyard near the powerhouse. The electricity at 33 kV voltage level will be transmitted to the 66 kV SEB sub-station. Appropriate arrangements for protection of the transmission line shall be made.

c) Step-up Transformers for the Switchyard

As mentioned earlier, single transformer is proposed to be provided in the switchyard adjacent to the powerhouse. These transformers shall be of 2850 kVA rating, outdoor type, oil filled, 50 Hz, 3 Phase, vector group Y n d 11, natural air cooled. The windings shall be of copper. The connections at HV winding side shall be star and LV winding side shall be delta. Off-load taps on HV side shall be (+) 2.5% to (-) 7.5% in steps of 2.5%. The LV side shall be suitable for cable box whereas HV side shall be suitable for the selected conductor.

The temperature rise on any part of the transformer shall not exceed 40^0 C by oil thermometer and 60^0 C in winding by resistance methods (RTDs) under full load conditions. The cover of the tank of the transformer shall be bolted to the tank for easy maintenance. C.B.I.P. manual and IS code 2026 – 1977 will be followed for detailed design of transformers.

d) Transmission Lines

Chikkar Dam is located in Gujarat State and it is proposed to evacuate the power from this HEP to nearby substation in Gujarat State. The nearest Substation with a capacity of 66 kV is situated at Waghai town of Dang District of Gujarat State. Total length of the transmission line from switchyard to GETCO's 66kV substation is assessed to be app. 7.0 Km. Necessary arrangement with 33/66kV step up transformer, LA, PT's, CT's and Breaker with control panels and metering panels shall be made at Sub-Station end for 33 kV incomer line.

8.4.3.2.18 Drawings

The general arrangement drawing with Plan view, Section view and L-Section of Powerhouse has been prepared and appended in Appendix-8.9 in Volume-V.

8.4.3.2.19 Cost Estimate (S-Power Plant)

The cost of Electro-Mechanical Works has been computed by utilizing the quotations obtained from leading E and M equipment manufacturers from the reputed equipment manufacturers, the price quoted by one of the reputed manufacturer was found to be most realistic and hence the same has been adopted in formulating the cost estimate for EandM works.

The cost of the Transmission line from Powerhouse to SEB has been computed based on the prevailing rates of the State's power transmission organizations.

Total cost of S-Power Plant which includes prices for Manufacture, Supply, and Transportation up to Project Site of EandM Equipments, Erection and Commissioning of EandM Equipments and Transmission cost up to 66 kV SEB situated at Waghai town of Dang District are Rs 9.85 Crores.

Schedule of requirements for supply of Electro-mechanical equipments has been appended as Annexure-I to III in Appendix-8.9 of Volume-V.

Details of cost estimate have been annexed as Annexure-IV in Appendix-8.9 of Volume- V.

8.4.4 Dabdar Dam Power House

8.4.4.1 Power Potential Study

8.4.4.1.1 Type of Project

The Dabdar reservoir is planned as storage type multipurpose project. The Storage Capacity of the reservoir is proposed for diversion of water for link canal scheme and committed downstream release for environmental requirements including fulfilling the Domestic, Industrial and irrigation requirements of local people. The inflows from Chikkar reservoir and link demands to be met from Dabdar reservoir are to be released through Power house. The present power potential study is carried out keeping the following factors into consideration.

8.4.4.1.2 Hydrology, Sedimentation Studies and Criteria for Fixing up Reservoir Levels

Water Availability

The water availability studies of Par, Auranga, Ambica and Purna river basins and at Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan dam sites have been carried out by the Hydrological Studies Organisation, CWC, New Delhi as a part of "Hydrological Studies of Par-Tapi-Narmada Link Project". The monsoon monthly net yields and non-monsoon net yield series have been developed by CWC for the period from 1975 to 2006 at Dabdar dam site using rainfall runoff models developed at

Kudkas GandD site on Khapri River (tributary of Ambica River). The non-monsoon yield is distributed in to non-monsoon monthly yields in the proportion of the observed flow at the GandD site. This net yield is considered for power potential studies. The planned utilizations under Dabdar reservoir considered for the studies are: i) Local domestic and industrial water demand, ii) Environmental and ecological requirements downstream of proposed dam site, iii) en-route irrigation requirement of Dabdar Feeder pipe line and iv) releases into Dabdar Feeder pipe line , after power generation, for further transfer to Par-Tapi-Narmada Link Canal. The details of monthly inflows in to Dabdar reservoir for the period from 1975 to 2006 are given in Annexure: 1 of Appendix – 8.4 of Volume-V.

Parameters Used in Power Potential Study

Full Reservoir Level: FRL of the Reservoir has been kept at 169.00 m.

Minimum Draw Down Level (MDDL): The MDDL level has been considered at Elevation 139.00 m. The MDDL shall be kept as to satisfy the submergence requirement of the proposed power intake of generating plant.

Tail Water Level: The off-take level of Feeder pipe line from Dabdar reservoir i.e. 136.96 m has been considered as Tail Water Level for power potential studies.

Water Conductor Losses: The power house has been proposed to be constructed at the toe of the dam hence, keeping in view the entire length of water conductor system, the water conductor losses have been considered as 0.20 m in the present study.

Design Net Head = Gross head – Water Conductor losses.

Efficiencies: The efficiencies applicable for most of the small hydro turbines and generator units, considered for the purpose of calculation of annual energy are given below:

Efficiency of Turbine	:	95%
Efficiency of Generator	:	98%
Overall efficiency of turbine- generator	:	93%

8.4.4.1.3 Reservoir Operation

Operation of the reservoir has been kept in such a way that maximum level shall be achieved during monsoon period and during non- monsoon season reservoir shall be depleted up to minimum reservoir level to the extent possible.

8.4.4.1.4 Simulation Studies

Simulation Studies have been done based on net yield series generated at Dabdar dam site for 32 year i.e. from the year 1975-76 to 2006-07.The parameters involved in the simulation studies include monthly inflows into the reservoir, various demands, evaporation losses and elevation-area- capacity relationship of the reservoir after 50 years of the sedimentation. The details of simulation study carried out for the assessment of power potential are at Appendix 8.4 (Power Potential study of Dabdar reservoir) in Volume – V.

8.4.4.1.5 Firm Power

The firm annual energy that could be generated at Dabdar Power plant in the 90% dependable year (1989-90) with an installed capacity of 3.2 MW is 16.60 MU.

8.4.4.1.6 Installed Capacity

One of the most commonly used criterion for optimization of the installed capacity is based on the analysis of incremental energy that is generated with a unit increase in the installed capacity. In the present optimization studies, energy generation has been analyzed with different installed capacities, ranging from 0.25 MW to 4.50 MW. The energy computations are done for 50% and 90% dependable years and for all the 32 years flow data available. The installed capacity is increased in steps of 0.25 MW. In each case, unrestricted energy and the firm energy have been computed, with and without spill. The results for 90% dependable year are summarized in Table 8.14:

Table 8.14
Incremental Energy Benefits in a 90% Dependable Year (1989-90)

Sl. No.	Installed Capacity	Annual Energy Gen.	95% Energy	Annual PLF	Incremental Power	Incremental Capacity	Variation in incre. Annual Energy
	MW	MU	MU	%	d(KWh)	d(kW)	d(kWh)/ d(kW)
1	0.250	1.822	1.731	79.049			
2	0.500	3.096	2.941	67.153	1210	250.0	4.840
3	0.750	4.368	4.150	63.161	1208	250.0	4.834
4	1.000	5.577	5.298	60.482	1149	250.0	4.594
5	1.250	6.584	6.255	57.124	957	250.0	3.827
6	1.500	7.502	7.127	54.240	872	250.0	3.488
7	1.750	8.420	7.999	52.180	872	250.0	3.488
8	2.000	9.338	8.871	50.636	872	250.0	3.488
9	2.250	10.256	9.743	49.434	872	250.0	3.488
10	2.500	11.174	10.616	48.473	872	250.0	3.488
11	2.750	11.940	11.343	47.085	727	250.0	2.909
12	3.000	12.672	12.038	45.808	695	250.0	2.782
13	3.250	13.404	12.734	44.727	695	250.0	2.782
14	3.500	13.986	13.286	43.334	553	250.0	2.211
15	3.750	14.532	13.805	42.025	519	250.0	2.075
16	4.000	15.067	14.314	40.851	509	250.0	2.036
17	4.250	15.394	14.624	39.281	310	250.0	1.241
18	4.500	15.407	14.636	37.129	12	250.0	0.049

The ratio of incremental energy to incremental installed capacity (d(kWh)/ d(kW) for 90% dependable year is plotted against the installed capacity in Figure 8.4:

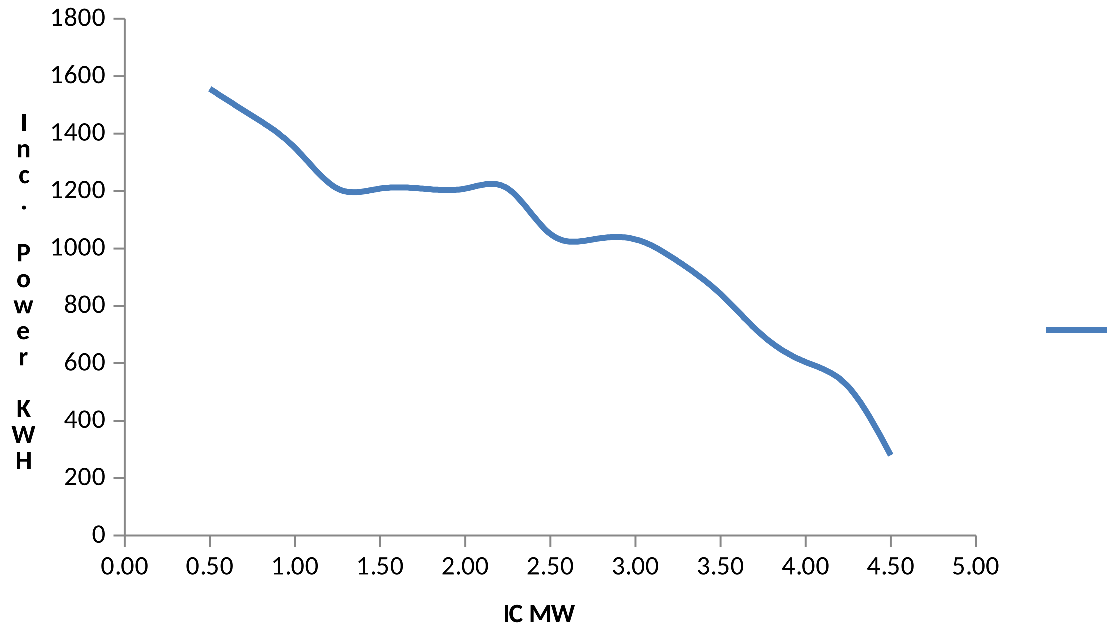

Fig 8.4: Incremental Power vs. Installed Capacity (90% Dependable year)

8.4.4.1.7 Scope for Seasonal/Secondary Power Generation

The power releases are dependent on Link canal monthly demands which are to be met from Dabdar reservoir through the Dabdar feeder pipe line which are constant in each month. Therefore, there is no scope for secondary power generation.

