Greenko

Saundatti INTEGRATED RENEWABLE ENERGY WITH STORAGE PROJECT (IRESP)

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CHAPTER – 1
EXECUTIVE SUMMARY

1. Introduction

Proposed Saundatti Integrated Renewable Energy with Storage Project (IRESP) is located in Belagavi Distt of Karnataka. Saundatti IRESP is a 4 GW project i.e. 2 GW of Solar Project and 2 GW of wind project with storage capacity of 1200/9600 MWH. This entire project is a self-identified project and is a first of its kind in the country which will supply firm dispatchable renewable power to the Discom /Grid for 24 Hrs i.e. round the clock (RTC). All three components of Saundatti IRESP are in closed vicinity therefore power from all three components will be pooled in a common pooling station and will be connected to PGCIL sub-station at Dharwad.

Storage component of Saundatti IRESP is a pumped storage project of 1200/9600 MWH storage capacity, located in Belagavi district of Karnataka. Saundatti IRESP- Storage Project will comprise of two reservoirs i.e. Renuka Sagar Reservoir (already existing) and Saundatti IRESP Reservoir (to be constructed in natural depression). This project is a one of its kind because the proposed reservoir is not located on any river course and the existing Renuka Sagar reservoir is located across river Malaprabha. The proposed Saundatti IRESP reservoir is in a natural depression and it is far away from any river course.

The Saundatti IRESP - Storage Project is located in Belagavi district of Karnataka. It envisages creation of reservoir across Jagavalla Halla which joins river Malaprabha, a tributary of River Krishna near village Somapura under Tallur Grama Panchayat, Saundatti Taluk about 80 Kms from Belagavi. The Saundatti IRESP - Storage Project is proposed in between two reservoirs i.e. Saundatti IRESP Reservoir as Upper reservoir (to be constructed newly) and the existing Renuka Sagar (Malaprabha) Reservoir as Lower reservoir. This scheme envisages non-consumptive re-utilization of 1 TMC of water of the Renuka Sagar reservoir by recirculation. The water in the Renuka Sagar reservoir (existing lower reservoir) will be pumped up and stored in the proposed Saundatti IRESP reservoir (upper Reservoir) and will be utilized for power generation. The Geographical co - ordinates of the proposed Saundatti IRESP reservoir are at longitude 75° 00’ 42.57" East and latitude is 15° 51’ 36.83" North and that of Renuka Sagar reservoir (existing) are15° 49’ 17.15" N and 75° 05’ 48.23" E. Proposed Rating of the Saundatti IRESP Pump storage project is 1200 MWH.

2 Scope of Report

The proposed Saundatti IRESP – Storage project is a self-identified project and this Pre-feasibility Report has been prepared by M/s Aar Vee Associates to study, evaluate and establish the technical feasibility and economic viability of the proposed Saundatti IRESP.

3. Scope of Works

The Saundatti IRESP - Storage Project envisages construction of upper reservoir across Jagavalla Halla whereas existing Renuka Sagar reservoir near Naviluteertha village in Saundatti Taluk of Belagavi District will be the lower reservoir. The Renuka Sagar reservoir (Existing) is under operation with a live storage capacity of 34.346 TMC and Saundatti IRESP reservoir is proposed for the live storage capacity of 1.01 TMC.

Proposed Scheme will involve construction of 96m high Dam for creation of Saundatti IRESP reservoir of 1.75 TMC gross capacity. Intake structure and trash rack for six numbers of independent penstocks in which one penstock will be bifurcated in to two penstock as hydraulic short circuit to connect two units will be taking off from Saundatti IRESP reservoir. Surface Power House will be located on the Right bank of the upper reservoir at about 1300m from the intake structure and shall be equipped with five vertical-axis reversible Francis type units composed each of a generator/motor and a pump/turbine having generating/pumping capacity of 200MW/230MW and two units of 100MW/105MW respectively.

Indoor Gas insulated switchgear (GIS) will be provided in a separate building located nearby area of the Main Power House. Step up transformers will be placed adjacent to the GIS building, which will be connected by bus duct galleries to machine hall.

One no 400 KV Multi circuit Transmission Line of length **60** Kms shall be used by the plant with one double circuit connected to PGCIL Narendra 400 KV substation at Dharwad and other double circuit connected to IRESP CPSS with Quad Moose conductor for evacuation of generated Power and for Supply of power during pumping mode.

The Saundatti IRESP - Storage Project envisages construction of

- 96 m high Dam for creation of Saundatti IRESP reservoir of 1.75 TMC gross storage capacity
- Power Intake Structure
- 2 nos. of 817m long and 12.0m dia concrete lined head race tunnel
- 25 m wide typical Surge Chamber
- 5 nos. of 375 m long and 6.0m dia. inclined circular steel lined Penstock tunnel /

Pressure Shaft each for each unit of 200 MW

- 1 no 375 m long and 6.0m dia inclined circular steel lined Penstock tunnel/ Pressure shaft bifurcated to 2 penstocks to feed 2 units of 100 MW
- A surface Power house having an installation of five nos. reversible Francis turbine each of 200 MW capacity (3 units of fixed speed and 2 units of variable speed turbines) and two nos. reversible Francis turbine each of 100 MW capacity (1 unit of fixed speed and 1 unit of variable speed turbines) operating under a rated head of 149.82 m in generating mode and 156.92 m in pumping mode.
- 55 m wide and FSD of 6.3m Tail race channel 2.39 KM long connecting to the Existing Renuka Sagar reservoir.

4. Hydrology

The total catchment area of the Renuka Sagar Reservoir is 2176 Sq. Km and the design flood discharge is 5239 cumec. The gross storage capacity of the Renuka sagar reservoir is 1108.41 Mcum (37.731 TMC) and the live storage is 972.56 Mcum (34.346 TMC). Operational pattern of Saundatti IRESP - Storage Plant has been kept in such a way that 1.0 TMC of water will be utilized for the proposed Saundatti IRESP - Storage Project without affecting the existing commitments at existing Renuka sagar Reservoir. The project is a pumped storage scheme and hence, no consumptive utilization of water is required for its operation. The Saundatti IRESP reservoir on upper side is proposed with a live storage of 1.01 TMC to facilitate the pumping operations.

5. Installed Capacity

The Saundatti IRESP is proposed with a Storage Capacity of 9600 MWH with Rating of 1200 MWH. This project is comprising of 5 units of 200 MW each and 2 units of 100 MW each. The installed capacity of a pumped storage scheme is influenced by the requirements of daily peaking power requirements, flexibility in efficient operation of units, storage available in the reservoirs and the area capacity characteristics. The Project will generate 1200 MWH by utilizing a design discharge of 925.68 Cumec and rated head of 149.82 m. The Saundatti IRESP will utilize 1360 MW to pump 1.0 TMC of water to the upper reservoir in 9.20 hours.

The Key parameters of Saundatti IRESP Operation are as follows:

Sl. No.	Parameter	Unit	Value
1	Storage Capacity	MWH	9600
2	Rating	MWH	1200

3	No. of Units	Nos.	7
4	Rated Head in Turbine mode	m	149.82
5	Total Design Discharge	Cumec	925.68
6	Design Discharge per unit of 200 MW	Cumec	154.28
7	Design Discharge per unit of 100 MW	Cumec	77.14
8	Generation Duration	Hrs	8.00
9	Turbine Capacity – 5 Units	MW	200
10	Turbine Capacity – 2 Units	MW	100
11	Annual Energy Generation	MU	3329
12	Pump Capacity – 5 Units	MW	230
13	Pump Capacity – 2 Units	MW	105
14	Rated Head in Pump mode	m	156.92
15	Pumping Duration	Hrs.	9.20
16	Annual Energy consumption	Mu	4338
17	Cycle Efficiency	%	76.74

The volume of water required for turbine mode of operation is equated to the pumped mode. Annual energy generation by Saundatti IRESP in Turbine mode is 3329 MU. Annual energy consumption by Saundatti IRESP in Pump mode is 4338 MU and the Cycle efficiency is 76.74%.

6. Power Evacuation

One no 400 KV Multi circuit Transmission Line of length **60** Kms shall be used by the plant with one double circuit connected to PGCIL Narendra 400 KV substation at Dharwad and other double circuit connected to IRESP CPSS with Quad Moose conductor for evacuation of generated Power and for Supply of power during pumping mode.

7. Environmental Aspects

Upper and lower reservoir for Saundatti IRESP will consist of proposed Saundatti IRESP reservoir (to be constructed newly) and the existing Renuka Sagar reservoir. There will be submergence of additional land required for the proposed Saundatti IRESP reservoir for the pumped storage project. Also, the land required is for the construction of power house complex and its apparent works Viz., Intake structure, Head Race Tunnel, Surge Chamber,

Penstocks, powerhouse, Tail Race Pool and Tail Race Channel etc. Total land required for the construction of various components is about 285 Ha. The project area is in Kagehala forest under Savadati Range. Tail race channel falls totally in private land area. Based on assessment of environmental impacts, management plans must be formulated for Catchment Area Treatment, compensatory afforestation and other environmental issues like rehabilitation & resettlement. These issues would be addressed during the investigations for DPR.

8. Construction Planning & Schedule

It is proposed to construct the project within a period of 3 years including infrastructure development which is proposed to be completed within 6 months.

9. Project Cost Estimate

The estimate of the project cost has been prepared as per the "Guidelines for formulation of Detailed Project Reports for Hydro- Electric Schemes" issued by Central Electricity Authority in January 2015 (Revision 5.0) to arrive at hard cost of the project at March 2018 price level. Quantities have been worked out based on preliminary designs and drawings of different component works. Unit rate analysis was done as per the Guidelines for the preparation of Detailed Project Report of Irrigation and Multipurpose Projects and Guidelines for the preparation of Estimates for River valley projects. The quantities and ratings of various Hydro Mechanical and Electro-mechanical equipment's have been worked out based on system design and equipment sizing calculations. The total project cost works out as given below:

S.NO.	Description of Item	Cost in Crores
1	Cost of Civil & other works	2609.94
2	Cost of Power Plant Electro Mechanical Equipment including Transmission line	1841.67
3	Total Project Cost	4451.61
4	Interest during Construction	534.19
5	Total cost of the Project	4985.80

10. Economic Financial Analysis

The economical evaluation of Saundatti IRESP - Storage Project will be arrived at as part of the Integrated Renewable Energy Project Financial Analysis. The calculations have been worked out considering a debt- equity ratio of 70: 30 and annual interest rate was at 9.50%.

11. Conclusions

The Saundatti IRESP is envisaged to be completed in a period of 3 years. The project cost works out to Rs. 4985.80 Crores. The project would generate designed energy of 3329 MU. Other benefit of this storage project can be in the form of spinning reserve with almost instantaneous start-up from zero to full power supply, supply of reactive energy, primary frequency regulation, voltage regulation, etc.

CHAPTER – 2

SALIENT FEATURES OF THE PROJECT

1		**NAME OF THE PROJECT**	**SAUNDATTI IRESP - STORAGE PROJECT**
2		**Location**	
	a	Country	India
	b	State	Karnataka
	c	District	Belagavi
3		**Geographical Co-Ordinates**	
	a	**Saundatti IRESP Reservoir - Upper (Now Proposed)**	
		Latitude	15° 51’ 36.83" N
		Longitude	75° 00’ 42.57" E
	b	**Renuka Sagar Reservoir - Lower (Existing)**	
		Latitude	15° 49’ 17.15" N
		Longitude	75° 05’ 48.23" E
4		**Access to Project Site**	
	a	Airport	Belagavi
	b	Rail head	Dharwad
	c	Road	Dharwad (45 Km)
	d	Port	Karwar
5		**Project**	
	a	Type	Pumped Storage Project
	b	Storage Capacity	9600 MWH
	c	Rating	1200 MWH
	d	Peak operation duration	8.00 Hours daily
6		**Saundatti IRESP Reservoir - Upper (Now Proposed)**	
	a	Live Storage	1.01 TMC
	b	Dead Storage	0.74 TMC
	c	Gross Storage	1.75 TMC

	d	Full Reservoir level (FRL)	EL +793.00 m
	e	Top of bund level	EL + 795.00
	f	Min. Draw Down Level (MDDL)	EL +760.00 m
	g	Deepest Foundation Level	EL +699.00 m
	g	Height of Dam from Deepest foundation level	96.00 m
	h	Total length at the top of dam	435.0 m
	i	Top width of the dam	6.0 m
7		**Renuka Sagar Reservoir - Lower (Existing)**	
	a	Catchment Area	2176 Sq. KM
	b	Max. flood discharge	5239 cumecs
	c	Live Storage	972.56 MCum (34.346 TMC)
	d	Dead Storage	95.85 MCum (3.385 TMC)
	e	Gross Storage	1108.41 MCum (37.731 TMC)
	f	Full Reservoir level (FRL)	EL +633.832 m
	g	Min. Draw Down Level (MDDL)	EL +623.93 m
	h	Length of Dam	154.53 m
	i	Height of Dam	40.23 m
8		**Power Intake**	
	a	Type	Open Semi Circular
	b	Elevation of Intake centre line	EL +745.26 m
	c	Elevation of bell mouth bottom	EL +735.77 m
9		**Head Race Tunnel**	**Concrete Lined**
	a	Head Race Tunnel – 2No’s	Twin Tunnels
	b	Type of tunnel	Modified Horse Shoe
	c	Diameter of Tunnel	12.0 m
	d	Length of Tunnel	817 m each
	e	Bed Slope	1 in 1437
10		**U/S Surge Chamber**	
	a	Type	Open Surge
	b	Dimensions	L 150.00m x B 25.00 m x H 65.00 m