8.4.4.1.8 Size and Type of Generating Units

The proposed 3.2 MW Dabdar Hydro-Electric Project would have a surface power station located on the right bank of Khapri River at toe of the Dabdar Dam. The installed capacity of 3.2 MW would be provided by 2 number Francis turbine driven generating units of 1.6 MW each. The units would operate under a gross head range of 32.04.m to 10.00 m. The rated net head has been worked out as 24.49 m.

8.4.4.1.9 Number of Generating Units

Keeping in view the power potentinal analysis for 50%, 90% dependable years and average annual energy from the year 2001-02 to 2006-07 and in order to maximum utilization of releases, a plant with 2 units of 1.6 MW each has been proposed.

8.4.4.2 Electrical and Mechanical Works

The proposed 3200 kW Dabdar Hydro-Electric Project would have a surface power station located on the right bank of the Khapri river at toe of the Dabdar Dam, proposed across river Khapri near village Dabdar in Dharampur taluka of Valsad district in Gujarat State. The installed capacity (3.2 MW) would be provided by 2.0 number Francis turbine driven generating units of 1.6 MW each. The units would operate under a gross head range of 32.04 m to 10.00 m. The rated net head has been worked out as 24.49 m. The step-up 3.3kV/33 kV three phase Transformers would be at the unloading bay level on the downstream side, the power house service bay also being at EL 139.80 m. From the transformers, power would be taken to the switchyard by short overhead lines. Power would be transmitted from switchyard by 33 kV outgoing transmission lines.

This project is being developed as storage type multipurpose scheme with a dam toe type power station. The gross head range would be about 32.04 m to 10.00 m. The average tail water level has been taken as 136.96 m. The selection criteria for electro-mechanical works including turbine, generator, transformer, controls and protections and all other associated works for the power plant including Power evacuation and its transmission to sub-station for Dabdar HEP are discussed below.

8.4.4.2.1 Turbine

i) Selection of Type of Turbine: As per the power potential studies, two turbines of 1600 kW Installed Capacity each have been proposed. The selection of type of turbine for a Hydro Power Project is a function of its specific speed. As per IS: 12800 (Part 3):1991, head variation has been considered from 125% to 65% and accordingly trial speed has been calculated. Based on the calculation, rotational speed has been taken as 375 rpm with Horizontal Francis Turbine. Details of design parameters for Dabdar Hydro Electric Project are given at Appendix – 8.10 of Volume-V of report.

For the given head condition, Francis turbines are recommended. Each turbine shall be capable of running at 120 % of rated capacity. Each turbine shall be horizontal shaft type suitable for coupling directly to horizontal shaft synchronous generator of 1600 kW plus 20% overload i.e., 1920 kW rating.

ii) Turbine Setting: Setting of Francis runner has been calculated to eliminate any chance of development of cavitations as per Thoma's criteria (ref: IS: 12800 (Part 3):1991).

iii) Runner Diameter: Runner dia D_3 computed as per IS: 12800 (Part 3):1991 is 1180. The manufacturer has provided runner dia. as 1200 mm. All other turbine and casing dimensions have been computed with respect to above value of D_3 as adopted by the manufacturer viz. 1200 mm.

8.4.4.2.2 Francis Turbine and Associated Equipments

i) Type: The Turbine shall be of the Horizontal Shaft Francis suitable for coupling directly to horizontal shaft synchronous generator. The direction of rotation shall be anti-clock wise when viewed from coupling end. The turbine shall be capable of giving outputs higher than rated outputs to match the over load capability of generator.

ii) Spiral Casing: The Turbine shall be of spiral casing type so constructed as to allow all the removable parts to be dismantled conveniently. The design shall also permit removal of rotating parts without disturbing the guide apparatus. The design shall also permit horizontal/vertical movement of runner shaft by an amount sufficient for adjustment of bearing and for clearing the joint at the coupling between the turbine and the generator.

iii) Runner: The Runner shall be of 13/4 chromium-nickel steel. The runner shall be cast integrally of stainless steel. The runner will have adequate number of blades which shall be polished and ground smooth and shall be free from roughness, cracks, high spots etc. The finished machine and ground runner shall be dynamically balanced.

iv) Shaft and Coupling (If required): The turbine shaft is not applicable, as Turbine Runner is proposed to be mounted on the extended shaft of Generator.

v) Turbine Guide and Thrust Bearings: The turbine will be provided with an oil-lubricated guide bearing with suitable Babbitt lining for the shaft. The bearing shall be designed for the turbine radial and axial loads. The bearing will be split to facilitate dismantling. Bearing shall be provided with suitable instrumentation for monitoring the temperature and oil level.

vi) Draft Tube Each turbine shall be provided with a draft tube liner/suction bend of welded construction of structural steel. The design of the draft tube shall be such as to ensure the best overall efficiency for the turbine and stable and pulsation –free operation of the machines.

vii) Wicket–Gate Mechanism with Gate Operating Mechanism:
The generator side and draft tube side head cover shall be of suitable construction of steel, to accommodate guide bearings, casings, labyrinth rings, shaft sealing, guide vane bearings etc. The head covers will be suitably designed to resist the superimposed hydraulic load, such that any consequential deflections / slopes of the head cover would not hamper the -functioning of the wicket-gate operating mechanism.
Guide Vanes: Each guide vane and its stem will be an integral casting in Stainless steel. The contacting surface of gates and the gate stems will be smooth and finish machined. All guide vane bearings (Axial/radial) shall be maintenance free, with appropriate sealing against water flow channel by ‘O’ rings.

The angular movement of the gates will be so limited and the mechanism so designed that the bedding faces of the guide vanes close, with no gap, with the servomotor at its closed position.
Levers/Links: The guide vane links/levers to be clamped to the guide vane stem and locked in position during assembly. A suitably designed frictional clutch mechanism to prevent possible damage to the wicket gates in case of trapped foreign bodies between the gates will be provided.

Gate Operating Ring: A suitably designed gate operating ring will be operated by a servo-motor. The operating ring will be provided with maintenance free bushes.
Servomotor: Double Acting servomotors operated by governor oil pressure shall be mounted on the generator side head-cover. The servo-motor shall be supplied with a feedback transmitter. Servo-motor will be of sufficient capacity to operate the gates, when supplied with oil at minimum pressure.

8.4.4.2.3 Inlet Valves

Two Nos. Flat disc type butterfly valves, each of 1400 mm dia and operated by hydraulic pressure are proposed to be provided upstream of each turbine inlet to isolate any one of the machines in case of emergency and to afford flexibility of operation of the power plant. The valve will be opened by using an oil servomotor and closed by counter weight under all operating conditions. The counter weight shall be provided as a fail-safe feature, so that it will have a closing bias in case of fault condition. The body shall be welded construction, with its operating feet to take all Horizontal loads at foundations. The body to house door trunions complete with self lubricated PTFE/chevron type bushes for bearings.

The disc shall be fabricated from steel plates. The valve disc will have a peripheral sealing ring of rubber. The disk shall be optimally designed to provide minimum resistance to flow. Oil operated servomotors shall be mounted on a mounting frame for opening under balanced conditions, so that separate foundations for oil servomotor are avoided. The oil pressure system for operating the valve shall be common with the governor oil, pressure system. The bypass valve with hydraulically operated main valve shall be provided for opening the valve under balanced conditions.

An inlet pipe of suitable bore shall be flanged u/s of the valve, about 500mm long for welding to the penstock at site. A dismantling joint of telescopic type shall be located d/s of the valve.

8.4.4.2.4 Governing Equipment

The turbine shall be equipped with suitable electronic governor conforming to IEC No. 308/Hydro-Mechanical governor complete with all accessories. Standard protections like over speed device, brake control, emergency shut down and alarm etc., shall be provided in the governing system.

8.4.4.2.5 Pressure Oil System

Each unit will be provided Oil pressure units systems comprise a sump tank and a pressure tank separate for each generating unit. Two numbers of electrically operated governor oil pumps will be provided, one for normal running and the other acting as standby for each unit. Provision of emergency shutdown of the unit without any oil pump shall be made.

8.4.4.2.6 Generator

i) General: There are two types of generators namely:

1. Synchronous, and
2. Induction.

Induction generators are generally about 20% cheaper than the synchronous generators of same output. Whereas synchronous generators are self contained in developing its own excitation power, induction generators require an external source for providing it with the magnetization power. The induction generator uses excitation power supplied from an external source, which is normally the grid. However, in case of grid failure, black start of machines will be difficult. Since Paikhed Small HEP is not a very small project, dependability on grid could result in loss of power due to standstill generator. Hence it has been proposed to use synchronous generators.

ii) Speed Rise and Runaway Speed: Each generator shall be designed and constructed so as to be capable of running for a period of 15 minutes at a maximum runway speed. The runaway speed test shall be considered successful if after undergoing the test, 'no injury' is apparent. The runaway speed test may be carried out at a site and at works.

iii) Cooling System: Generator shall be of open type construction with IP: 23 /IC: 01 enclosure

iv) Stator: The stator frame shall be manufactured of cast iron/fabricated steel construction. The frame shall be designed to withstand the bending stresses and deflections due to its self weight and the weight of the core supported by it.

The stator core shall be built up by segmental punching made of low loss silicon sheet steel non-oriented type and end plates. Each punching shall be properly debarred and applied with insulating varnish on both the sides.