	c	Expansion Chamber	L 250.00m x B 30.00 m x H 12.00 m
11		**Penstock Tunnel/Pressure Shafts**	
	a	Type	Finished steel lined - circular
	b	Number of Penstocks	5 Nos Independent Penstocks & 1 No Independent Penstock bifurcated in to 2
	c	Diameter of penstock	6.0 m
	d	Length of penstock	375 m
12		**Powerhouse**	
	a	Type	Surface Powerhouse
	b	Dimensions including DT	L 200.00m x B 24.00 m x H 56.50 m
13		**Tail Race Channel**	Trapezoidal
	a	Length of the channel	2390 m
	b	Bed width	55m width
	c	Full supply depth	5.6m
	d	Bed fall	1 in 5000
13		**Tailrace Trash rack**	
	a	Type	Inclined
	b	Sill Level	EL +585.78 m
	c	Top of trash rack	EL +642.0 m
14		**Hydro-Mechanical Equipment**	
	a	**Intake Structure**	
		Trash Rack	
		No. of bays in each trash rack	6 Nos.
		Dimensions	W 1.75 m X H 17.06 m – 6 nos. & 4 sets
		Intake Service Gate - 2 Nos.	W 8.00 m X H 12.50 m (Vertical lift fixed wheel type)
		Intake Stop Log Gate - 2 Nos.	W 8.00 m X H 12.50 m (Vertical lift fixed wheel type)
	b	**Draft Tube Gates**	High pressure steel type slide gates
		No. of gates per unit	2 per unit - W 6.50 m X H 7.00 m (Vertical lift fixed wheel type)
	c	**Penstock Gates**	
		No. of gates per unit	1 per unit - W 6.50 m X H 6.50 m (Vertical lift fixed wheel type)

15		**Electro Mechanical Equipment**	
	a	**200MW Turbines**	
		Pump Turbine	Francis type, vertical shaft reversible pump-turbine
		Total No of units	5 Units (2 Nos with Variable speed & 3 Nos with Fixed Speed)
		Rated Pumping Head	156.92 m
		Pump Capacity	230 MW
		Rated Head in Turbine mode	149.82 m
		Turbine Capacity	200 MW
		Turbine Design Discharge	154.28 Cumec for each unit
		Synchronous speed	166.67 rpm
	i	**Generator-Motor**	
		Type	Three (3) phase, alternating current synchronous, generator motor semi umbrella type with vertical shaft
		Number of units	5 Units
		Rated Capacity	Generator – 200MW; Pump Input - 230MW
		Rated Voltage	13.8KV
	ii	**Main Power Transformer**	
		Type	Indoor, 3-Ph transformers with Off-load tap changer (OLTC)
		Number of units	5 Units
		Rated Capacity of each unit	250 MVA
		Rated Voltage	Primary – 13.8 kV; Secondary - 400 kV adjustable range of the secondary voltage: -10% to +10%(3kV/tap)
	b	**100MW Turbines**	
		Pump Turbine	Francis type, vertical shaft reversible pump-turbine
		Total No of units	2 Units (1 Nos with Variable speed & 1 Nos with Fixed Speed)
		Rated Pumping Head	156.92 m
		Pump Capacity	105 MW
		Rated Head in Turbine mode	149.82 m
		Turbine Capacity	100 MW
		Turbine Design Discharge	77.14 Cumec for each unit

		Synchronous speed	250 rpm
	i	**Generator-Motor**	
		Type	Three (3) phase, alternating current synchronous, generator motor semi umbrella type with vertical shaft
		Number of units	2 Units
		Rated Capacity	Generator – 100MW; Pump Input - 105MW
		Rated Voltage	13.8KV
	ii	**Main Power Transformer**	
		Type	Indoor, 3-Ph transformers with Off-load tap changer (OLTC)
		Number of units	2 Units
		Rated Capacity of each unit	120 MVA
		Rated Voltage	Primary – 13.8 kV; Secondary - 400 kV adjustable range of the secondary voltage: -10% to +10%(3kV/tap)
16		**420KV Gas Insulated Switchgear**	**(GIS)**
	1	Type of GIS	Indoor Type
	2	No. of GIS units	One No
	3	Location	Inside GIS Building above ground
	4	Scheme	Double Busbar Arrangment
17		**POWER EVACUATION**	
	a	Voltage Level (KV)	400 KV
	b	Length (KM)	60 Kms
	c	Structure	400KV Multi Circuit Towers
	d	Conductor	Twin Moose
	e	Maximum Power required while pumping	1550 MVA (Approx)
	f	Number of Circuits proposed	Four Circuits
	g	Terminating at	One double circuit connected to PGCIL Narendra 400 KV substation at Dharwad and other double circuit connected to IRESP CPSS.
18		**Estimated Cost**	
	a	Civil Works & Other works	2609.94 Cr

	b	E & M Works incl transmission	1841.67 Cr
	c	I DC	534.19 Cr
		Total Project Cost with IDC	4985.80 Cr

CHAPTER – 3
PROJECT AREA

3.1 General

Saundatti IRESP - Storage Project is located in Belagavi district of Karnataka. It envisages creation of a reservoir across a Jagavalla Halla depression which is flowing NW – SE direction, joining the Malaprabha reservoir near Yekkundi village. The project is about 80 km from District headquarters Belagavi via Yeragatti. Nearest railhead and Airport are located at Dharwad and Belagavi respectively. The nearest Village to project is Somapura about 3 Km, which comes under Tallur Grama Panchayat, Saundatti Taluk. The Storage Capacity of the Project is proposed as 9600 MWH.

Karnataka is one of the 29 states of India, situated on the country's southwestern coast. The state is the seventh largest state covering an area of 1,91,976 km2 (74122 sq. mi). As per 2011 census of India, the state is the eighth largest by population with 6,11,30,704 inhabitants.

The state borders Kerala in the south, Maharashtra in the northwest, Karnataka in the northeast, Arabian sea in the west, Tamil Nadu in the south east. Karnataka is divided into 30 districts and 4 administrative divisions. The state is geographically consisting of 4 principal regions, the coastal region of Karavali, the hilly Malenadu region comprising the Western Ghats, Malnadu region of Kolar, Bengaluru and Tumakuru and the Bayaluseeme region comprising the plains of the Deccan plateau. Geographically, the two main river systems of the state are the Krishna and its tributaries, the Bhima, Ghataprabha, Vedavathi, Malaprabha, and Tungabhadra, in the north, and the Kaveri and its tributaries, the Hemavati, Shimsha, Arkavati, Lakshmana Thirtha and Kabini, in the south. Most of these rivers flow out of Karnataka eastward, reaching the sea at the Bay of Bengal.

The total forest cover of the state after the bifurcation is left with an area of 22,862 km2. The forest in the state can be broadly divided into four major biotic provinces. They are Deccan Plateau, Central Plateau, Eastern Highland, East Coastal Plains. Though several etymologies have been suggested for the name Karnataka, the generally accepted one is that Karnataka is derived from the Kannada words karu and nādu, meaning "elevated land". Karu nadu may also be read as karu, meaning "black", and nadu, meaning "region", as a reference to the black cotton soil found in the Bayalu Seeme region of the state. The British used the word Carnatic, sometimes Karnatak, to describe both sides of peninsular India, south of the Krishna.

Karnataka has a rich diversity of flora and fauna. It has a recorded forest area of 38,720 km2 (14,950 sq. mile) which constitutes 20.19% of the total geographical area of the state. These forests support 25% of the elephant and 10% of the tiger population of India. Many regions of Karnataka are yet unexplored, so new species of flora and fauna are found periodically. The Western Ghats, a biodiversity hotspot, includes the western region of Karnataka. Two sub-clusters in the Western Ghats, viz. Talacauvery and Kudremukh, both in Karnataka, are on the tentative list of World Heritage Sites of UNESCO. The Bandipur and Nagarahole National Parks, which fall outside these sub clusters, were included in the Nilgiri Biosphere Reserve in 1986, a UNESCO designation. The Indian roller and the Indian elephant are recognised as the state bird and animal while sandalwood and the lotus are recognised as the state tree and flower respectively. Karnataka has five national parks: Anshi, Bandipur, Bannerghatta, Kudremukh and Nagarhole. It also has 27 wildlife sanctuaries of which seven are bird sanctuaries.

Wild animals that are found in Karnataka include the elephant, the tiger, the leopard, the gaur, the sambar deer, the chital or spotted deer, the muntjac, the bonnet macaque, the slender loris, the common palm civet, the small Indian civet, the sloth bear, the dhole, the striped hyena and the golden jackal. Some of the birds found here are the great hornbill, the Malabar pied hornbill, the Ceylon frogmouth, herons, ducks, kites, eagles, falcons, quails, partridges, lapwings, sandpipers, pigeons, doves, parakeets, cuckoos, owls, nightjars, swifts, kingfishers, bee-eaters and munias. Some species of trees found in Karnataka are Callophyllum tomentosa, Callophyllum wightianum, Garcina cambogia, Garcina morealla, Alstonia scholaris, Flacourtia montana, Artocarpus hirsutus, Artocarpus lacoocha, Cinnamomum zeylanicum, Grewia tilaefolia, Santalum album, Shorea talura, Emblica officinalis, Vitex altissima and Wrightia tinctoria. Wildlife in Karnataka is threatened by poaching, habitat destruction, human-wildlife conflict and pollution.

3.2 Malaprabha River

The Malaprabha river flows through Karnataka state. The Malaprabha river originates from Chorla ghats, which is a part of Western Ghats. It is a tributary to the Krishna river and it flows through the Dharwad district. The Malaprabha river is an important river in north Karnataka. The ancient temple of Shri Mauli Devi, which is located at the origin of the Malaprabha river, is a well-known pilgrimage centre in India. Badami, Pattadakal and Aihole temples, which are situated on the bank of Malaprabha river are famous in India. Some historical places are located on the bank of the Malaprabha river as well as in the vicinity of the river.

The Malaprabha river originates in the Western Ghats, in the Kanakumbi village of Belagavi district at an altitude of 792 meters above the sea level. The Kanakumbi village is 16 km west of Jamboti village, Khanapur Taluka, Belagavi District in Karnataka state. The Malaprabha river flows first in east direction and then north-west, for almost 300 km and then it merges with Krishna river, at Kudala Sangama in Bagalkot district, Karnataka state. Merging of these two rivers is done at height of 488 meters from sea level.

The Bennihalla, Tuparihalla and Hirehalla are the tributaries of the river. Including its tributaries, the Malaprabha river covers 11,549 Sq. km area. The catchment area of the river lies between 15° 00' and 16° 12' North latitude and 74° 14' and 76° 05' East longitude, in Karnataka state. The Malaprabha river flows from Kanakumbi, then Khanakpur-Soundatti-Nargund-Kudal Sangam, before it merges with the Krishna river at Kudal Sangama. The confluence of the Malaprabha river with the Krishna river is almost 304 km away from the origin of the Malaprabha river in Western Ghats.

The Bennihalla, Tuparihalla and Hirehalla are the main tributaries of the Malaprabha river. All these rivers originate in district Dharwad. The Bennihalla, Tuparihalla and Hirehalla, all are small streams. The Bennihalla originates at an elevation of 548 meters from sea level.

3.3 Climate

Climate of Karnataka presents an exceptional diversity. While the hilly and plateau regions demonstrate a different climatic behaviour, the plain presents comparatively a warmer atmosphere. Due to this diversity in climate and weather of Karnataka, it has been divided into 3 major parts:

- Coastal Karnataka, which includes: Dakshina Kannada and Uttara Kannada districts.
- North Interior Karnataka, which includes: Belagavi, Bidar, Bijapur, Dharwad, Gulbarga and Raichur districts.
- South Interior Karnataka, which includes: the remaining districts of Bengaluru Rural, Bengaluru, Bellary, Chikmagalur, Chitradurga, Kodagu, Hassan, Kolar, Mysuru, Mandya, Shimoga and Tumkur districts.

The most famous city of Karnataka is Bengaluru which is best known for its awesome weather and panoramic views. Bengaluru is also known as 'air-conditioned city'. During most of the time in year Bengaluru's atmosphere remains pleasant, it's douched with a nice shower, which dissolves a unique jolliness in the air during summers and winters. The coastal regions and highly elevated places reveal uniformity in day and night temperature. Till now the highest recorded temperature is 45.60° C at Raichur in 1928 while the lowest temperature of an individual station was recorded 2.80° C on December 16, 1918 in Bidar.

3.3.1 Summers

The average weather of Karnataka is dry and warm over different regions and summers start from the month of April which last till the month of May. These months are the hottest months in Karnataka, somewhere the humidity percentage is comparatively low but as the month of June starts; pervaded humidity in the air could make you uncomfortable as the monsoon is reaching the state soon. The average temperature remains around 34°C with 75% humidity.

3.3.2 Monsoon

Monsoon season starts from June and lasts till September, as prominent downfalls in temperature are noted but at this time the percentage of humidity gets a little higher in atmosphere. The Tropical Monsoon climate covers the entire coastal belt and adjoining areas. This area experiences heavy rainfall 3456 mm annually while the North interior Karnataka and its adjoining areas; Bijapur, Bagalkot, Belagavi, Haveri, Gadag, Dharwad, Gulbarga, Bellary, Koppal and Raichur districts experience mediocre rainfall of 731mm per annum. On the other side, the South interior Karnataka receives a blissful shower of monsoon annually.

3.4 Mineral Resources

The state of Karnataka is abundant in mineral resources. It is said to be one of the most mineral rich states of India. The mineral belt covers an area of 1.92 lakh sq.km including 30 districts of the state. Karnataka is also endowed with the green stone belt with valuable mineral resources such as gold, silver, copper, iron-ore, manganese, limestone, dolomite, asbestos, bauxite, chromite, kaolin and granite rock.

3.4.1 Other Minerals in Karnataka

Other minerals found scattered across the state are Chromite, Dolomite, and Bauxite. Chromite is found in altered ultrabasic rocks in the districts of Chikmagalur, Chitradurga, Hassan, Mysuru and Shimoga. Dolomite's presence has been recorded at a number of places. There is a possibility of a reserve of 1112 million tonnes of Dolomite deposits in the regions of Belagavi and Bijapur districts. Bauxite is found in the Chikmagalore district.

Karnataka is among the very few Indian states to formulate a progressive mineral policy as early as the year 2000. Features such as transparency in granting mineral concessions, adoption of modern techniques in mining and emphasis on value addition and sustainability make this policy so progressive.

3.5 Education

The average literacy rate of Karnataka is 75.36 percent. Male literacy rate in Karnataka is

82.47 percent. Female literacy rate in Karnataka is 68.08 percent. Total literates in Karnataka are 40,647,322 people. Male literates in Karnataka are 22,508,471. Female literates in Karnataka are 18,138,851.

3.6 General Features of the Project

Saundatti IRESP - Storage Project is located in Belagavi district of Karnataka. It envisages creation of reservoir across a Nalla called Jagavalla Halla joining the Malaprabha reservoir near Yekkundi village. There is no consumptive use of water as the same water is used for both pumping and generation. The project envisages construction of a Dam to form reservoir, an Intake Structure, Head Race Tunnel, Surge Chamber, Penstock tunnel and a surface Power House. Storage Capacity of the Project is proposed as 9600 MWH. There are no monuments of archaeological or national importance which would be affected by project activities directly or indirectly.

CHAPTER – 4

POWER SCENARIO

4.1. Karnataka State Power Position

Karnataka has 22289.96 MW capacity as on 28.02.2018 against 96294.45 MW in southern region and 334146.91 MW in all India.

4. All India Installed Capacity (MW) Region-wise as on 28.2.2018

	Thermal				Nuclear	Hydro	RES	Grand Total
Region	Coal	Gas	Diesel	Total				
Northern	52489.20	5781.26	0.00	58270.46	1620.00	19423.77	12620.69	91934.92
Western	69508.62	10806.49	0.00	80315.11	1840.00	7447.50	19339.09	108941.70
Southern	44382.02	6473.66	761.58	51617.26	3320.00	11808.03	29549.16	96294.45
Eastern	26921.64	100.00	0.00	27021.64	0.00	4942.12	1037.66	33001.42
North-East	520.02	1736.05	36.00	2292.07	0.00	1342.00	281.70	3915.77
Islands	0.00	0.00	40.05	40.05	0.00	0.00	18.61	58.66
ALL INDIA	193821.50	24897.46	837.63	219556.59	6780.00	44963.42	62846.90	334146.91

INSTALLED CAPACITY (IN MW) OF POWER UTILITIES IN THE STATES/UTS LOCATED IN SOUTHERN REGION INCLUDING ALLOCATED SHARES IN JOINT & CENTRAL SECTOR UTILITIES

State	Ownership/ Sector	Mode Wise Break Up						As on 28.02.2018	
		Thermal				Nuclear	Hydro (Renewables)	RES (MNRE)	Total
		Coal	Gas	Diesel	Total				
Karnataka	State	5020	0	127.92	5147.92	0	3599.8	155.33	8903.05
	Private	1958.5	0	25.2	1983.7	0	0	8276.01	10259.71
	Central	2429.2	0	0	2429.2	698	0	0	3127.2
	Sub-Total	**9407.7**	**0**	**153.12**	**9560.82**	**698**	**3599.8**	**8431.34**	**22289.96**

As per CEA Report for February 2018

Energy Power Supply Position Report								
State	February 2018				'April 2017 to February 2018			
	Energy Requirement	Energy Supplied	Energy not supplied		Energy Requirement	Energy Supplied	Energy not supplied	
	MU	MU	MU	%	MU	MU	MU	%
Karnataka	6234	6228	5	0.1	61035	60928	-107	-0.2

As per CEA Report for February 2018

Peak Power Supply Position Report								
State	February 2018				'April 2017 to February 2018			
	Energy Requirement	Energy Supplied	Energy not supplied		Energy Requirement	Energy Supplied	Energy not supplied	
	MU	MU	MU	%	MU	MU	MU	%
Karnataka	10205	10205	0	0	10381	10347	-34	-0.3

Karnataka energy requirement was 61035 MU and the supply was 60928 MU. Karnataka has a short fall of 107 MU.

4.2 Necessity of Hydro Power Development

The demand and supply position in Karnataka, discussed above, clearly brings out the immediate need for taking up new generation schemes in the state to bridge the gap between supply and demand. Karnataka has the largest hydro power potential among all the states of the Southern region. The need for implementing new hydroelectric schemes in the region for providing peak power besides energy at competitive rates therefore needs no further emphasis. In this power shortage scenario, the option available is to bridge the gap (to a great extent) between demand and supply adopting energy conservation measures optimally utilizing the existing generation capacity by improving Plant Load Factor (PLF) at the supply side and by adopting various energy efficiency measures at the demand side.

In addition of above the most reliable option for energy storage is development of Pumped storage schemes, which is the most widely used form of bulk-energy storage, which uses the simple combination of water and gravity to capture off-peak power and releases it at times of high demand. Along with energy management, pumped storage systems are also helpful in controlling electrical network frequency and provide reserve generation. Thermal plants are much less able to respond to sudden changes in electrical demand, potentially causing frequency and voltage instability. Pumped storage plants, like other hydroelectric plants, can respond to load changes within seconds.

In view of the power scenario described above, the Saundatti IRESP - Storage Scheme envisaged with Storage Capacity of 9600 MWH with Rating of 1200 MWH and will help a long way in meeting the projected power demand.

CHAPTER – 5

SURVEY & GEOTECHNICAL INVESTIGATIONS

5.1 General

The following investigations shall be carried out specifically for the proposed project and are briefly discussed in this Chapter:

- Topographical survey
- Geology & Geotechnical investigations
- Construction material investigations
- Hydrological & Meteorological investigations

5.2 Topographical Survey

Topographical maps (D43D1 and D43C13) of Survey of India were referred for preliminary investigation, reconnaissance and for finalizing the proposed project layout.

5.3 Reconnaissance Survey

The main aim of the project is to utilize the existing Renuka Sagar reservoir and proposed Saundatti IRESP reservoir to act as lower and upper reservoirs respectively for the proposed Saundatti IRESP - Storage Project.

A reconnaissance survey is made for the river, existing reservoirs, possible intake and exit locations, penstock tunnels, power house area and TRC. All salient features of the area are noted during the reconnaissance survey.

5.4 Geological Survey & Investigation

5.4.1 Physiography

The Belagavi district is divided into three physiographical divisions.

- Malenaadu Tract (Western Ghat Region)
- Gadinaadu Tract (Border area Region)
- Bayalunaadu Tract (Plain Land Region)

The “Malenaadu” tract is the Western Ghat area, with lush green forests, sharply undulating topography, and heavy rainfall. Many 1st order streams traverse this area. There are many natural springs in this tract. The “Gadinaadu” (intermediary) tract shows medium range flat to gently rising hills, with shrubby greenery, receiving an average rainfall. The streams are of 3rd & 4th order. The “Bayalunaadu” tract shows vast, flat terrain, with flat topped barren hills. The rainfall received is less than 650 mm.

5.4.2 Soil

Soil is an index of the bedrock. Most of the soil is a bi-product of weathering of the bedrock. The Basalt area is covered by black cotton soil where the rock is directly subjected to weathering. Wherever the Zeolitic beds are exposed the soil is brownish with specks of amygdaloids, chalcedony, quartz and calcite, etc. The Sandstone and Quartzite formation are covered by brown, or deep gray, sandy soil. The Lime stone and Dolomite are covered by calcareous dark gray soil.The Schist covered by yellow and purple shale shows yellow and purple soils. The BHQ bands are not altered sufficiently and in many areas the bands are exposed at surface. Broken BHQ pieces and deep brown soil is observed around these deposits. Phyllite having limited weathering shows dark gray coloured soil covering. The Granite and Gneissic Granite, show light brown to deep brown and deep gray soils often mixed with sand and feldspar. The dykes are surrounded by black cotton soil.

5.4.3 Regional Geology

The complex geological formations can be observed in the Belagavi district. The Schist and Banded Ferruginous Quartzite, the peninsular gneiss by Granite and Gneissic Granites, the Kaladgi formations, Sandstone, Quartzite, Shale and Limestone and Dolomite, Basalt (Deccan Trap) and the Laterite formations are observed in the district. The Geological Succession of Belagavi District as follows:

- Laterite, Sand deposits - Recent.
- Deccan Basalt - Tertiary,
- Sand Stone, Dolomite, Limestone - Kaladagi series,
- Schist, Gneiss, Granite - Archean.

The Archaen Schist is an extension of the Dharawar schist belt. The formation is overlaid by thick cover of shale, the thickness varying from 15 to 25m as observed in many villages of Khanapur and Bailhongal, Belagavi talukas. In few places like, Marihal in Belagavi taluka, Shivanur, Nichanaki villages of Bailhongal taluka, the shale cover extends up to 100 m. The Schist encountered below shale cover is greyish in colour, exhibit well developed platy structures. Individual plates can be easily separated. It is usually weathered up to 25-30 m. It shows a general trend of NW 10-SW 10SE dipping due east. The Schist formation is observed in Bailhongal, Khanapur, Belagavi and Saundatti talukas.

Phyllite is a hard formation, resembling schist by its grey colour, having trend, dip etc similar and occurring adjoining the schist. Joints and platy structures are poorly developed. It is massive in nature, breaking in to irregular, angular fragments or

irregular massive boulders. It shows a trend of NNW-SSE, and occurs parallel to schist. Such formation occupies limited extent in the Central part of Bailhongal taluka and Western parts of Saundatti shallow weathering, and non-porous nature, seepage of water is limited to shallow depth and hence regularly proved to be a poor aquifer. 16 villages of Bailhongal taluka and western part of Saundatti taluka, which are traversed by these formations acute shortage of water.

The BHQ exposures occur parallel to the schist formation. The quartz and hematite impart a mixed brownish colour to the rock. Well-developed banded structures can be clearly observed. Exposures of BHQ are observed in the Bailhongal taluka. This is characterized by compact platy structure of hematite and quartz bands. Both Schist and BHQ show a general trend of NNW-SSE direction, dipping due East.

The Sandstone, Quartzite and Limestone, Shaly Limestone represent the Kaladagis. The Sand stones are horizontally bedded, fine to coarse grained, exhibiting white, buff, pink, yellow colours. Many structural features, like parallel bedding current bedding, ripple marks, folds, faults, brecciation, conglomeration etc. can be observed. Usually in the lower contours, the rock is weathered up to 25-45 m. Flat topped hill ranges can be seen in Hukkeri, Ramadurga, Saundatti and Bailhongal Talukas. This is the second largest formation observed in the district. Lot of sandstone is being used as building material. There are few natural springs in Sandstone rock are also found, few of the springs are physically observed at the Yallamma temple, Sogal-kshetra, Hunashiwari math, Rudrapur fort etc.

The huge quartzite exposures are available in Ramadurga and Saundatti talukas. The Lime stone occurrence restricted to the eastern part of Gokak taluka and NE part of Ramadurga and South, western part of Khanapur taluka. This is greyish coloured, compact, and often thickly bedded. Ca% varies from 42-48%, Mg 14 %-17%. Si02 in Yadwad area ranges up to 7% Limestone of Belagavi district is massive in nature and occurs as massive deposits. This is being used for preparation of Lime, and Cement.