The stator winding shall be star connected. The terminal leads of each phase are brought out to a separate terminal box. Six Nos. (Two resistance element per phase) embedded temperature detectors for each generator of resistance type shall be provided for stator winding located symmetrically. The connections on the resistor elements shall be well insulated and extended to a box on the outside of stator frame. The generator stator windings will be provided with epoxy insulation of class "F" type.

v) Rotor: The design and construction of the rotor shall as per latest practice and also in accordance with the best modern practice. The factor of safety at minimum runaway speed based on yield point of material shall not be less than 1.5.

Necessary flywheel effect shall be determined, in case required moment of inertia is not available from rotor, separate flywheel shall be provided to furnish additional flywheel effect. A mechanical over speed device with electrical contacts (two sets) one for alarm and other for trip shall be mounted on non-driving end of the generator and in case of shorting of diodes there shall be trip command.

vi) Shaft The generator shaft shall be made of the best quality carbon steel properly heat-treated. The shaft shall be of adequate size to operate at all speeds including maximum runway speed and shall be able to withstand short circuit stresses without excessive vibrations or distortion.
The shaft shall be accurately machined all over and polished where it passes through the bearings and accessible points for alignment check.

vii) Bearings: The generator bearings shall be Antifriction ball / roller type / Tilting Pad. One No. of bearing shall be mounted on DE and NDE. These bearing shall be guaranteed for minimum continuous working for 100,000 (one hundred thousand) hours and shall be of proven design and performance and have minimum maintenance.

Bearings shall be adequately insulated to prevent any harmful circulating currents. The bearings shall be designed to withstand operation of runaway speed for a period of 15 minutes.

Dial type thermometer with two NO contacts shall be provided one Number on each DE and NDE bearings. At each bearing one no. duplex RTD shall be provided for indication/recording and alarm as well as for tripping the unit in case of high temperature.

The guaranteed operating temperature of the bearing at rated output and overload condition shall be indicated. However the bearing temperature for "alarm" and "unit trip" shall not be higher than 75^{0} C and 80^{0} C respectively.

viii) Heaters: The heater suitable for 240 volts, single-phase AC supply shall be provided

ix) Brakes For stopping the generating units quickly, each generator shall be provided with pneumatically operated brakes, which will be operated automatically or manually. The generator brake would consist of a suitable number of brake shoes, which will operate against a polished segmental steel brake track bolted to rotor or to any other component such as fly wheel, if any.

x) Terminal Box: Separate terminal boxes shall be provided for the following:

- Phase terminals of the generator.
- Neutral terminals of the generator.
- Space heater.
- Temperature detectors.

The phase and neutral terminal boxes shall be of phase segregated type. Terminal boxes shall be of weatherproof construction to eliminate entry of dust, vermin and water with a degree of protection IP: 54.

8.4.4.2.7 Electrical Control and Protection Equipments

i) General

Digital Electronic governor with Oil Pressure Unit (OPU) is proposed to be housed in one of the corners of the powerhouse. This system will serve the following four purposes:

- Indication
- Metering
- Protection
- Control

All the indications such as butterfly valve on/off status, breaker on / off status etc. will be indicated on the unit control board incorporated in the Electronic Governor. 110 Volt D.C. lamps of different colour codes will be used for this purpose.

ii) Metering

All the necessary parameters like voltage, frequency, power factor, current, power, energy, unit hour running etc. will be measured through suitably scaled meters mounted on the unit control board of the Governor.

iii) Controls

All Controls like control for closing the butterfly valves and motor operated circuit breakers for load switching will be incorporated in the Digital Electronic Governor. Thus, the electronic unit control shall have a complete and coordinated set of instruments, controls and safety devices for indication, metering and protection related to all conditions of running of the plant including activating / de-activating various protection devices during emergency operating conditions for the plant.

8.4.4.2.8 D.C. System

Float cum boost charger 110 Volt, 150 AH capacity and tubular batteries will be provided for feeding power to indication lamps, protection relay coils, and initial impulse to the self excitation system by means of field flashing and to operate few emergency lights.

Central Board of Irrigation and Power (CBIP) Technical report no. 79 (Manual on Sub-Station, Chapter 1 on substation battery charging equipment and D.C. switch gear) will be followed for detailed designing.

8.4.4.2.9 Fire Protection

Latest techniques available for control of fire using fire-fighting equipments, smoke detectors etc. will be used. Automatic system with manual override is recommended.

8.4.4.2.10 Material Handling in the Power House

It is proposed to provide a girder type electric operated crane with a capacity of 10T. The hoisting operation shall be done by electric motor operated hoist, which can be operated from the generator floor level. The EOT crane would facilitate a small group of erection and maintenance personnel to handle both erection and maintenance activities.

8.4.4.2.11 Auxiliary Power Supply

Three Phase, 33 kV / 415 V Star / Delta 150 kVA capacity step-down transformer will be used for feeding the station lighting and heating load for power house, illumination for approach road and switch yard.

Emergency lights on important places will be operated by D.C. battery provided in the powerhouse. 150 kVA diesel generator set will also be provided for illumination in powerhouse, staff colony, streetlights and switchyard during shut down of machines.

8.4.4.2.12 Cables and Boxes

Heat shrink type cable and boxes shall be provided for HT cable connecting generator to control panel, neutral grounding and relays.

8.4.4.2.13 Station Drainage System

Adequate provision will be made for collection of any leakage water around the turbine and its delivery to a lowest point of the station drain. A drain connector at lowest point of scroll case for drawing into the draft tube will be provided.

8.4.4.2.14 Ventilation System

It is proposed to install six (06) nos. of exhaust fans of 300 mm size, 1000 RPM mounted at a suitable elevation facing towards the tail race.

8.4.4.2.15 Draft Tube Gate

Two nos. Slide type gates have been envisaged at the draft tube structure on the tailrace side. The clear opening is 5.10 m wide x 2.34 m high. The gates shall be designed for a head corresponding to average tail water level of EL 136.96 m (sill EL 132.19 m).

The gate shall be lifted under balanced head conditions created by filling valve. The gate shall be operated by means of independent rope drum hoist of 15t capacity (Tentative) mounted on trestle at deck level of EL 139.80 m.

8.4.4.2.16 Tailrace Channel

The tail race channel will connect the draft tubes of the power house with the Dabdar feeder pipe line.

8.4.4.2.17 Switchyard

A comparatively flat terrace exists near powerhouse at EL + 138.00 m where the switchyard has been proposed with 33 kV Outdoor Switchyard Equipments comprising of Vacuum Circuit Breakers, CT's, PT's, LA's, Isolators, Jumpers, and Structure etc. In this location one no. three phase power transformer will be kept on plinth. Earth mat will be laid underground. Proper fuse sets, switches etc. will be mounted on M.S. poles. The total area will be strongly fenced as per Indian electrical safety rules. High voltage cable will be laid underground in cable trenches. The power cable will connect low voltage side of the step-up transformer.

8.4.4.2.18 Grounding Systems

i) General

The following equipments / systems are required to be earthed:

- Neutral points of different voltages
- Equipment frame work and other metallic parts
- Boundary fence, steel structures etc.
- Lightning arrestor

ii) Design

The grounding system shall conform to IS 3043-1987 or latest edition and Indian Electricity Rules 1956 along with latest amendments. Power house and switch yard areas shall be protected against electric shocks by providing electrodes and earthing mat for the power house and switchyard areas as per computed/measured electrical resistivity values. Earthing electrodes shall be uniformly distributed and located adjacent to fencing of switchyard and powerhouse.

8.4.4.2.19 Transmission And Distribution Works

a) General

Dabdar Hydro Electric Power Project is proposed to be a grid-connected scheme. However, it is proposed to evacuate the power to the existing 66 kV sub-station of SEB located in Waghai town. The distance of sub-station from Dabdar Small switchyard is approximately 6.0 km.

b) Power Evacuation

It is proposed that the electricity shall be generated at 3.3 kV level and evacuated at 33 kV level.

Two numbers Step-up transformer, of 4075 kVA rating and 3.3 kV / 33 kV voltage level for these machines shall be provided at switchyard near the powerhouse. The electricity at 33 kV voltage level will be transmitted to the 66 kV SEB sub-station. Appropriate arrangements for protection of the transmission line shall be made.

c) Step-up Transformers for the Switchyard

As mentioned earlier, two transformers are proposed to be provided in the switchyard adjacent to the powerhouse. These transformers shall be of 4075 kVA rating, outdoor type, oil filled, 50 Hz, 3 Phase, vector group Y n d 11, natural air cooled. The windings shall be of copper. The connections at HV winding side shall be star and LV winding side shall be delta. Off-load taps on HV side shall be (+) 2.5% to (-) 7.5% in steps of 2.5%. The LV side shall be suitable for cable box whereas HV side shall be suitable for the selected conductor.

The temperature rise on any part of the transformer shall not exceed 40^0 C by oil thermometer and 60^0 C in winding by resistance methods (RTDs) under full load conditions. The cover of the tank of the transformer shall be bolted to the tank for easy maintenance. C.B.I.P. manual and IS code 2026 – 1977 will be followed for detailed design of transformers.

d) Transmission Lines

Dabdar Dam is located in Gujarat State and it is proposed to evacuate the power from this SHP to nearby substation in Gujarat State. The nearest Substation with a capacity of 66 kV is situated at Waghai town of Dang District of Gujarat State. Total length of the transmission line from switchyard to GETCO's 66kV substation is assessed to be approx. 6 Km. Necessary arrangement with 33/66kV step up transformer, LA, PT's, CT's and Breaker with control panels and metering panels shall be made at Sub-Station end for 33 kV incomer line.

8.4.4.2.20 Drawings

The general arrangement drawing with Plan view and Section view of Powerhouse has been prepared and appended in Appendix-8.10 in Volume-V.

8.4.4.2.21 Cost Estimate (S-Power Plant)

The cost of Electro-Mechanical Works has been computed by utilizing the quotations obtained from leading E and M equipment manufacturers. of the various Quotations obtained from the reputed equipment manufacturers, the price quoted by one of the reputed manufacturer was found to be most realistic and hence the same has been adopted in formulating the cost estimate for EandM works. The cost of the Transmission line from Powerhouse to SEB sub -station has been computed based on the prevailing rates of the State's power transmission organizations.

Total cost of S-Power Plant which includes prices for Manufacture, Supply, and Transportation up to Project Site of EandM Equipments, Erection and Commissioning of EandM Equipments and Transmission cost up to 66 kV SEB situated at Waghai town of Dang District is Rs 13.89 Crores.