Dolomite is observed to occur in Limestone areas of Yadwad in Gokak taluka. A large deposit if Dolomite is observed near Yaragatti, Yarzarvi villages in Saundatti taluka. Sahley limestone is noticed around sidnal, Godachi village in Ramadurga taluka, being used as paving stone. Mg % is up to 21-27% with Ca % up to 29 - 30%. This is massive in nature, very brittle and often stands as hard, non-weathered stretch. In Talaewadi-Krishnapur range of Khanapur taluka there are at least 7-8 huge caves in limestone and dolomite are in area.

The Deccan Basalt, generally known as “Trap” of Deccan Trap” occupy a large extent in

the Northern part, thinning out towards South. The origin of Trap is resultant of volcanic eruptions in the Pune region of Maharashtra State and surface flows in to Karnataka. At least 3-4 volcanic flows can be seen above ground levels, (640m) and 3-4 flows, below surface levels. Individual trap flow is marked by inter-trepan bed, usually filled with Zeolites, Amygdaloids, Quartz, jasper, Calcite etc as cavity filling deposits. Well-developed onion of exfoliation type weathering, vertical and columnar joints can be noticed. Flat-topped hill ranges can be seen in Belagavi, Khanapur, Hukkeri, Chikkodi, Athani and Raibag talukas. This formation being the younger, it is observed to be over lying sandstone, schist, gneisses, limestone etc. At surface the rock is weathered up to 8-15m at various places. In many parts of Athani taluka, central parts of Chikkodi and Raibag taluka, the inter-trepan beds are exposed in the form of reddish, deep brownish soil, often mixed with the amygdaloids, jaspers, zeolites etc.

Laterite of this district is an altered product of Deccan trap. In a cross section, one can observe laterite at top followed by leached out alumina clay, grading down in to weathered of massive trap. It is exposed as covering over the trap bedrock. The alumina content is usually less than 30% but some detached, 49-59% alumina rich deposits (Bauxit) are observed in southwestern parts of Khanapur and Belagavi talukas. Because of its porous nature, laterite behaves as good receptor of water, allowing percolation up to the depth bedrock. This being followed by Deccan trap the water start to spread horizontally and at many places appear in the form of contact springs as observed in Khanapur and Belagavi talukas. Hence there are more than 15 villages having the water springs and using as their water supply sources.

Following table shows taluka wise distribution of geological formations in the district Belagavi.

Taluka	**Geological formation**
Athani	Daccan Trap
Belagavi	Schist, Laterite, Basalt, sandstone, Gneiss
Chikkodi	Daccan Trap
Gokak	Granite, Gneiss, sandstone, Basalt, Limestone, Dolomite.
Hukkeri	Basalt, sandstone Quartzite
Khanapura	Schist, Granite, Gneiss, Basalt, Limestone, Bauxite, Manganese, Iron ore, Limestone, Dolomite, Dyke,

	Clays.
Raibag	Daccan Trap
Ramadurga	Shale, Basalt, Quartzite, Sandstone, Gneiss, Limestone, Shaley Lime Stone
Saundatti	Sandstones and Quartzite
Bailahongal	Phyllite and Deccan trap, BHQ

5.4.4 General Geology of Proposed Dam Area

The proposed Dam axis area comprising with U shaped valley which is comprising vertical and sub vertical rock abutment at both banks of Halla and having well exposed rock exposers of sandstone and quartzite of Saundatti taluka of Belagavi formation which are having almost horizontal bedding which are dipping towards downstream of Halla (nalla) (NE). The well exposed quartzite which is massive in nature and having 30 cm to 2m thick beds which are separated with very thin layers of shale/ limestone and jointed with three prominent set of Joints having tight in nature and partly open also at places along with a bedding joints which are having very low dip angle (5-10-degree dipping towards 45 – 60NE). The both banks of Halla is covered with shallow depth overburden due to vertical joints and horizontal joint system of rocks disintegrated blocks of rocks are falling in foothills and converted in to debris which is partly flows in runoff water of monsoon rains and rest as accumulated at places and stored as debris.

Main Joints at Proposed Dam Area are as follows-

Dip Direction (° in Whole Circle)	Dip Amount (°)	Persistence (m)
300 – 340	70-75	> 15
240 – 270	75-85	5 – 7
130 – 150	65-75	3 – 5

And a Bedding Joint 050 – 065° and dipping amount between 5 – 10° having more than 50m persistence and partly open to tightly jointed also.

Photograph Showing Horizontal bedding and vertical to sub vertical jointing system at proposed dam both Abutments.

But the Halla Bed is covering with planned forest which is comprising with UK Liptus trees which are having about 10-15 years old because they all are and having 0.3 to 0.60m diameter of trunks. This kind of trees trunks reflect there may be an overburden depth between 10 – 15m. and river bed overburden characteristics is compacted debris overlaid by a thick layer of silty soil which is seem in locally cut sections in Halla bed which is nomenclature as clay or siltstone as shown in following photographs.

Photograph Showing Planned Forest in reservoir area and nature of overburden at Halla Bed.

Near the proposed dam axis, a check dam has constructed by some forest personals for maintaining the ground water level and getting saturated the planned forest. That may be a land mark for identification of proposed dam location. The downstream of proposed location comprising with slightly wider U-shaped valley which is approx. 300 m distance between both banks of Halla at bed of Halla it is slightly at crest level of both banks, and after some meters its getting kinked sharply towards left banks hence this is not a suitable location for construction of any dam structure. About 75 – 100m above from selected location which has finalized near the check dam location again valley is wider and forest is slightly less, and valley is almost in W shape, at bed of Halla it is about 150-170m wide and at top of hill it is about 260m wide. both banks of Halla is governed by vertical rocks at top 70-80 m heights and gentle slopes are also observed at both banks, wheres the bed rocks may available at shallow depths.

At this location the Halla bed is flowing NW - SE and about a stretch of 200 m downstream is straight and about 750m upstream also straight and wider in upstream.

Therefore, this location is seems good for housing any Dam structures, although the depth of overburden also need to identified through ERST ets. before reaching any conclusion.

Photographs showing Right Bank & Left Bank of Proposed Dam Axis

5.4.5 Tests & Investigations and Geological Mapping Scales

Considering that detail and dependable geological map of site constitute the backbone of all investigation and civil design, it is necessary that the detail geological map of the project components is carried out as per following details. The desired mapping shall pay special attention to demarcation of exposed rock and overburden deposits, and structural details, in particular foliation, master joints and shear.

For confirming the Halla bed and finalization of acceptable foundation level of Dam foundation at least 03 drill holes at proposed dam axis and 2 Nos at 50 M downstream of proposed axis need to drill up to 30 m in bed rocks, which can be executed during detail designing of project. ERT can be done in DPR Stage which will provide the information about depth of overburden in Halla bed. Bed rocks are exposed in both banks of Dam abutments and its physical property also known with field tests but for chemical property it is require conducting some laboratory tests at DPR Stage. A 25m deep 2.5 m wide and 2.0m high exploratory drift at both banks also require for optimizations of stripping limits of dam abutments and rock to rock and rock to concrete shear test also require because beddings are almost horizontally laid at both banks of proposed dam locations.

Engineering geological mapping of Tail Race tunnel and Penstock area need to cover lithology, discontinuities, any major structural features like faults, folds, etc. may be carried out in 1:5000 scale. For Proposed Power House area, the geological mapping of the entire complex is required. It is necessary to cover sufficient area around the components of the powerhouse complex. As the site is in rather complex geological setting, special efforts are required to carefully demarcate features like the rock slide, rock condition of the rock slide escarpment and all.

5.4.6 Geology of Powerhouse and Tunnels

As per the details collecting during surface geological mapping at glance it was confirmed that both banks of proposed location are comprising with excellent rocks and suitable to housing underground structures, with keeping axis of craven almost perpendicular to the main bedding joints. During construction and detail designing of projects In- situ test will give finial orientation of cavern based upon results of hydro-fracture tests and shearing tests.

For making any size of tunnels the adjacent rock outcrops are very suitable except some minor faults and shear joints which may be negotiated during construction of tunnels. For tunnelling TBM will be the most suitable method of excavations because the rocks are almost horizontally bedded and vertically to sub vertically dissecting with bedding joints hence falling of rocks may occur frequently if support of rocks may not provide on time although in TBM tunnelling pre-cast support are provided along with excavation of phase.

5.4.7 Geology of Rim Area

Along the Halla Bed a complete traverse was taken towards 3 KM up stream of proposed dam axis along with river bed and observations were recorded. The banks of Halla are fairly stable due to horizontally bedded of rock beds and vertically jointed. No slide zone was recorded in upside of axis up to 4 KM distance.

Photographs are showing Geology of RIM area of Dam

5.6 Construction Material

The excavated material from the tunnels and the power house components may be sorted, crushed, tested and utilized for the construction activities.

5.7 Further Studies for Survey & Geotechnical Investigation

Detailed topographic survey shall be carried out for the proposed Saundatti IRESP Reservoir area and for the all other project components. Similarly, large scale contour plans shall be prepared for taking up the detailed geological mapping of the proposed sites to

identify the shear zones and fault zones and to suggest sub- surface explorations.

5.8 Control Benchmarks

A network of control points shall be established in the project area, using auto-levels and Differential Global Positioning System (DGPS). Traversing shall be conducted between the DGPS points by using Total Station. Height control shall be established with respect to the existing bench mark.

CHAPTER – 6
HYDROLOGY & POWER POTENTIAL STUDIES

6.0 Introduction

Determination of Power Potential is the primary step in planning a Hydro Power Plant. The power potential of the project shall be dependent on the project layout, operating water levels, data on long term flow availability, selected turbo generating equipment type and its parameters etc.

This storage project is being planned on the allocated water of 1TMC for utilization by recirculation from existing Renuka Sagar reservoir. Secondly the proposed upper Saundatti IRESP reservoir is not located across any stream and the existing Renuka Sagar reservoir is located across river Malaprabha. Therefore no Specific hydrological studies are required to be carried out and similarly power potential studies are also required to be carried out for the power potential possibility to be generated by recirculation of inflows in between these reservoirs.

The Saundatti IRESP - Storage Project is proposed to utilize the water available in the existing Renuka Sagar reservoir located on river Malaprabha tributary to Krishna River near Naviluteertha village in Saundatti Taluk of Belagavi district. For forming the new upper reservoir to store the pumped water from lower reservoir, it is proposed to construct a Dam for the height of about 96m from the deepest foundation level. Two head race tunnels of 12m each starts from the power intake structure which is located on right side of upper reservoir conveys the water up to the Surge chamber. Six independent pressure shafts emerging from the Surge chamber will convey the water to the powerhouse. The water from power house out fall is let back to the existing Renuka Sagar reservoir through Tail Race Channel.

The Key parameters of proposed Saundatti IRESP Upper Reservoir are as follows:

Sl. No.	Parameter	Unit	Value
1	Full Reservoir Level (FRL)	m	EL 793.00
2	Minimum Draw Down Level (MDDL)	m	EL 760.00
3	Live Storage	TMC	1.01
4	Dead Storage	TMC	0.74
5	Gross Storage	TMC	1.75

6	Deepest Foundation Level (m)	m	EL 699.00
7	Height of Dam from Deepest foundation level	m	96.00

The Key parameters of Existing Renuka Sagar Lower Reservoir are as follows:

Sl. No.	Parameter	Unit	Value
1	Catchment Area of Reservoir	Sq. Km	2176
2	Design Flood Discharge	Cumec	5239
3	Full Reservoir Level (FRL)	m	EL 633.832
4	Minimum Draw Down Level (MDDL)	m	EL 623.93
5	Live Storage	TMC	34.346
6	Dead Storage	TMC	3.385
7	Gross Storage	TMC	37.731
8	Length of Dam	m	154.53
9	Height of Dam	m	40.23

SAUNDATTI PSP – UPPER RESERVOIR							
AREA CAPACITY TABLE							
ELEVATION (m)	Depth (m)	AREA (M.sq.m)	Sqrt Area	Sqrt(A1 * A2)	Capacity (MCM)	Cum.capacity (MCM)	Cum.capacity (TMC)
699	0	0.000000	0.0000	0.0000	0.0000	0.0000	0.0000
700	1	0.010000	0.1000	0.0000	0.0033	0.0033	0.0001
710	10	0.097000	0.3114	0.0311	0.4605	0.4638	0.0164
720	10	0.226000	0.4754	0.1481	1.5702	2.0340	0.0718
730	10	0.357000	0.5975	0.2840	2.8902	4.9242	0.1739
740	10	0.485000	0.6964	0.4161	4.1937	9.1179	0.3220
750	10	0.596000	0.7720	0.5376	5.3955	14.5133	0.5125
760	10	0.700000	0.8367	0.6459	6.4730	20.9864	0.7411
770	10	0.799000	0.8939	0.7479	7.4895	28.4759	1.0056
780	10	0.890000	0.9434	0.8433	8.4409	36.9168	1.3037
790	10	1.000000	1.0000	0.9434	9.4447	46.3615	1.6372
793	3	1.110000	1.0536	1.0536	3.1636	49.5251	1.7490

6.1 Malaprabha River

The Malaprabha river flows through Karnataka state. The Malaprabha river originates from Chorla ghats, which is a part of Western Ghats. It is a tributary river to the Krishna river and it flows through the Dharwad district. The Malaprabha river originates in the Western Ghats, in the Kanakumbi village of Belagavi district at an altitude of 792 meters above the sea level. The Kanakumbi village is 16 km west of Jamboti village, Khanapur Taluka, Belagavi District in Karnataka state. The Malaprabha river flows first in east direction and then north-west, for almost 300 km and then it merges with Krishna river, at Kudala Sangama in Bagalkot district, Karnataka state. Merging of these two rivers is done at height of 488 meters from sea level.