Schedule of requirements for supply of Electro-mechanical equipments has been appended as Annexure-I to III in Appendix-8.10 of Volume-V.

Details of Cost estimate have been annexed as Annexure-IV in Appendix-8.10 of Volume-V.

8.4.5 Kelwan Dam Power House

8.4.5.1 Power Potential Study

8.4.5.1.1 Type of Project

The Kelwan reservoir is planned as storage type multipurpose project. The Storage Capacity of the reservoir is proposed for diversion of water for link canal scheme and committed downstream release for environmental requirements including fulfilling the Domestic, Industrial and irrigation requirements of local people. The monthly demands of Kelwan feeder pipe line are considered to be released through the Power house. The present power potential study is carried out keeping the following factors into consideration.

8.4.5.1.2 Hydrology, Sedimentation Studies and Criteria for Fixing up Reservoir Levels

Water Availability

The water availability studies of Par, Auranga, Ambica and Purna river basins and at Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan dam sites have been carried out by the Hydrological Studies Organisation, CWC, New Delhi as a part of "Hydrological Studies of Par-Tapi-Narmada Link Project". The monsoon monthly net yields and non-monsoon net yield series have been developed by CWC for the period from 1975 to 2006 at Kelwan dam site using rainfall runoff models developed at Kalibel GandD site maintained by Government of Gujarat just upstream of the Kelwan dam site on Purna River. The non-monsoon yield is distributed in to non-monsoon monthly yields in the proportion of the observed flow at the GandD site. This net yield is considered for power potential studies. The planned utilizations under Kelwan reservoir considered for the studies are: i) Local domestic and industrial water demand, ii) Environmental and ecological requirements downstream of proposed dam site, and iii) en-route irrigation requirement of Kelwan Feeder pipe line and requirement of Par-Tapi-Narmada Link Canal to be met from Kelwan reservoir. The details of monthly inflows in to Kelwan reservoir for the period from 1975 to 2006 are given in Annexure: 1 of Appendix – 8.5 of Volume-V.

Parameters Used in Power Potential Study

Full Reservoir Level: FRL of the Reservoir has been kept at 164.00 m.

Minimum Draw Down Level (MDDL): The MDDL level has been considered at Elevation 136.00 m. The MDDL shall be kept as to satisfy the submergence requirement of the proposed power intake of generating plant.

Tail Water Level: The off-take level of Feeder pipe line from Kelwan reservoir i.e. 135.46 m has been considered as Tail Water Level for power potential studies.

Water Conductor Losses: The power house has been proposed to be constructed at the toe of the dam hence, keeping in view the entire length of water conductor system, the water conductor losses have been considered as 0.20 m in the present study.

Design Net Head = Gross head – Water Conductor losses.

Efficiencies: The efficiencies applicable for most of the small hydro turbines and generator units, considered for the purpose of calculation of annual energy are given below:

Efficiency of Turbine	:	95%
Efficiency of Generator	:	98%
Overall efficiency of turbine- generator	:	93%

8.4.5.1.3 Reservoir Operation

Operation of the reservoir has been kept in such a way that maximum level shall be achieved during monsoon period and during non- monsoon season reservoir shall be depleted up to minimum reservoir level to the extent possible.

8.4.5.1.4 Simulation Studies

Simulation Studies have been done based on net yield series generated at Kelwan dam site for 32 year i.e. from the year 1975-76 to 2006-07.The parameters involved in the simulation studies include monthly inflows into the reservoir, various demands, evaporation losses and elevation-area- capacity relationship of the reservoir after 50 years of the sedimentation. The details of simulation study carried out for the assessment of power potential are at Appendix 8.5 (Power Potential study of Kelwan reservoir) in Volume – V.

8.4.5.1.5 Firm Power

The firm annual energy that could be generated at Kelwan Power plant in the 90% dependable year (1985-86) with an installed capacity of 2.5 MW is 13.07 MU.

8.4.5.1.6 Installed Capacity

One of the most commonly used criterion for optimization of the installed capacity is based on the analysis of incremental energy that is generated with a unit increase in the installed capacity. In the present optimization studies, energy generation has been analyzed with different installed capacities, ranging from 0.25 MW to 4.00 MW. The energy computations are done for 50% and 90% dependable years and for all the 32 years flow data available. The installed capacity is increased in steps of 0.25 MW. In each case, unrestricted energy and the firm energy have been computed, with and without spill. The results for 90% dependable year are summarized in Table 8.15:

Table 8.15
Incremental Energy Benefits in a 90% Dependable Year (1985-86)

Sl. No.	Installed Capacity	Annual Energy Gen.	95% Energy	Annual PLF	Incremental Power	Incremental Capacity	Variation in incre. Annual Energy
	MW	MU	MU	%	d(KWh)	d(kW)	d(kWh)/ d(kW)
1	0.250	0.988	0.939	42.877			
2	0.500	1.906	1.811	41.349	872	250.0	3.488
3	0.750	2.824	2.683	40.840	872	250.0	3.488
4	1.000	3.742	3.555	40.586	872	250.0	3.488
5	1.250	4.660	4.427	40.433	872	250.0	3.488
6	1.500	5.484	5.209	39.646	782	250.0	3.128
7	1.750	6.216	5.905	38.518	695	250.0	2.782
8	2.000	6.948	6.600	37.673	695	250.0	2.782
9	2.250	7.647	7.264	36.856	664	250.0	2.656
10	2.500	8.193	7.783	35.539	519	250.0	2.075
11	2.750	8.739	8.302	34.461	519	250.0	2.075
12	3.000	9.169	8.711	33.146	409	250.0	1.637
13	3.250	9.480	9.006	31.633	295	250.0	1.180
14	3.500	9.660	9.177	29.931	171	250.0	0.684
15	3.750	9.760	9.272	28.225	95	250.0	0.381

Sl. No.	Installed Capacity	Annual Energy Gen.	95% Energy	Annual PLF	Incremental Power	Incremental Capacity	Variation in incre. Annual Energy
	MW	MU	MU	%	d(KWh)	d(kW)	d(kWh)/ d(kW)
16	4.000	9.760	9.272	26.461	0	250.0	0.000

The ratio of incremental energy to incremental installed capacity (d(kWh)/ d(kW) for 90% dependable year is plotted against the installed capacity in Figure 8.5.

Fig 8.5: Incremental Power vs. Installed Capacity (90% Dependable year)

8.4.5.1.7 Scope for Seasonal/Secondary Power Generation

The power releases are dependent on Link canal monthly demands which are to be met from Kelwan reservoir through the Kelwan feeder pipe line which are constant in each month. Therefore, there is no scope for secondary power generation.

8.4.5.1.8 Size and Type of Generating Units

The proposed 2.5 MW Kelwan Hydro-Electric Project would have a surface power station located on the left bank of Purna River at toe of the Kelwan Dam. The installed capacity of 2.5 MW would be provided by 2 number Francis turbine driven generating units of 1.25 MW each. The units would operate under a gross head range of 28.54 m to 10.00 m. The rated net head has been worked out as 22.16 m.

8.4.5.1.9 Number of Generating Units

Keeping in view the power potentinal analysis for 50%, 90% dependable years and average annual energy from the year 2001-02 to 2006-07 and in order to maximum utilization of releases, a plant with 2 units of 1.25 MW each has been proposed.

8.4.5.2 Electrical and Mechanical Works

The proposed 2500 kW Kelwan Hydro-Electric Project would have a surface power station located on the left bank of the Purna river at toe of the Kelwan Dam, proposed across river Purna near village Kelwan in Ahwa taluka of The Dangs district in Gujarat State. The installed capacity (2.5 MW) would be provided by 2 number Francis turbine driven generating units of 1.25 MW each. The units would operate under a gross head range of 28.54 m to 10.00 m. The rated net head has been worked out as 22.16 m. The step-up 3.3kV/33 kV three phase Transformers would be at the unloading bay level on the downstream side, the power house service bay also being at EL 138.80 m. From the transformers, power would be taken to the switchyard by short overhead lines. Power would be transmitted from switchyard by 33 kV outgoing transmission lines.

This project is being developed as storage type water supply scheme with a dam toe type power station. The average tail water level has been taken as 135.46 m. The selection criteria for electro-mechanical works including turbine, generator, transformer, controls and protections and all other associated works for the power plant including Power evacuation and its transmission to sub-station for Kelwan HEP are discussed below:

8.4.5.2.1 Turbine

i) Selection of Type of Turbine: As per the power potential studies, two turbines of 1250 kW Installed Capacity each have been proposed. The selection of type of turbine for a Hydro Power Project is a function of its specific speed. As per IS: 12800 (Part 3):1991, head variation has been considered from 125% to 65% and accordingly trial speed has been calculated. Based on the calculation, rotational speed has been taken as 428.6 rpm with Horizontal Francis Turbine. Detail of design parameters for

Kelwan Hydro Electric Project is given at Appendix – 8.11 of Volume-V of report.
For the given head condition, Francis turbines are recommended. Each turbine shall be capable of running at 120 % of rated capacity. Each turbine shall be horizontal shaft type suitable for coupling directly to horizontal shaft synchronous generator of 1250 kW plus 20% overload i.e., 1500 kW rating.

ii) Turbine Setting: Setting of Francis runner has been calculated to eliminate any chance of development of cavitations as per Thomas's criteria (ref: IS: 12800 (Part 3):1991.

iii) Runner Diameter: As per IS: 12800 (Part 3):1991, runner dia D_3 is computed. The manufacturer has provided runner dia. as 800 mm. All other turbine and casing dimensions have been computed with respect to above value of D_3 as adopted by the manufacturer viz. 800 mm. Details are given at Appendix-8.11 of Volume-V.

8.4.5.2.2 Francis Turbine and Associated Equipments

i) Type: The Turbine shall be of the Horizontal Shaft Francis suitable for coupling directly to horizontal shaft synchronous generator. The direction of rotation shall be anti-clock wise when viewed from coupling end. The turbine shall be capable of giving outputs higher than rated outputs to match the over load capability of generator.

ii) Spiral Casing: The Turbine shall be of spiral casing type so constructed as to allow all the removable parts to be dismantled conveniently. The design shall also permit removal of rotating parts without disturbing the guide apparatus. The design shall also permit horizontal/vertical movement of runner shaft by an amount sufficient for adjustment of bearing and for clearing the joint at the coupling between the turbine and the generator.