The Bennihalla, Tuparihalla and Hirehalla are the tributaries of the river. Including its tributaries, the Malaprabha river covers 11,549 Sq. km area. The confluence of the Malaprabha river with the Krishna river is almost 304 km away from the origin of the Malaprabha river in Western Ghats.

The difference in catchment area at the proposed Saundatti IRESP reservoir is about 0.386 Sq. Km and since only one stream is joining in the proposed location of reservoir, no specific hydrology study is required and hence no design flood is considered for designing the reservoir.

6.2 Discharge Series

Based on the inflow data and the storage capacity of the existing reservoir, power potential study was carried out to assess the installed capacity. The Saundatti IRESP is envisaged to utilize 1.0 TMC of water to be pumped from the existing Renuka Sagar reservoir to the proposed upper Saundatti IRESP reservoir in 9.2hours. The project is a pumped storage scheme and hence, no consumptive utilization of water is required for its operation.

6.3 Renuka Sagar Reservoir (Existing)

The existing Renuka Sagar reservoir will be utilised as a lower reservoir to enable Saundatti IRESP to operate as a peak station. The FRL & MDDL of existing Renuka Sagar reservoir is at EL 633.832m & EL 623.93 m respectively. The live storage capacity of existing reservoir is 34.346 TMC. Water will be pumped to the proposed upper reservoir through TRC.

The proposed upper Saundatti IRESP reservoir is located at EL 699.00m and the FRL and MDDL of this reservoir is at EL 793.00m & 760.00m respectively. The live storage of the proposed reservoir is kept for 1.01 TMC. A tail race channel of approx. 2390m will

discharge the flows in to existing Renuka Sagar reservoir after power generation.

6.4 Operation of Pumped Storage Project

The Saundatti IRESP is proposed with Storage Capacity of 9600 MWH with Rating of 1200 MWH. This project is comprising of 5 units of 200 MW each and 2 units of 100 MW each. The Project will generate 1200 MWH by utilizing a design discharge of 925.68 Cumec and rated head of 149.82m. The Saundatti IRESP will utilize 1360 MW to pump 1.0 TMC of water to the upper reservoir in 9.2hours.

The Key parameters of Pumped Storage Operation are as follows:

Sl. No.	Parameter	Unit	Value
1	Storage Capacity	MWH	9600
2	Rating	MWH	1200
3	No. of Units	Nos.	7
4	Rated Head in Turbine mode	m	149.82
5	Total Design Discharge	Cumec	925.68
6	Design Discharge per unit – for 200 MW	Cumec	154.28
7	Design Discharge per unit – for 100 MW	Cumec	77.14
10	Generation Duration	Hrs.	8.00
11	Annual Energy Generation	Mu	3329
12	Pumping Head	m	156.92
13	Pumping Duration	Hrs.	9.20
14	Annual Energy consumption	Mu	4338
15	Cycle Efficiency	%	76.74

The volume of water required for turbine mode of operation is equated to the pumped mode. Annual energy generation by Saundatti IRESP in Turbine mode is 3329 MU and Annual energy consumption by Saundatti IRESP in Pumping mode is 4338 MU and the Cycle efficiency is 76.74%

6.5 Operating Head

The energy computations have been carried out based on headwater/full reservoir level (HWL/FRL), tail race water level conditions, efficiency of the turbo-generator and the minimum and maximum load. Full reservoir level at Saundatti IRESP reservoir is at EL+793.00 m and MDDL is at EL+760.00m. Normal tail water level corresponding to above design discharge at Tail Pool is EL +623.43m. The bed level of the tail race Channel is kept at EL + 617.83 m.

CHAPTER – 7
DESIGN FEATURES OF MAJOR COMPONENTS

7.0 Introduction

The Saundatti IRESP - Storage Project is located in Belagavi district of Karnataka. It envisages creation of reservoir across Jagavalla Halla which joins the river Malaprabha, a tributary of River Krishna near Village Somapura which comes under Tallur Grama Panchayat, Saundatti Taluk about 80 Kms from Belagavi. It originates Chorla ghats which is a part of Western Ghats in Karnataka and also flows through Dharwad district. It merges with Krishna river, at Kudala Sangama in Bagalkot district, Karnataka state. The Malaprabha river flows first in east direction and then north-west, for almost 300 km and then it merges with Krishna river, at Kudala Sangama in Bagalkot district, Karnataka state. Merging of these two rivers is done at height of 488 meters from sea level. The Bennihalla, Tuparihalla and Hirehalla are the main tributaries of the Malaprabha river. All these rivers originate in district Dharwad.

The scheme will involve construction of 96m high Dam for creation of Saundatti IRESP reservoir with gross storage capacity of 1.75TMC, and the Saundatti IRESP - Storage Project is proposed in between two reservoirs i.e. Saundatti IRESP Reservoir as Upper reservoir (to be constructed newly) and Renuka Sagar Reservoir as Lower reservoir (existing). Water will be let out from the Saundatti IRESP reservoir through Power Intake and Head race tunnel of 817m long to feed the Saundatti IRESP, having an Storage Capacity of 9600 MWH with Rating of 1200 MWH. This project is comprising 5 units of 200 MW each and 2 units of 100 MW each. The water after power generation will be conveyed through a 2.39km long Tail Race Channel to discharge water in to Lower reservoir of existing Renuka Sagar reservoir. General Layout of the proposed scheme is enclosed in the drawing AA/POWER/2153/001.

The Key parameters of the proposed Upper Saundatti IRESP Reservoir are as follows:

Sl. No.	Parameter	Unit	Value
1	Top of Bund	m	EL 795.00
2	Full Reservoir Level (FRL)	m	EL +793.00
3	Minimum Draw Down Level (MDDL)	m	EL +760.00
4	Live Storage	TMC	1.01
5	Dead Storage	TMC	0.74

6	Gross Storage	TMC	1.75
7	Deepest Foundation Level (m)	m	EL +699.00
8	Height of Dam from Deepest foundation level	m	96.00

The Key parameters of the Existing Renuka Sagar Lower Reservoir are as follows:

Sl. No.	Parameter	Unit	Value
1	Catchment Area	Sq. Km	2176
2	Design Flood Discharge	Cum	5239
3	Full Reservoir Level (FRL)	m	EL 633.832
4	Minimum Draw Down Level (MDDL)	m	EL 623.93
5	Live Storage	TMC	34.346
6	Dead Storage	TMC	3.385
7	Gross Storage	TMC	37.731
8	Length of Dam	m	154.53
9	Height of Dam	m	40.23

7.1 Intake Structure

The intake structure of Saundatti IRESP will be constructed on the right side of Saundatti IRESP reservoir. The Intake structure will have 2 vents each of will be fitted with a semicircular reinforced concrete trash rack structure to avoid entry of floating material and debris. Hence the floating debris will not enter the Head Race Tunnel. There is a provision of service gate and Stop log gate with vent size 8.0m x 12.5m. The total design discharge for the HRT is 925.68 Cumec.

The centre line of the head race tunnel emerging from the trash rack is EL +745.26m and the trash rack is proposed to rest on rock at around EL +735.77m. Radius of the trash rack is 14.60 m.

7.2 Head Race Tunnel

A modified horse shoe shaped head race tunnel of 12.0 m diameter and 817m length up to the surge shaft is designed to carry a discharge of 925.68 cumecs. The tunnel alignment

has been fixed with adequate rock cover. This tunnel will also be provided with suitable rock support system depending upon the geological strata formations enroot. Apart from the rock support system, the headrace tunnel will be provided with 720 mm thick cement concrete lining to reduce the head loss due to friction.

7.3 Surge Shaft

To take care of pressure rise in case of sudden load rejection and to meet the sudden demand of water in case of sudden load acceptance, a Surge Shaft of 25 m wide and 150m long with top elevation at EL +805.0m has been provided at the tail-end of headrace tunnel. The surge shaft is also provided with gates for the penstocks.

During preparation of detailed report transient studies for finalization of dimensions of Surge Shaft needs to be carried out. In case transient studies reveal that during maximum down surge condition, the water level in the surge shaft goes below the crown of HRT, it is proposed to provide expansion chambers at right angle to the flow. The Surge shaft is provided with adequate rock support system and a reinforced concrete lining of 500 mm thickness up to the top.

7.4 Penstock Tunnel / Pressure Shaft

Five independent pressure shaft / penstock tunnels of 6.0 m diameter are proposed to provide supply of water to feed five units of 200 MW. One penstock of 6.0m dia bifurcated into 2 will feed 2 units of 100 MW. The length of the penstocks up to powerhouse location shall be 375m. Flow through the penstocks shall be controlled through the gates provided at the surge chamber during maintenance. Flow from each of these penstocks to turbines shall be controlled by a butterfly valve (MIV) in the power house. Economical dia. of the pressure shaft has been worked out by cost optimization studies for various diameters. Accordingly, a diameter of 6.00m has been adopted to carry the design discharge of 154.28 Cumec for each unit.

7.5 Power House

The Power house for pumped storage plant is proposed near to upper reservoir. The project envisages the utilization of the Rated head of 149.82 m. The Pumped storage plant comprises of 7 units. The Key parameters of Pumped Storage Operation are as follows:

Sl. No.	Parameter	Unit	Value
1	Storage Capacity	MWH	9600
2	Rating	MWH	1200
2	No. of Units	Nos.	7

3	Turbine Capacity – 5 Units	MW	200
4	Turbine Capacity – 2 Units	MW	100
5	Rated Head in Turbine mode	m	149.82
6	Design Discharge per unit of 200 MW	Cumec	154.28
7	Design Discharge per unit of 100 MW	Cumec	77.14
8	Total Design Discharge	Cum	925.68
10	Generation Duration	Hrs.	8.00
12	Annual Energy Generation	Mu	3329
13	Pump Capacity – 5 Units	MW	230
14	Pump Capacity – 2 Units	MW	105
15	Pumping Head	m	156.92
16	Pumping Duration	Hrs.	9.20
17	Annual Energy consumption	Mu	4338
18	Cycle Efficiency	%	76.74

Pumping operation is proposed at 9.2 hours/day. No Pumping operation is envisaged in the monsoon. Each day turbine volume is equal to the Pumped volume.

Turbine operation is proposed at 8.00 hours/day during morning peaking and evening peaking hours. During monsoon period, pumped storage project can operate in turbine mode to maximize the energy generation for any surplus flows.

Two alternative types of powerhouse viz., surface and underground types have been studied. Considering the topography of the proposed location, surface power house is provided. As the proposed power house involves little deeper excavation, intricate supporting arrangements for the cut slopes involving anchors etc., are provided. The control room is proposed in the downstream of machine hall above the Draft tubes.

However, a detailed study can be carried out for selection of location and type of power house at the time of preparation of DPR.

7.6 Machine Hall

The internal dimensions of power house have been proposed with length 200m and width 24.00m including service bay. The units have been kept at about 23.00m spacing while the erection bay have been proposed as 30m long. For housing control room and various

auxiliaries/offices, 4 nos. floor have been proposed on the D/s side of Power house over the draft tube. The main inlet valve is proposed to be housed in power house just u/s of turbine. 2 Nos EOT crane of 400/60 tones capacity has been proposed in erection bay and unit bay to facilitate erection and repair of heavy equipment including main inlet valves.

7.7 Muck Disposal

By constructing a 817m long twin tunnel and Power house complex, Surge chamber, TRC etc. the quantity of muck to be generated is estimated to be about 72.15 lakh Cum. It is expected that about 57.90 lakh Cum of this will be used for making aggregates and construction of roads etc. The rest will require to be disposed off in a planned manner. This is the most important aspect to be dealt with. It is proposed to dump about 10.00 Lakh Cum of muck in the reservoir bed as there is no water course is existing and the remaining quantity of muck is proposed to dump in 3 different locations of dumping sites and they are to be identified at suitable places. Retaining walls will be constructed for retaining the muck. After the filling is done, rehabilitation of this site will be done to ensure that neither it flows in to the water stream nor it poses any other environmental threat. Plantation, wherever possible, will also be done on these sites so that these get stabilized over a period of time and do not pose any environmental problem. Detailed analysis of the muck disposal mechanism shall be studied at the time of preparation of Detailed Project Report.

CHAPTER – 8

ELECTRO - MECHANICAL EQUIPMENTS

8.0 Electro-Mechanical Equipments

The Electro-Mechanical equipment required for the proposed Hydel scheme comprises of the following:

- Butterfly Valve for each Turbine.
- Turbine/Pump and its auxiliaries like lubricating oil system, Governor and its oil pressure unit, Grease lubrication system and cooling water system etc.
- Generator/Motor and its auxiliaries like Excitation & Automatic Voltage Regulation system, Cooling system, Brakes, PLC and Automation arrangement etc.,
- Control, Protection, metering, measurement and annunciation panels for Turbine, generators, and 400KV feeders.
- Bus duct shall be provided for connecting generator to the generating transformer, UAT, LAVT, NGT etc., for trouble free reliable operation.
- Generator Transformers with ON Load tap changer along with control and protective gear and breakers etc.
- One no. 420KV Gas Insulated switch-gear (GIS) unit with bus sectionalize is proposed for connecting to two different sources.
- Auxiliary Power supply system consisting of unit auxiliary transformers, station auxiliary transformer, D.G Set for alternative emergency supply and station/ unit auxiliary boards for station auxiliaries, unit auxiliaries.
- Control supply system consisting of station battery, charger and its distribution system.
- The station auxiliaries like EOT crane, D.T crane, Air Compressor system, Dewatering and Drainage system, firefighting equipment, Air conditioning, Ventilation system and illumination system.
- Power evacuation system consists of transmission line, protection/ metering equipment, CT's, PT's, LA's along with its supporting structures and Receiving end equipment including bay extension at the other end.

A brief description of the Electro-Mechanical equipment is as follows.

8.2 MECHANICAL EQUIPMENT:

The Mechanical equipment consists of Turbine, Main Inlet Valve, Governor, instrumentation & control system, oil pumping, cooling water, Drainage, Dewatering system, crane etc.

8.2.1 Butter Fly Valve:

Each Turbine is provided with a Butterfly valve to act as a main inlet valve in order to achieve quick closing to cut off the water supply for the Turbine in the event of any machine tripping on a lock out fault. The Butter fly valve will be of plain door type with rubber seals designed to open under unbalanced conditions and close against full flow in emergency. The Butter fly valve shall be normally opened and closed by hydraulic system and also have backup closing system with dead weight for closing during emergency. Hydraulic operated Bypass valve is provided across the Butterfly valve for smooth operation with pressure balance condition.

i) Size and Body:

The Size of the Butter fly valve proposed is 6000mm. It shall be fabricated from steel plates and provided with PTFE/Grease lubricated bronze bushes for bearings and cup seals for trunions and stainless steel sealing ring for the main seal.

ii) Door:

It shall have plane door fabricated from steel plates. The valve door shall have peripheral sealing ring of solid rubber.

iii) Sealing Device:

The valve will be provided with adequately reinforced rubber sealing held in position by means of removable sealing ring fixed by rust less screws against stainless steel ring secured to the valve body.

iv) Dismantling Joint:

The Joint shall be of Telescopic type and located on downstream of valve facilitating dismantling of valve during maintenance.

v) Lever:

A lever will be provided to the trunnion and a dead weight will be mounted on other end.

vi) Servo Motor:

Servo Motor of double acting type comprising of fabricated steel cylinder with covers, piston and pressure oil system will be provided in a complete shape.

8.2.2 Turbine/Pump:

The machines have four running modes namely

- "generate"
- "spin generate"

- "spin pump"
- "pump"

Involving two directions of rotations and power flow. The shutdown condition can be treated as a further mode. The diversity of the control requirements is therefore much greater. In the first two modes of operation, a machine rotates in the turbines (as opposed to pump) direction, that is clockwise when viewed from above. It can generate at any load (generate) or having been started in the "generate mode" can have its load reduced and water level in the pump/turbine runner chamber and the draft tube lowered by compressed air, thus leaving the machine spinning as a synchronous compensator with its runner in air.

In the second operation (two modes), the direction of rotation is reversed. The set is run as a motor with a SFC controller, the water level in the pump turbine having lowered. When the machine is synchronizing it can remain running as a synchronous compensator (spin pump) or water can be admitted to the pump/turbine and pumping carried out at a fixed guide vane setting (pump).

Final Design:

The final design of the Turbine components would be carried out by means of Model Test results of Turbine.

8.2.3 Materials and Construction Features of Turbine:

Runner:

The turbine runner will be integrally cast / welded in stainless steel material having 13% chromium and 4% nickel and properly stress relieved. The runner will have suitable no. Of vanes polished and ground smooth and will be mounted on the turbine shaft. Adequate number of relief holes will be provided in the runner for the water past runner crown seal.

Guide Vanes:

Guide vanes will be of cast stainless steel material conforming to 13% chromium and 4% nickel and finished smooth. Guide vane operating mechanism will be of forged or fabricated steel. Each guide vane will be supported in grease or self lubricated bearings. Synthetic rubber seals will be provided to prevent leakage of water. The guide vanes will be operated by guide vane servomotor for which the pressurized oil will be supplied from the pressure oil system. The control of guide vane opening will be through the governor.

Guide Vane Operating Mechanism:

Guide vane operating mechanism will consist of levers, friction coupling / shear pins, links, servomotor connecting rods, guide vane, regulating ring etc. The mechanism will be designed and constructed to withstand stresses due to servomotor and wear and tear.

Turbine/pump Shaft:

A turbine/pump shaft will be provided for mounting the turbine runner. The material of turbine/pump shaft will be of carbon steel forging conforming to BS 29 or ASTM A 668 Class D.

The shaft will have adequate diameter to operate safely in combination with generator. The turbine shaft will be connected directly to the generator shaft by means of a suitable coupling.

Shaft Sleeves:

The shaft will be provided with renewable stainless steel sleeve. The sleeve will be of split construction and securely fastened to the turbine shaft.

Shaft Seal:

The shaft seal will be provided to prevent leakage of water through the gap between the shaft and turbine cover. The shaft seal will be of labyrinth type seal with white metal lining.

Thrust and Guide Bearing:

The Thrust and Guide Bearing will be of the self contained, oil lubricated pedestal type, water cooled. The bearing assembly will consist of Vertical tilting pad thrust and journal bearing. The journal pads will be lined with tin base white metal. The bearing accommodates the thrust pads below the thrust collar to carry thrust load. As the bearing is self lubricated / oil bath type, no external lubrication system required.

Stay Ring Assembly:

The stay ring assembly will be made of fabricated steel plate conforming to IS - 2062 Gr. ‘B’. The stay ring assembly will have set of streamlined stay vanes to guide the water flow.

Spiral Casing:

Spiral casing will be of welded construction fabricated from steel plates conforming to IS -2062 Gr. ‘B’ designed to withstand the maximum operating pressure including water hammer. The stay ring assembly will be welded to the spiral casing. The spiral casing will be anchored in concrete. The upstream flanged end of spiral casing will be bolted to the dismantling joint of turbine inlet BF valve.

Draft Tube:

The draft tube will be made of fabricated steel plates conforming to IS – 2062 Gr. - ‘B’. Draft tube will be fabricated in 2 or 3 parts namely draft tube cone and draft tube liner etc., and will be heavily reinforced by ribs and anchored in the concrete.

Oil Pumping Unit:

The oil pumping unit will be provided for supply of pressurized oil for the following:

a) Guide vane Servomotor

b) Turbine inlet butterfly valve

For regulation of flow through guide vanes, the pressurized oil will be supplied through servo valve, which will receive an electronic signal from governor. The oil-pumping unit will be provided with two pumps (one main and one standby) with auto-changeover facility along with other required accessories. For ensuring availability of stored pressurized oil, adequate capacity of nitrogen bladder type accumulators will be provided which is a modern practice and this will avoid compressed air system with air receiver, pressure oil receiver etc., for the governor pressure oil system. The pressure oil system will be provided with necessary instrumentation and control system for the safe and reliable operation of the units.

OPU system for the inlet valve and for Governing system shall be separate and of adequate capacity. i.e, two complete operations could be carried out with absence of power supply. Two electrical pumps shall be operated in Main and standby pump will operate at level – 2 pressure drop.

Governing System:

The turbine will be controlled by an electronic governor. The system will be so designed that the main functions of speed control, power control are handled as a separate program parts and shall be programmed to suit Francis turbine having adjustable guide vanes. Governor shall also support RGMO mode of operation as per clause 5.2(f) of the Indian Electricity Grid Code with latest amendments.

Cooling Water System:

Water required for cooling and shaft sealing of the machine will be taken from the Tail race and supplied to various coolers such as turbine bearing coolers, generator bearing oil coolers, governor oil cooler, stator air coolers and turbine shaft seal etc. through booster pumps and suitable duplex strainers as required. The cooling water system will be provided with necessary instrumentation such as flow switches, differential pressure switches across the strainers and pressure switches etc., for safe and reliable operation of the units.

Considering site ambient condition option for Chilled water to be considered during detailed engineering for cooling water system.

8.2.4 Auxiliary systems:

I) Air Conditioning System:

Chiller units of adequate capacity shall be provided for air-conditioning of the important areas of the plant. Chiller units are to be placed in transformer cavern. Detailed design of same shall be done at DPR stage.

II) Ventilation System:

Adequate ventilation tunnels have been proposed in this report for the underground system, consists of Transformer cavern, Power house and other areas. Air Handling units are to be placed in transforrmer cavern. Detailed design of same shall be done at DPR stage.

III) Crane and Hoists:

Two nos EOT cranes of 400/60 Tons capacity each will be installed in the power house building for handling equipment during erection and maintenance. For handling of intake and draft tube gates suitable electrically operated hoisting mechanism will be provided individually. Tandem operation of two EOT cranes shall be provided.

IV) Dewatering and Drainage System:

For Dewatering of turbine casing water up to the Tail race gate, Six (6) numbers of submersible pumps each of capacity **500 m3/hr** will be provided. The Dewatering sump will be located in the station floor and a pipe from the Tail race will be embedded and connected to the Dewatering sump. An isolation valve will be provided in this pipe which will be opened during Dewatering. The discharge from the pumps will be taken above the maximum flood level. The discharge line will be provided with necessary isolation valves and piping. Necessary level switches will be provided in the Dewatering sump to facilitate auto start / stop of the pumps.

To remove drain water collected in the drainage sump located in the BF valve pit / Station floor, Six (6) numbers of sump pumps each of capacity **400 m^3/hr** will be installed with necessary piping and valves. The discharge from the pumps will be taken above the maximum flood level. The discharge line will be provided with necessary isolation valves and piping. Necessary level switches will be provided in the drainage sump to facilitate auto start/stop of the pumps.

V) Fire Protection System:

The proposed fire protection system shall be designed to provide adequate safety measures in the area susceptible to fire in the power station. TAC classifies hydel

power generating stations as “Light hazard Occupancy” and hence the system shall be designed accordingly. This system is designed as per applicable requirements of NFPA 851 (recommended practice for Fire Protection for Hydroelectric Generating Plants).

Fire protection system design and drawings enclosed.

VI) Air Compressor System

Suitable Tank mounted air compressor system to meet the station requirements such as for brakes, cleaning etc. is provided

8.3 ELECTRICAL EQUIPMENT:

The Electrical scheme showing the major system, such as the Generator and its connections to 420KV GIS switchgear for Power evacuation to near by substations, 13.8KV Switchgear and 415V Auxiliary Power distribution.

8.3.1 Generator/Motor:

The synchronous generator/Motor will be 200/230 MW (5 Nos.), & 100/105 MW (2No’s), 13.8KV, 3 phase with 0.9 PF (lag), 50Hz with Static type excitation system, suitable for parallel operation with the grid. The generator winding will be of Class F insulation with temperature rise limited to Class B and will be star connected. The generator neutral (star point) will be grounded through suitably rated grounding/ distribution Transformer with loading resistor connected to secondary side to restrict earth fault current to a safe limit. Six terminals of the generator, 3 on the phase side and 3 on the neutral side will be brought out for external connection. The short circuit ratio of the generator shall be greater than 1 for better stability on faults.

I) Generator Stator:

The stator frame makes up part of the stator segments and is assembled together with the core and coil. The stator winding is insulated with epoxy resin.

II) Generator Rotor:

The rotor comprises of a welded steel rotor center (outside serves as a yoke) and magnetic poles bolted on the periphery.

III) Excitation System:

The excitation system will be of static type system. This is also one of the most popular and very fast response excitation system for large synchronous machines. The excitation voltage is controlled by (silicon Controlled Rectifier – SCR). The voltage is supplied by a pair of brushes and slip rings. The ceiling voltage of the

excitation system will be at least 150% to 200% of the normal field voltage and response ratio will be about 2.0.

Static excitation system consists of mainly following parts -

a) Rectifier Transformer.

b) Thyristor Rectifier Banks.

c) Excitation start up and field discharge equipment.

d) Regulator and operation control circuit.

Excitation system will have both auto mode and manual mode.