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iv) Shaft and Coupling: The turbine shaft is not applicable, as Turbine Runner is proposed to be mounted on the extended shaft of Generator.

v) Turbine Guide and Thrust Bearings: The turbine will be provided with an oil-lubricated guide bearing with suitable Babbitt lining for the shaft. The bearing shall be designed for the turbine radial and axial loads. The bearing will be split to facilitate dismantling. Bearing shall be provided with suitable instrumentation for monitoring the temperature and oil level.

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vii) Wicket–Gate Mechanism with Gate Operating Mechanism:
The generator side and draft tube side head cover shall be of suitable construction of steel, to accommodate guide bearings, casings, labyrinth rings, shaft sealing, guide vane bearings etc. The head covers will be suitably designed to resist the superimposed hydraulic load, such that any consequential deflections / slopes of the head cover would not hamper the -functioning of the wicket-gate operating mechanism.

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The angular movement of the gates will be so limited and the mechanism so designed that the bedding faces of the guide vanes close, with no gap, with the servomotor at its closed position.

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8.4.5.2.3 Inlet Valves

Two Nos. butterfly valves, each of 950 mm dia and operated by hydraulic pressure are proposed to be provided upstream of each turbine inlet to isolate any one of the machines in case of emergency and to afford flexibility of operation of the power plant. The valve will be opened by using an oil servomotor and closed by counter weight under all operating conditions. The counter weight shall be provided as a fail-safe feature, so that it will have a closing bias in case of fault condition. The body shall be welded construction, with its operating feet to take all Horizontal loads at foundations. The body to house door trunions complete with self lubricated PTFE/chevron type bushes for bearings.

The disc shall be fabricated from steel plates. The valve disc will have a peripheral sealing ring of rubber. The disk shall be optimally designed to provide minimum resistance to flow. Oil operated servomotors shall be mounted on a mounting frame for opening under balanced conditions, so that separate foundations for oil servomotor are avoided.

The oil pressure system for operating the valve shall be common with the governor oil, pressure system. The bypass valve with hydraulically operated main valve shall be provided for opening the valve under balanced conditions.

An inlet pipe of suitable bore shall be flanged u/s of the valve, about 500mm long for welding to the penstock at site. A dismantling joint of telescopic type shall be located d/s of the valve.

8.4.5.2.4 Governing Equipment

The turbine shall be equipped with suitable electronic governor conforming to IEC No. 308/Hydro-Mechanical governor complete with all accessories. Standard protections like over speed device, brake control, emergency shut down and alarm etc., shall be provided in the governing system.

8.4.5.2.5 Pressure Oil System

Each unit will be provided Oil pressure units systems comprise a sump tank and a pressure tank separate for each generating unit. Two numbers of electrically operated governor oil pumps will be provided, one for normal running and the other acting as standby for each unit. Provision of emergency shutdown of the unit shall without any oil pump shall be made.

8.4.5.2.6 Generator

i) General: There are two types of generators namely:

1. Synchronous, and
2. Induction.

Induction generators are generally about 20% cheaper than the synchronous generators of same output. Whereas synchronous generators are self contained in developing its own excitation power, induction generators require an external source for providing it with the magnetization power. The induction generator uses excitation power supplied from an external source, which is normally the grid. However, in case of grid failure, black start of machines will be difficult. Since Kelwan HEP is not a very small project, dependability on grid could result in loss of power due to standstill generator. Hence it has been proposed to use synchronous generators.

ii) Speed Rise and Runaway Speed: Each generator shall be designed and constructed so as to be capable of running for a period of 15 minutes at a maximum runway speed. The runaway speed test shall be considered successful if after undergoing the test, ‘no injury’ is apparent. The runaway speed test may be carried out at a site and at works.

iii) Cooling System: Generator shall be of open type construction with IP: 23 /IC: 01 enclosure

iv) Stator: The stator frame shall be manufactured of cast iron/fabricated steel construction. The frame shall be designed to withstand the bending stresses and deflections due to its self weight and the weight of the core supported by it.

The stator core shall be built up by segmental punching made of low loss silicon sheet steel non-oriented type and end plates. Each punching shall be properly debarred and applied with insulating varnish on both the sides.

The stator winding shall be star connected. The terminal leads of each phase are brought out to a separate terminal box. Six Nos. (Two resistance element per phase) embedded temperature detectors for each generator of resistance type shall be provided for stator winding located symmetrically. The connections on the resistor elements shall be well insulated and extended to a box on the outside of stator frame. The generator stator windings will be provided with epoxy insulation of class “F” type.

v) Rotor: The design and construction of the rotor shall as per latest practice and also in accordance with the best modern practice. The factor of safety at minimum runaway speed based on yield point of material shall not be less than 1.5.

Necessary flywheel effect shall be determined, in case required moment of inertia is not available from rotor, separate flywheel shall be provided to furnish additional flywheel effect. A mechanical over speed device with electrical contacts (two sets) one for alarm and other for trip shall be mounted on non-driving end of the generator and in case of shorting of diodes there shall be trip command.

vi) Shaft The generator shaft shall be made of the best quality carbon steel properly heat-treated. The shaft shall be of adequate size to operate at all speeds including maximum runway speed and shall be able to withstand short circuit stresses without excessive vibrations or distortion.

The shaft shall be accurately machined all over and polished where it passes through the bearings and accessible points for alignment check.

vii) Bearings: The generator bearings shall be Antifriction ball / roller type / Tilting Pad. One No. of bearing shall be mounted on DE and NDE. These bearing shall be guaranteed for minimum continuous working for 100,000 (one hundred thousand) hours and shall be of proven design and performance and have minimum maintenance.

Bearings shall be adequately insulated to prevent any harmful circulating currents. The bearings shall be designed to withstand operation of runaway speed for a period of 15 minutes.

Dial type thermometer with two NO contacts shall be provided one Number on each DE and NDE bearings. At each bearing one no. duplex RTD shall be provided for indication/recording and alarm as well as for tripping the unit in case of high temperature.

The guaranteed operating temperature of the bearing at rated output and overload condition shall be indicated. However the bearing temperature for "alarm" and "unit trip" shall not be higher than 75^{O} C and 80^{O} C respectively.

viii) Heaters: The heater suitable for 240 volts, single-phase AC supply shall be provided

ix) Brakes For stopping the generating units quickly, each generator shall be provided with pneumatically operated brakes, which will be operated automatically or manually. The generator brake would consist of a suitable number of brake shoes, which will operate against a polished segmental steel brake track bolted to rotor or to any other component such as fly wheel, if any.

x) Terminal Box: Separate terminal boxes shall be provided for the following:

- Phase terminals of the generator.
- Neutral terminals of the generator.
- Space heater.
- Temperature detectors.

The phase and neutral terminal boxes shall be of phase segregated type.
Terminal boxes shall be of weatherproof construction to eliminate entry of dust, vermin and water with a degree of protection IP: 54.

8.4.5.2.7 Electrical Control And Protection Equipments

i) General

Digital Electronic governor with Oil Pressure Unit (OPU) is proposed to be housed in one of the corners of the powerhouse. This system will serve the following four purposes:

- Indication
- Metering
- Protection
- Control

All the indications such as butterfly valve on/off status, breaker on / off status etc. will be indicated on the unit control board incorporated in the Electronic Governor. 110 Volt D.C. lamps of different colour codes will be used for this purpose.

ii) Metering

All the necessary parameters like voltage, frequency, power factor, current, power, energy, unit hour running etc. will be measured through suitably scaled meters mounted on the unit control board of the Governor.

iii) Controls

All Controls like control for closing the butterfly valves and motor operated circuit breakers for load switching will be incorporated in the Digital Electronic Governor. Thus, the electronic unit control shall have a complete and coordinated set of instruments, controls and safety devices for indication, metering and protection related to all conditions of running of the plant including activating / de-activating various protection devices during emergency operating conditions for the plant.

8.4.5.2.8 D.C. System

Float cum boost charger 110 Volt, 150 AH capacity and tubular batteries will be provided for feeding power to indication lamps, protection relay coils, and initial impulse to the self excitation system by means of field flashing and to operate few emergency lights. Central Board of Irrigation and Power (CBIP) Technical report no. 79 (Manual on Sub-Station, Chapter 1 on substation battery charging equipment and D.C. switch gear) will be followed for detailed designing.

8.4.5.2.9 Fire Protection

Latest techniques available for control of fire using fire-fighting equipments, smoke detectors etc. will be used. Automatic system with manual override is recommended.

8.4.5.2.10 Material Handling in the Power House

It is proposed to provide a girder type electric operated crane with a capacity of 10T. The hoisting operation shall be done by electric motor operated hoist, which can be operated from the generator floor level. The EOT crane would facilitate a small group of erection and maintenance personnel to handle both erection and maintenance activities.

8.4.5.2.11 Auxiliary Power Supply

Three Phase, 33 kV / 415 V Star / Delta 150 kVA capacity step-down transformer will be used for feeding the station lighting and heating load for power house, illumination for approach road and switch yard. Emergency lights on important places will be operated by D.C. battery provided in the powerhouse. 150 kVA diesel generator set will also be provided for illumination in powerhouse, staff colony, streetlights and switchyard during shut down of machines.

8.4.5.2.12 Cables and Boxes

Heat shrink type cable and boxes shall be provided for HT cable connecting generator to control panel, neutral grounding and relays.

8.4.5.2.13 Station Drainage System

Adequate provision will be made for collection of any leakage water around the turbine and its delivery to a lowest point of the station drain. A drain connector at lowest point of scroll case for drawing into the draft tube will be provided.

8.4.5.2.14 Ventilation System

It is proposed to install eight (08) nos. of exhaust fans of 300 mm size, 1000 RPM mounted at a suitable elevation facing towards the tail race.

8.4.5.2.15 Draft Tube Gate

Two nos. Slide type gates have been envisaged at the draft tube structure on the tailrace side. The clear opening is 3.40 m wide x 2.34 m high. The gates shall be designed for a head corresponding to average tail water level of 135.46 m (sill EL 131.19 m).

The gate shall be lifted under balanced head conditions created by filling valve. The gate shall be operated by means of independent rope drum hoist of 12t (Tentative) capacity mounted on trestle at deck level of EL 138.80 m.

8.4.5.2.16 Tailrace Channel

The tail race channel will connect the draft tubes of the power house with the Kelwan feeder pipe line.