IV) Brakes:

Generator will be provided with air-operated brakes to bring the rotor parts of the generator and turbine to stop from about 30% of rated speed during normal operation. The brakes will also be suitable for application at higher speed during emergency shutdown of the unit, in order to bring the rotor to rest at faster rate. The brakes will operate automatically/ manually from local control panel/ unit control board.

VI) Neutral grounding cubicle

Neutral grounding cubicle consists of current transformers for protection, 3 phase star formation, Grounding transformer with resistor connected to the secondary of transformer, earth isolation switch with pad lock arrangement.

8.3.2 13.8KV LAVT Cubicle:

The power generated will be fed to 13.8KV side of the each transformer through respective Lightning Protection Voltage Transformer (LAVT) cubicle and neutral terminals are connected to Neutral grounding cubicle by means of Bus Duct. The auxiliary loads of the respective Units will be fed from Unit Auxiliary Transformers. These transformers shall be connected to the 13.8KV LAVT Cubicle.

The main electrical parameters of the switchgear will be:

a)	Rated voltage	-	13.8KV	
b)	Rated short circuit current	-	125kArms&75kArmsfor	3 seconds
c)	Rated current of bus bars	-	12,000 A & 6000 A	

LAVT Cubicle will consist of Lightning Protection equipment and voltage transformers. The Lightning Protection equipment would comprise of lightning arresters with suitable discharge characteristics to suit the Generator insulation level in parallel with suitably rated

capacitor for smoothening the rate of rise of impulse voltage.

The LAVT cubicle will be connected by means of Bus Duct to Generator and to the Generator transformer. The Voltage transformer will be single phase, star connected, dry type units with draw out features. Current transformers for protection metering on line side of the Generator were provided in this cubicle.

8.3.3 Step-up Transformers:

Power generated at 13.8kV will be stepped up to 400KV by means of 5 nos 3-Ph 260MVA & 2 Nos 3-Ph 120 MVA 13.8/400KV oil filled transformers. These Step-up transformers will be installed in Transformer Cavern. Capacity of the transformers arrived based on the Power Factor 0.9, Derating factor.

The main electrical parameters of each transformer will be:

(a)	Voltage ratio	-	13.8KV/400KV, 3 phase, 50 Hz
(b)	Rating	-	260.0 MVA and 120MVA
(c)	Cooling Method	-	OFWF (Oil Forced and Water Forced)
(d)	13.8KV connection	-	Delta
(e)	400KV connection	-	Delta/Star with neutral solidly earthed.
(f)	ON load tap changer	-	In the range of +/-10.0% in step of 2.5% as per IS 10028 (part – I)

The 13.8KV terminals (Primary) will be suitable for Bus Duct connection and 400KV terminals for connection to GIS.

8.3.4 420KV GIS (1 No.):

One no 420KV Gas Insulated switch-gear (GIS) units are proposed. Each GIS unit is connected on the secondary side of three nos 3-phase transformers each.

Standards

The system and equipment shall be designed to the latest revisions of the following applicable standards. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose:

Sl. No.	Standards	Description
1	IEC 62271(All Parts)	“High voltage switchgear and control gear”,

2	IEEE C37.122-1993	IEEE Standard for Gas-Insulated Substations (GIS)
3	IEEE C37.123-1996	IEEE Guide to specifications for Gas- Insulated, Electric Power Substation Equipment
4	IEC 60694 1996 Edition	Common Clauses for high-voltage switchgear and control gear standards
5	IEC 60376 – 2005 Edition	Specification of technical grade sulphur hexafluoride (SF6) for use in electrical equipment

Arrangement and assembly

The arrangement shall be single-phase enclosed. The assembly shall consist of completely separate pressurized sections designed to minimize the risk of damage to personnel or adjacent sections in the event of a failure occurring within the equipment. Rupture diaphragms shall be provided to prevent the enclosures from uncontrolled bursting and suitable deflectors provide protection for the operating personnel. In order to achieve maximum operating reliability, no internal relief devices shall be installed because adjacent compartments would be affected. Modular design, complete segregation, arc-proof bushings and “plug-in” connection pieces shall allow ready removal of any section and

8.3.4 400KV Outdoor Connection:

Four incomers of 1CX1000Sqmm XLPE Cu cables from 420KV GIS will be connected to overhead 400KV M/C twin moose transmission lines.

8.3.5 Station & Unit Auxiliary Power Supply arrangement:

I) Reactor Transformers

2No’s of 80MVA, 400kV reactor transformer to compensate the reactive power requirement when running the units in pumping mode will be installed in the transformer cavern. Based on the manufacturer design, this may change to unit wise in 13.8kV level.

I) Station Transformers

HT station power will be derived by providing **1 no 20/25.0 MVA**, 400/13.8KV Station Transformer through **3 nos 35.0 MVA & 2 nos 20MVA** 13.8/13.8KV SFC (Static Frequency Converter) Transformers. These transformers will be connected to their respective 13.8kV bus through SFC Equipments, Starter Panel and necessary switchgear.

II) SFC Equipments:

The static frequency converter is a modular multilevel direct converter for fixed

machines and AC excitation for variable machines. SFC system is referred to as self-controlled synchronous motor. The thyristor converter is used to convert DC power to AC power with variable frequency in order to perform the varying frequency governing of synchronous motor. Different from the varying frequency governing of ordinary asynchronous and synchronous motor, the output frequency of self-controlled synchronous motor is controlled by synchronous motor rotor position. Each time the motor rotates passing a pair of magnetic poles, the converter AC output will change by one cycle accordingly, ensuring the synchronization between converter output frequency and motor rotation speed throughout the whole operation period.

The SFC system consists of thyristor rectifier, reactor, thyristor inverter and controller. The controller adjusts DC voltage output according to its operating conditions, controls the inverter to supply AC current with varying frequency to the stator of synchronous motor according to the rotor position, regulates the excitation equipment to provide DC current to the rotor of synchronous motor, and drags the motor rotation speed to the required value. According to different inverter control modes, the SFC working stages are divided into pulse commutation stage and load commutation stage.

SFC is mainly used for the startup of pumped storage power plant, gas turbine unit, and large synchronous motor. So far, it has been applied to most of large pumped storage power generation units and gas turbine power generation units.

III) Station Auxiliary Transformers

415V station power will be derived by providing **2 nos 1.5 MVA**, 13.8KV/415V Station Transformers. These transformers will be connected to the 13.8kV HT bus of 2 station transformers separately through necessary switchgear. The output at 415V is fed to the Station Board through incomer breakers. The Station Board feeds the auxiliary loads of the power plant which includes startup loads of units through Unit auxiliary boards, Dewatering pumps, drainage pumps, crane, air conditioning, ventilation, lighting load etc.

(a)	Voltage ratio	-	13.8KV/415V, 3 phase, 50 Hz
(b)	Rating	-	2 X 1.5 MVA
(c)	Type	-	Dry Type (CRT)
(d)	Primary connection	-	Delta
(e)	Secondary connection	-	Star with neutral solidly earthed.
(f)	Off circuit Tap Changer (OCTC)	-	+/- 5% in step of 2.5%

III) Unit Auxiliary Transformers

415 V Unit auxiliary power will be derived by providing **7 nos 1.25 MVA**, 13.8KV/415V Unit auxiliary transformers. These transformers will be connected to the 13.8KV switchgear of each Generator. The auxiliary transformers will feed the unit auxiliary loads through an Unit Auxiliary board by means of suitably rated cables. The auxiliary loads of unit includes governor oil pumps, cooling water pumps etc. The transformer will be in service after the Generator kept on grid and feeds the loads uninterruptedly.

(a)	Voltage ratio	-	13.8KV/415V, 3 phase, 50 Hz
(b)	Rating	-	1.25 MVA
(c)	Type	-	Dry Type (CRT)
(d)	Primary connection	-	Delta
(e)	Secondary connection	-	Star with neutral solidly earthed.
(f)	Off circuit Tap Changer (OCTC)	-	-5% to +5% in steps of 2.5% suitable for bi-directional power flow.

IV) 415V Switchgear:

Station Auxiliary Board (SAB)

Station Auxiliary transformers will be connected to a separate bus section of 415V auxiliary switchgear.

The 415V auxiliary switchgear will feed the entire unit and station loads. The switchgear will be equipped with the following.

(a) Two nos ACB controlled incomer feeders from Station auxiliary transformers.

(b) ACB controlled Outgoing feeders to Unit auxiliary boards

(c) Outgoing feeders to battery chargers / lighting panels with MCCB.

(d) Motor feeders fitted with MPCB, DOL / Star- Delta Starter, thermal overload relays etc., are of draw out type

(e) The switchgear will be provided with the necessary current transformers, indicating instruments, relays, lamps, push buttons etc,

The main electrical parameters of the switchgear will be:

a) Rated Voltage – 415V

b) Rated short circuit breaking current 50kA for One Second

c) Rated bus bar current – 2500A

Unit Auxiliary Boards

The Unit Auxiliary transformer will be connected to a separate bus section of 415V auxiliary switchgear of unit auxiliary Board. The Unit Auxiliary board will feed the entire unit loads of each Turbine-Generator. The switchgear will be equipped with the following.

1. ACB controlled incomer feeder from Station auxiliary Board.
2. ACB controlled incomer feeder from Unit auxiliary Transformer
3. Outgoing feeders with MCCB.
4. Motor feeders fitted with MPCB, DOL / Star- Delta Starter, thermal overload relays etc., are of draw out type
5. The switchgear will be provided with the necessary current transformers, indicating instruments, relays, lamps, push buttons etc,

The main electrical parameters of the switchgear will be:

a) Rated Voltage – 415V

b) Rated short circuit breaking current – 50kA for One Second

c) Rated bus bar current – 2000 A

V) Power Station Auxiliary Services:

The various services in the power plant will be supplied at the following nominal voltages depending upon their ratings and function:

a)	Motors	-	415V, 3 phase AC supply
b)	Lighting and space heaters	-	230V, 1 phase AC supply
c)	Power receptacles	-	415V, 3 phase AC supply
d)	Control circuits AC	-	110V, 1 phase grounded AC supply for control circuits.
		-	220V ungrounded DC supply for control, indication and Instrumentation & Control system.

8.3.6 Emergency Power System:

I) Diesel Generator Set:

One number of 1000 kVA, 415V, 3 phase Diesel Generator set will be provided to meet the requirement of power supply during construction. This DG set will meet the requirement of power supply for emergency lighting and maintenance purposes

during AC power failure like operation of crane, operation of drainage and Dewatering pumps, ventilation system etc. The DG set will consist of a Diesel engine with engine mounted accessories, an Alternator rated for 1000 kVA, 415V, 3 phase, 50 Hz with exhaust system, fuel oil system, filters, piping, valves and fittings, etc.

II) Direct Current Supply System:

The DC system is the most reliable source of supply in the power station and will be used for the control and protection of power plant equipment. The DC system will be used for the following:

(a) Electrical control of equipment and indications / annunciations on the control panel.

(b) Emergency D.C lighting in case of total AC power failure

(c) The station battery will be sized to cater to the following type of loads:

i) Momentary load for 1 minute.

ii) Emergency load for 2 hours.

iii) Continuous load for 10 hours.

Four sets of 220 V, 400 AH (tentative) battery bank with four nos. float and float cum boost charger and DC distribution board will meet the DC loads. The batteries will be Lead Acid type only either Tubular or plante type, complete with racks, porcelain insulators, inter cell and inter-tier connectors. The chargers will be of silicon rectifier type with automatic voltage control and load limiting features. Under normal conditions, the battery will be on float charge. The float charger is connected to a distribution board and meets the requirements of DC load. In case of additional demand of load or AC supply failure, the battery will meet the requirements of DC loads. The boost charger will be designed to charge the fully discharged battery in 10 hours before putting it back on float charge.

8.3.7 Control, Instrumentation & Protection Systems:

I) Turbine-Generator/Pump-Motor Control Board:

There shall be one control panel each for the Turbine and the Generator fabricated out of 2 mm thick mild steel. It shall be freestanding type with single front design. The control panel shall be mounted on anti vibration pads. The panel shall be applied with synthetic enamel paint on antirust primer after sand blasting and acid picking.

Each Turbine-Generator control cubicle shall contain the following:

Measuring & Indicating instruments comprising of the following:

- MDM Meters (On HV and LV side) - 2 Nos.
- Voltmeter with selector switch - 1 No.
- Ammeter with selector switch - 1 No.
- Megawatt meter - 1 No.
- Megavar meter - 1 No.
- Power factor - 1 No.
- Frequency meter - 1 No.
- Speed indicator - 1 No.
- Temperature recorder of paper less type-60 points - 1 No.
- Energy meter – 0.2s class - 1 Set

(One main and check meters on the HT side of the GT
One meter on the LT side of the GT
One meter on the 11 KV tap off of the generator bus.
One main and check meters on the HT side of the ST.
One main and check meters on the 400KV feeder.)