8.4.5.2.17 Switchyard

A comparatively flat terrace exists near powerhouse at EL + 138.00 m where the switchyard has been proposed with 33 kV Outdoor Switchyard Equipments comprising of Vacuum Circuit Breakers, CT's, PT's, LA's, Isolators, Jumpers, and Structure etc. In this location one no. three phase power transformer will be kept on plinth. Earth mat will be laid underground. Proper fuse sets, switches etc. will be mounted on M.S. poles. The total area will be strongly fenced as per Indian electrical safety rules. High voltage cable will be laid underground in cable trenches. The power cable will connect low voltage side of the step-up transformer.

8.4.5.2.18 Grounding Systems

a) General

The following equipments / systems are required to be earthed:

- Neutral points of different voltages
- Equipment frame work and other metallic parts
- Boundary fence, steel structures etc.
- Lightning arrestor

b) Design

The grounding system shall conform to IS 3043-1987 or latest edition and Indian Electricity Rules 1956 along with latest amendments. Power house and switch yard areas shall be protected against electric shocks by providing electrodes and earthing mat for the power house and switchyard areas as per computed/measured electrical resistivity values. Earthing electrodes shall be uniformly distributed and located adjacent to fencing of switchyard and powerhouse.

8.4.5.2.19 Transmission and Distribution Works

a) General

Kelwan dam Hydro Power Project is proposed to be a grid-connected scheme. However, it is proposed to evacuate the power to the existing 66 kV sub-station of SEB located in Waghai town. The distance of sub-station from Kelwan SHP switchyard is approximately 17.50 km.

8.4.5.2.20 Power Evacuation

It is proposed that the electricity shall be generated at 3.3 kV level and evacuated at 33 kV level. One number Step-up transformer, of 4075 kVA rating and 3.3 kV / 33 kV voltage level for these machines shall be provided at switchyard near the powerhouse. The electricity at 33 kV voltage level will be transmitted to the 66 kV SEB sub-station. Appropriate arrangements for protection of the transmission line shall be made.

8.4.5.2.21 Step-up Transformers for the Switchyard

As mentioned earlier, Single transformer is proposed to be provided in the switchyard adjacent to the powerhouse. This transformer shall be of 4075 kVA rating, outdoor type, oil filled, 50 Hz, 3 Phase, vector group Y n d 11, natural air cooled. The windings shall be of copper. The connections at HV winding side shall be star and LV winding side shall be delta. Off-load taps on HV side shall be (+) 2.5% to (-) 7.5% in steps of 2.5%. The LV side shall be suitable for cable box whereas HV side shall be suitable for the selected conductor.

The temperature rise on any part of the transformer shall not exceed 40^0 C by oil thermometer and 60^0 C in winding by resistance (RTDs) under full load conditions. The cover of the tank of the transformer shall be bolted to the tank for easy maintenance. C.B.I.P. manual and IS code 2026 – 1977 will be followed for detailed design of transformers.

8.4.5.2.22 Transmission Lines

Kelwan Dam is located in Gujarat State and it is proposed to evacuate the power from this Small Hydro Power Project(SHP) to nearby substation in Gujarat State. The nearest Substation with a capacity of 66 kV is situated at Waghai town of Dang District of Gujarat State. Total length of the transmission line from switchyard to GETCO's 66kV substation is assessed to be app. 17.50 Km. Necessary arrangement with 33/66kV step up transformer, LA, PT's, CT's and Breaker with control panels and metering panels shall be made at Sub-Station end for 33 kV incomer line.

8.4.5.2.23 Drawings

The general arrangement drawing with Plan view and Section view of Powerhouse has been prepared and appended in Appendix-8.11 in Volume-V.

8.4.5.2.24 Cost Estimate (S-Power Plant)

The cost of Electro-Mechanical Works has been computed by utilizing the quotations obtained from leading E and M equipment manufacturers of the various Quotations obtained from the reputed equipment manufacturers, the price quoted by one of the reputed manufacturer was found to be most realistic and hence the same has been adopted in formulating the cost estimate for EandM works.

The cost of the Transmission line from Powerhouse to SEB has been computed based on the prevailing rates of the State's power transmission organizations.

Total cost of S-Power Plant which includes prices for Manufacture, Supply, and Transportation up to Project Site of EandM Equipments, Erection and Commissioning of EandM Equipments and Transmission cost up to 66 kV SEB situated at Waghai town of Dang District are Rs 11.73 Crores.

Schedule of requirements for supply of Electro-mechanical equipments has been appended as Annexure-I to III in Appendix-8.11 of Volume-V.

Details of Cost estimate have been annexed as Annexure-IV in Appendix-8.11 of Volume-V.

8.4.6 **Power House on Kelwan Feeder** pipe line **(Canal drop at RD 5.80 km)**

The proposed 2000 KW Kelwan feeder pipe line SHP would have a surface power station located at RD 5.80 km of the Kelwan Feeder pipe line where there is a natural ground fall of about 16 m. The installed capacity (2.00 MW) would be provided by 2 Kaplan turbine driven generating units of 1.00 MW each. The rated net head has been worked out as 15.97 m. The step-up 3.3kV/33 kV three phase Transformer would be at the unloading bay level on the downstream side. From the transformers, power would be taken to the switchyard by short overhead lines. Power would be transmitted from switchyard by 33 kV outgoing transmission lines.

This project is being developed as link diversion scheme. The link diversion for irrigation is considered for power generation after passing through the Power House. The average tail water level has been taken as 117.77 m. The selection criteria for electro-mechanical works including turbine, generator, transformer, controls and protections and all other associated works for the power plant for Kelwan Feeder pipe line SHP, power evacuation and its transmission to sub-station are discussed in following paragraphs:

8.4.6.1 Power Potential Study

8.4.6.1.1 Parameters Used in Power Potential Study

Full Supply Level of Feeder pipe line: The FSL of the Feeder pipe line before canal fall has been taken as FRL 133.775 m.

Tail Water Level: As per the full supply level of the link canal d/s of Kelwan Feeder pipe line Power House, average Tail Water Level (TWL) has been considered at an elevation of 117.752 m for power potential studies.

Water Conductor Losses: The power house has been proposed to be constructed at the canal fall located at RD 5.80 km of the Feeder pipe line. Hence, keeping in view the entire length of water conductor system, the

water conductor losses have been considered 0.20 m in the present calculation.
Design Net Head = Gross head – Water Conductor losses.

Efficiencies: The efficiencies applicable for most of the small hydro turbines and generator units, considered for the purpose of calculation of annual energy are given below:

Efficiency of Turbine	:	95%
Efficiency of Generator	:	98%
Overall efficiency of turbine- generator	:	93%

8.4.6.1.2 Net Discharge :

Net yield series for releases from Kelwan Reservoir for Link diversion for 32 year from the year 1975-76 to 2006-07 has been adopted for studies. The parameter involved in the present simulation Studies include monthly inflows into the reservoir, various demands, evaporation losses, elevations, area capacity relationship of the reservoir after 50 years of the sedimentation. A monthly working table including demand pattern of release of water considering the evaporation losses and committed releases are finalized for simulation studies. Requirement of Link canal to be met from Kelwan reservoir and irrigation requirement en-route the Feeder pipe line shall pass through the Power House. 5% Evaporation and transmission losses (including en-route irrigation use) are considered from Kelwan reservoir to Power House of Feeder pipe line.

8.4.6.1.3 Firm Power:

The average annual energy generation at Kelwan Feeder pipe line Power house with an installed capacity of 2.0 MW is 12.48 MU. The Power Potential studies carried out at the canal drop are appended as Appendix-8.6 of Volume-V.

8.4.6.1.4 Installed Capacity :

One of the most commonly used criterion for optimization of the installed capacity is based on the analysis of incremental energy that is generated with a unit increase in the installed capacity. In the present optimization studies, energy generation has been analyzed with different installed capacities, ranging from 0.25 MW to 2.25 MW. The energy computations are done for 50% and 90% dependable years and for all the 32 years flow data available. The installed capacity is increased in steps of 0.25 MW. In each case, unrestricted energy and the firm energy have been computed. The results for 90% dependable year are summarized in Table 8.16:

Table 8.16

Incremental Energy Benefits in a 90% Dependable Year (1985-86)

S. No.	Inst. Cap.	Annual Energy Gen.	95% Annual Energy Gen.	Annual P.L.F.	Incremental Power	Incremental Capacity	Variation in Incr. Annual Energy
	MW	MU	MU	%	d(KWH)	d(KW)	d(KWH)/dKW
1.	0.250	1.189	1.129	51.564			
2.	0.500	2.293	2.178	49.727	1049	250.0	4.195
3.	0.750	3.397	3.227	49.115	1049	250.0	4.195
4.	1.000	4.380	4.161	47.502	934	250.0	3.737
5.	1.250	5.298	5.033	45.966	872	250.0	3.488
6.	1.500	6.216	5.905	44.942	872	250.0	3.488
7.	1.750	7.134	6.778	44.211	872	250.0	3.488
8.	2.000	7.992	7.593	43.337	815	250.0	3.260
9.	2.250	8.295	7.880	39.979	287	250.0	1.149

The ratio of incremental energy to incremental installed capacity (d(kWh)/ d(kW) for 90% dependable year is plotted against the installed capacity in Figure 8.6:

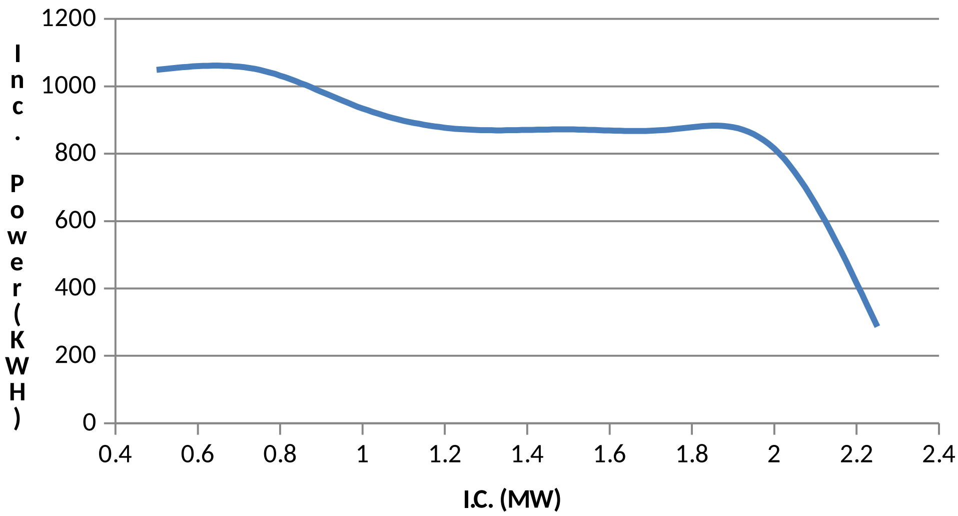

Fig 8.6: Incremental Power vs. Installed Capacity (90% Dependable year)

8.4.6.1.5 Scope for Seasonal/Secondary Power Generation :

The power releases are dependent on Link canal monthly demands to be met from Kelwan reservoir through the Kelwan feeder pipe line which are constant in each month. Therefore, there is no scope for secondary power generation.

8.4.6.1.6 Size and Type of Generating Units :

The proposed 2 MW Kelwan Feeder pipe line Hydro-Electric Project would have a surface power station located at RD 5.80 km of the canal where ground fall exists. The installed capacity of 2 MW would be provided by 2 numbers Kaplan turbine driven generating units of 1.0 MW each. The units would operate under a gross head 16.17 m. The rated net head has been worked out as 15.97 m.

8.4.6.1.7 Number of Generating Units :

Keeping in view the power potentinal analysis for 50%, 90% dependable years and average annual energy from the year 2001-02 to 2006-07 and in order to maximum utilization of releases, a plant with 2 units of 1.0 MW each has been proposed.

8.4.6.2 Electrical and Mechanical Works.

8.4.6.2.1 Turbine

i) Selection of Type of Turbine

As per the power potential studies carried out under Part – I - Power Potential, two turbines - each of 1000 kW capacity have been recommended. The selection of type of turbine for a Hydro Power Project is a function of its specific speed. As per IS: 12800 (Part 3):1991, head variation has been considered from 125% to 65% and accordingly trial speed has been calculated. The rotational speed has been taken as 600 with Kaplan Turbine. Details of design parameters for Kelwan Feeder pipe line Small Hydro Project is given at Appendix - 8.12 of Volume-V of report.

For the given head condition, Kaplan turbines are recommended. Each turbine shall be capable of running at 110 % of rated capacity. Each turbine shall be horizontal shaft type suitable for coupling directly to horizontal shaft synchronous generator of 1000 kW plus 10% overload i.e., 1100 kW rating.

ii) Runner Diameter and Turbine Setting

Runner dia D_3 computed as per IS: 12800 (Part 3):1991 is 1067. The manufacturer has provided runner dia. as 1100 mm. All other turbine and casing dimensions have been computed with respect to above value of D_3 as adopted by the manufacturer viz. 1100 mm. Details are given at Appendix-8.12 of Volume-V.

8.4.6.2.2 Kaplan Turbine and Associated Equipments

i) Type: The Turbine shall be of the Vertical Shaft Kaplan type suitable for coupling directly to the synchronous generator of 1000 kW rating (with 10% continuous over load capacity) in vertical set up with adjustable blades. The direction of rotation shall be anti-clock wise when viewed from coupling end. The turbine shall be capable of giving outputs higher than rated outputs to match the over load capability of generator. Each turbine shall comprise of runner, shaft, spiral case, stay ring, head cover, bottom ring, a set of guide vanes and operating mechanism, guide bearing, shaft seal and draft tube etc.

ii) Spiral Casing: The Turbine shall be of spiral casing type so constructed as to allow all the removable parts to be dismantled conveniently. The design shall also permit removal of rotating parts without disturbing the guide apparatus.

iii) Runner: The Runner shall be of 13/4 chromium-nickel steel. The runner shall be cast integrally of stainless steel. The runner will have adequate number of blades which shall be polished and ground smooth and shall be free from roughness, cracks, high spots etc. The finished machine and ground runner shall be dynamically balanced.

iv) Shaft and Coupling: Turbine shaft shall be of forged carbon steel; top cover, bottom ring, regulating ring, spiral case, stay ring and draft tube liner shall be fabricated from steel plate. Turbine bearing shall be babbit lined oil lubricated pivoted pad type and shall be located above the turbine shaft seal. A rubber or carbon ring type of shaft seal shall be provided to prevent leakage from gap between stationary and rotating parts of the turbine.

v) Turbine Guide and Thrust Bearings: The turbine will be provided with an oil-lubricated guide bearing with suitable Babbitt lining for the shaft. The bearing shall be designed for the turbine radial and axial loads. The bearing will be split to facilitate dismantling. Bearing shall be provided with suitable instrumentation for monitoring the temperature and oil level.

vi) Draft Tube Each turbine shall be provided with a draft tube liner/suction bend of welded construction of structural steel. The design of the draft tube shall be such as to ensure the best overall efficiency for the turbine and stable and pulsation –free operation of the machines.

vii) Wicket–Gate Mechanism with Gate Operating Mechanism:

The generator side and draft tube side head cover shall be of suitable construction of steel, to accommodate guide bearings, casings, labyrinth rings, shaft sealing, guide vane bearings etc. The head covers will be suitably designed to resist the superimposed hydraulic load, such that any consequential deflections / slopes of the head cover would not hamper the -functioning of the wicket-gate operating mechanism.

Guide Vanes: Each guide vane and its stem will be an integral casting in Stainless steel. The contacting surface of gates and the gate stems will be smooth and finish machined. All guide vane bearings (Axial/radial) shall be maintenance free, with appropriate sealing against water flow channel by ‘O’ rings.

Levers/Links: The guide vane links/levers to be clamped to the guide vane stem and locked in position during assembly. A suitably designed frictional clutch mechanism to prevent possible damage to the wicket gates in case of trapped foreign bodies between the gates will be provided.

Gate Operating Ring: A suitably designed gate operating ring will be operated by a servo-motor. The operating ring will be provided with maintenance free bushes.
Servomotor: Double Acting servomotors operated by governor oil pressure shall be mounted on the generator side head-cover. The servo-motor shall be supplied with a feedback transmitter. Servo-motor will be of sufficient capacity to operate the gates, when supplied with oil at minimum pressure.

8.4.6.2.3 Inlet Valves

Two Nos. butterfly valves each of 1200 mm dia. and operated by hydraulic pressure are proposed to be provided upstream of each turbine inlet to isolate any one of the machines in case of emergency and to afford flexibility of operation of the power plant. The valve will be opened by using an oil servomotor and closed by counter weight under all operating conditions. The counter weight shall be provided as a fail-safe feature, so that it will have a closing bias in case of fault condition.

The body shall be welded construction, with its operating feet to take all Horizontal loads at foundations. The body to house door trunions complete with self lubricated PTFE/chevron type bushes for bearings. The disc shall be fabricated from steel plates. The valve disc will have a peripheral sealing ring of rubber.

The disk shall be optimally designed to provide minimum resistance to flow. Oil operated servomotors shall be mounted on a mounting frame for opening under balanced conditions, so that separate foundations for oil servomotor are avoided.

The oil pressure system for operating the valve shall be common with the governor oil, pressure system. The bypass valve with hydraulically operated main valve shall be provided for opening the valve under balanced conditions.

8.4.6.2.4 Governing Equipment

Each turbine will be equipped with electro-hydraulic governor of digital type and compatible with station SCADA system. The governor shall be provided with necessary controls to enable accurate speed/ power regulation. The governor shall be suitable for peaking as well as base load operation.

Governor shall be provided a high pressure oil system (common for Governing system and MIV). The oil pressure system shall consists of sump tank, electric motor driven main and standby pumps mounted on the sump tank, oil pressure tank with associated accessories, bank of nitrogen bottles, oil piping and valves, instrumentation, protection, monitoring and control equipments.

8.4.6.2.5 Pressure Oil System

Each unit will be provided Oil pressure units systems comprise a sump tank and a pressure tank separate for each generating unit. Two numbers of electrically operated governor oil pumps will be provided, one for normal running and the other acting as standby for each unit. Provision of emergency shutdown of the unit shall without any oil pump shall be made.

8.4.6.2.6 Generator

i) General: General

The generator would be vertical shaft type; three phase synchronous type. The power factor of the generator would be 0.85 lagging. Optimum generating voltage would be 3.3kV. The generator would have continuous overload rating 110% of the rated capacity to match the turbine output at high heads. The stator and rotor windings would be of class F type epoxy insulation. The generator shall be air cooled open ventilated and shall designed in accordance with IS: 4722. The generator is provided with brushless excitation system.

The generator shall have a combined thrust and guide bearing located below the rotor and a guide bearing above the rotor. Brakes and jacking system of suitable capacity would be provided. Brake dust extraction system comprising pipes and pumps would be provided to extract the dust at the time of application of the brakes. Vibration detection system for continuously recording vibration frequency and amplitude would be provided. Creep detection device for detection of creep running of generator rotor would be provided.

ii) Speed Rise and Runaway Speed: Each generator shall be designed and constructed so as to be capable of running for a period of 15 minutes at a maximum runway speed. The runway speed test shall be considered successful if after undergoing the test, 'no injury' is apparent. The runaway speed test may be carried out at a site and at works.

iii) Cooling System: Generator shall be of open type construction with IP: 23 /IC: 01 enclosure

iv) Stator: The stator frame shall be manufactured of cast iron/fabricated steel construction. The frame shall be designed to withstand the bending stresses and deflections due to its self weight and the weight of the core supported by it.

The stator core shall be built up by segmental punching made of low loss silicon sheet steel non-oriented type and end plates. Each punching shall be properly debarred and applied with insulating varnish on both the sides.

The stator winding shall be star connected. The terminal leads of each phase are brought out to a separate terminal box. Six Nos. (Two resistance element per phase) embedded temperature detectors for each generator of resistance type shall be provided for stator winding located symmetrically. The connections on the resistor elements shall be well insulated and extended to a box on the outside of stator frame. The generator stator windings will be provided with epoxy insulation of class "F" type.

For the rated and 110% overload generator output within the permissible operating conditions, the temperature rise limits of the stator windings would be restricted and the limit would be as per latest Bureau of Indian Standards over the ambient air temperature prevailing at site.

v) Rotor: The design and construction of the rotor shall as per latest practice and also in accordance with the best modern practice. The factor of safety at minimum runaway speed based on yield point of material shall not be less than 1.5.

vi) Shaft The generator shaft shall be made of the best quality carbon steel properly heat-treated. The shaft shall be of adequate size to operate at all speeds including maximum runway speed and shall be able to withstand short circuit stresses without excessive vibrations or distortion.

The shaft shall be accurately machined all over and polished where it passes through the bearings and accessible points for alignment check.

The generator shall be designed to have a noise level not exceeding 90 db at a distance of one meter from the equipment.

vii) Bearings: The generator bearings shall be Antifriction ball / roller type / Tilting Pad. One No. of bearing shall be mounted on DE and NDE. These bearing shall be guaranteed for minimum continuous working for 100,000 (one hundred thousand) hours and shall be of proven design and performance and have minimum maintenance.
Bearings shall be adequately insulated to prevent any harmful circulating currents. The bearings shall be designed to withstand operation of runaway speed for a period of 15 minutes.

Dial type thermometer with two Number contacts shall be provided one Number on each DE and NDE bearings. At each bearing one no. duplex RTD shall be provided for indication/recording and alarm as well as for tripping the unit in case of high temperature.

The guaranteed operating temperature of the bearing at rated output and overload condition shall be indicated. However the bearing temperature for “alarm” and “unit trip” shall not be higher than 75^{o} C and 80^{o} C respectively.

viii) Heaters: The heater suitable for 240 volts, single-phase AC supply shall be provided

ix) Brakes For stopping the generating units quickly, each generator shall be provided with pneumatically operated brakes, which will be operated automatically or manually. The generator brake would consist of a suitable number of brake shoes, which will operate against a polished segmental steel brake track bolted to rotor or to any other component such as fly wheel, if any.

x) Terminal Box: Separate terminal boxes shall be provided for the following:

- Phase terminals of the generator.
- Neutral terminals of the generator.
- Space heater.
- Temperature detectors.

The phase and neutral terminal boxes shall be of phase segregated type.
Terminal boxes shall be of weatherproof construction to eliminate entry of dust, vermin and water with a degree of protection IP: 54.

8.4.6.2.7 Electrical Control and Protection Equipments

a) General

Digital Electronic governor with Oil Pressure Unit (OPU) is proposed to be housed in one of the corners of the powerhouse. This system will serve the following four purposes:

- Indication
- Metering
- Protection
- Control

All the indications such as butterfly valve on/off status, breaker on / off status etc. will be indicated on the unit control board incorporated in the

Electronic Governor. 110 Volt D.C. lamps of different colour codes will be used for this purpose.

i) Metering

All the necessary parameters like voltage, frequency, power factor, current, power, energy, unit hour running etc. will be measured through suitably scaled meters mounted on the unit control board of the Governor.

ii) Controls

All Controls like control for closing the butterfly valves and motor operated circuit breakers for load switching will be incorporated in the Digital Electronic Governor. Thus, the electronic unit control shall have a complete and coordinated set of instruments, controls and safety devices for indication, metering and protection related to all conditions of running of the plant including activating / de-activating various protection devices during emergency operating conditions for the plant.

b) D.C. System

100 AH VRLA type Battery bank with battery charger will be provided for feeding power to indication lamps, protection relay coils, initial impulse to the self excitation system by means of field flashing and to operate few emergency lights.

Central Board of Irrigation and Power (CBIP) Technical report no. 79 (Manual on Sub-Station, Chapter 1 on substation battery charging equipment and D.C. switch gear) will be followed for detailed designing.

c) Fire Protection

Latest techniques available for control of fire using fire-fighting equipments, smoke detectors etc. will be used. Automatic system with manual override is recommended.

d) Material Handling in the Power House

It is proposed to provide a girder type electric operated crane with a capacity of 10 tons. The hoisting operation shall be done by electric motor operated hoist, which can be operated from the generator floor level. The EOT crane would facilitate a small group of erection and maintenance personnel to handle both erection and maintenance activities.

e) Auxiliary Power Supply

Three Phase, 33 KV / 415 V Star / Delta 150 kVA capacity step-down transformer will be used for feeding the station lighting and heating load for power house, illumination for approach road and switch yard.

Emergency lights on important places will be operated by D.C. battery provided in the powerhouse. 150 kVA diesel generator set will also be provided for illumination in powerhouse, staff colony, streetlights and switchyard during shut down of machines.

f) Cables and Boxes

Heat shrink type cable and boxes shall be provided for HT cable connecting generator to control panel, neutral grounding and relays.

8.4.6.2.8 Station Drainage System

Adequate provision will be made for collection of any leakage water around the turbine and its delivery to a lowest point of the station drain. A drain connector at lowest point of scroll case for drawing into the draft tube will be provided.

8.4.6.2.9 Dewatering System

One turbine dewatering system shall be provided for dewatering all the hydraulic portion i.e. from penstock gate to draft tube gate. The draft tube shall be connected to the dewatering sump by gate valve provided with each unit through a pipe directly from where water shall be pumped out into tailrace. Two portable submersible pump motor sets of adequate capacity shall be provided for dewatering all the hydraulic paths. The pump motor shall be suitable for operation on 415 V + 10%, volt, 3 phase, 50 Hz. For lowering these pump in sump a suitable monorail above sump is to be provided in the civil works.

For dewatering the penstock, spiral isolating valves shall be provided on the inlet and outlet pipes to dewater to tail race through the draft tube up to the tail water level and rest of the water shall be pumped after closing the draft tube gates and pumping from the sump.

8.4.6.2.10 Ventilation System

It is proposed to install six (06) nos. of exhaust fans of 300 mm size, 1000 RPM mounted at a suitable elevation facing towards the tail race

8.4.6.2.11 Draft Tube Gate

Two nos. Slide type gates have been envisaged at the draft tube structure on the tailrace side. The clear opening is 2.652 m wide x 1.50 m high. The gates shall be designed for a head corresponding to average tail water level of 117.77 m (sill EL 112.271 m).

The gate shall be lifted under balanced head conditions created by filling valve. The gate shall be operated by means of independent rope drum hoist of 10t (Tentative) capacity mounted on trestle at deck level of EL 118.78 m.

8.4.6.2.12 Switchyard

A comparatively flat terrace exists near powerhouse, where the switchyard has been proposed with 33 kV Outdoor Switchyard Equipments comprising of Vacuum Circuit Breakers, CT's, PT's, LA's, Isolators, Jumpers, and Structure etc. In this location one no. three phase power transformer will be kept on plinth. Earth mat will be laid underground. Proper fuse sets, switches etc. will be mounted on M.S. poles. The total area will be strongly fenced as per Indian electrical safety rules. High voltage cable will be laid underground in cable trenches. The power cable will connect low voltage side of the step-up transformer.

8.4.6.2.13 Grounding Systems

General

The following equipments / systems are required to be earthed:

- Neutral points of different voltages
- Equipment frame work and other metallic parts
- Boundary fence, steel structures etc.
- Lightning arrestor

Design

The grounding system shall conform to IS 3043-1987 or latest edition and Indian Electricity Rules 1956 along with latest amendments. Power house and switch yard areas shall be protected against electric shocks by providing electrodes and earthing mat for the power house and switchyard areas as per computed/measured electrical resistivity values. Earthing electrodes shall be uniformly distributed and located adjacent to fencing of switchyard and powerhouse.

8.4.6.2.14 Transmission and Distribution Works

General

Kelwan feeder pipe line SHP is proposed to be a grid-connected scheme. However, it is proposed to evacuate the power to the existing 66 kV sub-station of SEB located in Waghai town. The distance of sub-station from Kelwan Feeder pipe line SHP switchyard is approximately 17.50 km.

Power Evacuation

It is proposed that the electricity shall be generated at 3.3 kV level and evacuated at 33 kV level.

One number Step-up transformer, of 2500 kVA rating and 3.3 kV / 33 kV voltage level for these machines shall be provided at switchyard near the powerhouse. The electricity at 33 kV voltage level will be transmitted to the 66 kV SEB sub-station. Appropriate arrangements for protection of the transmission line shall be made.

Step-up Transformers for the Switchyard

As mentioned earlier, Single transformer is proposed to be provided in the switchyard adjacent to the powerhouse. This transformer shall be of 2500 kVA rating, outdoor type, oil filled, 50 Hz, 3 Phase, vector group Y nd 11, natural air cooled. The windings shall be of copper. The connections at

HV winding side shall be star and LV winding side shall be delta. Off-load taps on HV side shall be (+) 5% to (-) 5% in steps of 2.5%. The LV side shall be suitable for cable box whereas HV side shall be suitable for the selected conductor.

The temperature rise on any part of the transformer shall not exceed 40^0 C by oil thermometer and 60^0 C in winding by resistance (RTDs) under full load conditions. The cover of the tank of the transformer shall be bolted to the tank for easy maintenance. C.B.I.P. manual and IS code 2026 – 1977 will be followed for detailed design of transformers.

Transmission Lines

Kelwan Feeder pipe line SHP is located in Gujarat State and it is proposed to evacuate the power from this SHP to nearby substation in Gujarat State. The nearest Substation with a capacity of 66 kV is situated at Waghai town of Dang District of Gujarat State. Total length of the transmission line from switchyard to GETCO's 66kV substation is assessed to be app. 17.50 Km. Necessary arrangement with 33/66kV step up transformer, LA, PT's, CT's and Breaker with control panels and metering panels shall be made at Sub-Station end for 33 kV incomer line.

8.4.6.2.15 Drawings

The general arrangement drawing Section view of Powerhouse has been prepared and annexed in the Appendix-8.12 of Volume-V.

8.4.6.2.16 Cost Estimate (S-Power Plant)

The cost of Electro-Mechanical Works has been computed by utilizing the quotations obtained from leading E and M equipment manufacturers of the various Quotations obtained from the reputed equipment manufacturers, the price quoted by one of the reputed manufacturer was found to be most realistic and hence the same has been adopted in formulating the cost estimate for EandM works.

The cost of the Transmission line from Powerhouse to SEB sub-station has been computed based on the prevailing rates of the State's power transmission organizations.

Total cost of S-Power Plant which includes prices for Manufacture, Supply, and Transportation up to Project Site of EandM Equipments, Erection and Commissioning of EandM Equipments and Transmission cost up to 66 kV SEB situated at Waghai town of Dang District is Rs 9.37 crores.

Schedule of requirements for supply of Electro-mechanical equipments has been appended as Annexure-I in Appendix-8.12 Volume-V.

Details of Cost estimate have been appended as Annexure-II in Appendix-8.12 of Volume-V.