- Indicating lamps for ON/OFF/ Trip - 1 set
- Controls comprising of the following:
- Start control switch with relays - 1 set
- Stop control switch with relay - 1 set
- Alarm annunciator - I set
- Master protection relays -1 set
- D.C. Failure
- Synchronizing scheme with auto synchronizer - 1 set
- One set of acknowledge, reset and test push button
- One hooter and blinking relay.
- Programmable logic controller (PLC) - 1 set

The control system shall be with manual controls with interlocks to facilitate the operation of Unit in case of failure of Automation system with programmable logic controller.

Programmable Logic Controller (PLC) System:

It is proposed to provide a programmable logic controller for the following functions:

a) Start/Stop of the turbine and generator/pump in sequence control.

b) Monitoring, recording & trending of the temperature inputs from RTD's

c) Monitoring of the alarm inputs from the turbine and generator/pump protection system.

d) Monitoring, recording & trending of all electrical and analog parameters through suitable transducers

e) Man Machine interface unit

The system shall be provided with redundant CPU and POWER SUPPLY and adequate memory.

The system shall have self-checking and self-diagnostic features for all internal faults and shall be capable of isolating the defective sub-system.

The system should be suitable for continuously operating without air conditioner in the power plant environment with temperature upto 45°C and high humidity.

II) Local Instrumentation:

The following instruments shall be mounted locally:

(1) Flow transmitters to check flow of cooling and sealing water to the bearings, Shaft Seal & Generator as required.

(2) DTT 's & RTD's for Turbine & Generator bearing temperature.

(3) Oil pressure gauge, Pressure transmitter, pressure switches of the Oil pressure unit, Level transmitters, gauges, and switches of bearing sumps, drainage and dewatering pits etc.,

All necessary instruments required for safe and auto operation of the turbine-Generator are provided.

III) Communication system:

a) Internal Telephone System: An Electronic telephone exchange is to be provided in the powerhouse control room for Communication system between different vulnerable locations of the project. It is also proposed to install a 10-line exchange with subscribers at various important locations of the project for quick communication of the information and instructions etc. Some of the typical locations may be as follows:

a) Control room

b) Switchgear room

c) Turbine pit

d) Machine hall

e) Unloading/erection bay

f) Drainage/ dewatering motor starter panel

g) Transformer Cavern

h) Outdoor yard

i) Staff quarters

j) Pump house

k) Security gates

b) External Communication: One Telephone connection shall be provided in the power station from the local Department of Telecommunication network for external communication.

c) Power Line Carrier Communication (PLCC): 1No PLCC set is proposed. Power-line communications systems operate by adding a modulated carrier signal to the wiring system. Different types of power-line communications use different frequency bands. Since the power distribution system was originally intended for transmission of AC power at typical frequencies of 50Hz, power wire circuits have only a limited ability to carry higher frequencies. The propagation problem is a limiting factor for each type of power-line communications. PLCC panels shall be provided with protection couplers for carrier inter tripping.

Data rates and distance limits vary widely over many power-line communication standards. Low-frequency (about 100–200 kHz) carriers impressed on high-voltage transmission lines may carry one or two analog voice circuits, or telemetry and control circuits with an equivalent data rate of a few hundred bits per second; however, these circuits may be many miles long. Higher data rates generally imply shorter ranges; a local area network operating at millions of bits per second may only cover one floor of an office building, but eliminates the need for installation of dedicated network cabling.

RTU panel shall be provided for Data and speech communication with the state Load Dispatch center. In addition with Data and Speech communications separate dedicated channels shall be provided for protection along with protection couplers.

GPS time synchronization equipments are provided for all the relays, governors, SCADA systems. For this purpose dual redundant gps antenna, dual redundant gps

receiver / master clock with comparator, slave clock, slave distribution amplifier, signal conditioners, signal receiver, power supply unit equipments are used.

FEATURES:

9 Continuous UTC reference, +5.30 hours offset (IST)

10 IRIG B Time Code output

11 RS 232 & 485 serial port interface

12 SNTP & NTP Ethernet Output

13 Pulse Output

14 BCD Output

15 DCF77 Output

16 Large size Time display

17 All weather water proof antenna

18 Synchronization software for Server /PC

19 Hot Redundant GPS / Master clock with comparator

20 Redundant power supply with Diode O-ring

21 Signal conditioner for various outputs

IV) Generator, Turbine, Auxiliary Transformer, Generator Transformer, 400KV line Protection relay equipments:

Integrated Numerical protection relays will be provided in redundant for each Generator and Generator transformer.

Generator protection

Redundant Generator numerical protection relays shall be of different make as per the latest protection philosophy. Relays shall be IEC61850 complaint and shall have GPS time synchronization provision in addition with Disturbance Reporting and Event logging provisions.

The following protections will be provided for the generators:

1. Backup Impedance (21)
2. Over Excitation (24)
3. Under Voltage/ Over Voltage (27/59)
4. Reverse power (32)
5. Under Power (37)

6. Loss of Field/ excitation (40)
7. Negative phase sequence (46)
8. Thermal Over Loading (49)
9. Breaker Failure (50BF)
10. Voltage Restrained Over current (51V)
11. PT fuse failure (60FL)
12. 100% Stator earth fault (64G)
13. Under/ Over frequency (81O/U)
14. Generator Differential (87G)
15. Annunciator (30)
16. Rotor Earth Fault (64F)
17. Master Trip relay (86G)
18. Trip Circuit Supervision (95)
19. Split phase based inter turn protection
20. Overall differential protection with 3 winding inputs (Generator, GT HV, and Generator Tap off).

Turbine Protections

The following protections will be provided:

1. Under/ Over Speed (12/14)
2. Governor Failure Relay (33/63)
3. Bearing Temperature (38T)
4. Oil pressure Failure (96.2 OPU)
5. Oil levels
6. Shear pin
7. vibrations etc

Auxiliary Transformer Protections

The following protections will be provided:

1. Under Voltage (27)
2. Instantaneous O/C & E/F (50/50N)
3. IDMTO/C & E/F (51/51N)
4. Master Trip (86)

Step-Up Generator Transformer Protections:

The following protections will be provided for step-up transformer:

1. Transformer Over Fluxing (49)
2. Instantaneous O/C & E/F (50/50N)
3. IDMT O/C & E/F (51/51N)
4. Transformer Differential (87GT)
5. Restricted earth fault (64Ref)
6. Annunciator (30)
7. Oil temperature, Alarm/Trip Aux (49OA/OT)
8. Winding temperature, Alarm/Trip Aux (49 WA/WT)
9. Buchholz/ Alarm/Trip Aux (63 A/T)
10. High Speed Tripping (Master) (86T)
11. Trip Circuit Supervision (95)
12. Low Oil Level Alarm (LOLA)
13. Oil Surge Trip (OSR-T)
14. Pressure Relief Device Trip Aux. (PRD-T)
15. Apparatus thermal device (26)
16. Liquid Switch (71)

400KV Line protections:

400KV feeder protection shall be redundant with numerical protection relays and shall be of different make as per the latest protection philosophy. Relays shall be compatible to IEC 61850 Protocol. Disturbance Recorder evaluation cum event logger units shall be included.

The following protections will be provided for the lines:

- Impedance (21)
- Over/ under voltage (27/59)
- AC Directional over current (67/67N)
- Frequency (81)
- Master Trip (86)
- Trip Circuit Supervision (95)
- AC Reclosing Relay / Auto Reclose (79)
- Instantaneous Overcurrent Relay (50)

- Phase Angle Measuring or Out-of-Step Protective Relay (78)
- Bus Differential (87B)
- Overvoltage Relay (59)
- 400KV reactor protection
- 400KV bus bar protection
- 400KV cables protection
- Bus coupler protection

V) Safety Earthing & Lighting protection system:

Separate earthing grids will be provided for powerhouse and switchyard area and they will be interconnected. The buried portion of the earth conductor will be of mild steel and exposed earth conductors will be of galvanized steel. Required number of earthing pits will be provided. The earthing grid will be designed to have a system resistance below 1 ohm. Detailed Design and drawings enclosed.

A lightning protection system will be provided as per IS - 2309 and Indian Electricity Rules. The protections will consist of roof conductors, air terminals and down conductors and will be provided for outdoor Switch Yard**.**

VI) Fire detection and Alarm System:

Control rooms, switchgear rooms, battery rooms etc shall be provided with Analogue Addressable Microprocessor based fire detection and alarm system. Multi-sensor detectors, Heat detectors, Manual call points, Sounders etc shall be provided wherever required as per IS – 2189.

8.3.8 Lighting System:

The power station lighting system will comprise the following:

I) Normal 230V AC Lighting System:

The lighting circuit in the normal 230V AC lighting system would be fed through 13.8/0.415KV, 3-phase, 4 wire transformer connected to 415V distribution system. Detailed design enclosed.

II) Direct Current Emergency Lighting system:

Direct current emergency lights would be provided at strategic points in the power station, viz. Near entrances, staircases, the main control room, Turbine area, switchyard area etc.

These would be fed from the station 220V DC system and would be off when the normal

AC power supply is available. These would be automatically switched on when the normal AC supply fails.

The proposed illumination levels for various areas are given below:-

AREA	Illumination Level
Control Room	300 lux
Switchgear/MCC room	250-300 lux
TG building	260lux
Outlying areas	30-40 lux
Switch yard	25-35 lux
stores	100-150 lux
Battery Room	100 lux
Administration building and Office rooms	300 lux
Roads	20 lux

8.3.9 Cabling:

All cables will be selected to carry the full load current under site conditions, with permissible voltage drop/dip. In addition, these cables will be rated for short circuit capacity wherever required. The following types of cables will be used:

- Four nos 400kV XLPE 1C Copper Cables of 1000 Sqmm dia:

  FEATURES: Copper conductor – stranded, Inner semi-conductive layer – firmly bonded to the XLPE insulation, XLPE main insulation – cross-linked, Outer semi-conductive layer – firmly bonded to the XLPE insulation, Copper wire screen with semi-conductive swelling tapes as longitudinal water barrier, HDPE oversheath – halogen-free, as mechanical protection, optionally: with semi-conductive and/or flame-retardant layer.

- For 13.8KV power cables – 13.8KV (UE) grade, stranded aluminum conductor, XLPE insulated, extruded PVC Inner sheathed, armoured, extruded FRLS-PVC (Flame retardant and low smoke – poly vinyl chloride) outer sheathed cables conforming to IS-7098.

- For low voltage power cables – 1100 V grade, stranded aluminum conductor, extruded PVC insulated, extruded PVC inner sheathed, armoured, extruded FRLSPVC outer sheathed cables conforming to IS-1554.

- Control and protection cables – 1100 V grade, annealed high conductivity copper

conductor, extruded PVC insulated, extruded PVC inner sheathed, armoured, and extruded FRLS-PVC outer sheathed.

- Signal and supervisory cables – Annealed tinned copper conductor in stranded circular construction, extruded PVC insulated, extruded PVC inner sheathed, armoured, and extruded FRLS – PVC outer sheathed, in twisted pairs and screened.
- Cables will be laid in ladder type galvanized steel cable trays or in trenches.

8.3.10 Power Evacuation & Transmission Lines:

One no 400 KV Multi circuit Transmission Line of length **60** Kms shall be used by the plant with one double circuit connected to PGCIL Narendra 400 KV substation at Dharwad and other double circuit connected to IRESP CPSS with Quad Moose conductor for evacuation of generated Power and for Supply of power during pumping mode. The Power required for pumping operation of the plant shall also be drawn from the same circuit.

CHAPTER – 9

ENVIRONMENTAL ASPECTS

9.0 Introduction

The Project is envisaged as a Pumped Storage Project being developed near existing Renukasagar Reservoir. The Saundatti IRESP - Storage Project is located in Belagavi district of Karnataka. It envisages creation of reservoir across Jagavalla Halla which joins river Malaprabha, a tributary of River Krishna near village Somapura under Tallur Grama Panchayat, Saundatti Taluk about 80 Kms from Belagavi. This chapter broadly covers the impacts likely to occur during construction and operation of the project.

9.1 Description of the Environment

9.1.1 Upper & Lower Reservoirs

The Saundatti IRESP - Storage Project is proposed in between two reservoirs i.e. Saundatti IRESP Reservoir as Upper reservoir (to be constructed newly) and the existing Renuka Sagar (Malaprabha) Reservoir as Lower reservoir. This scheme envisages non-consumptive re-utilization of 1 TMC of water of the Renuka Sagar reservoir by recirculation. The water in the Renuka Sagar reservoir (lower reservoir) will be pumped up and stored in the proposed Saundatti IRESP reservoir (upper Reservoir) and will be utilized for power generation. The Geographical co - ordinates of the proposed Saundatti IRESP reservoir are at longitude 75° 00’ 42.57" East and latitude is 15° 51’ 36.83" North and that of Renuka Sagar reservoir (existing) are15° 49’ 17.15" N and 75° 05’ 48.23" E.

9.1.2 Climate

Climate of Karnataka presents an exceptional diversity. While the hilly and plateau regions demonstrate a different climatic behaviour, the plain presents comparatively a warmer atmosphere. Due to this diversity in climate and weather of Karnataka, it has been divided into 3 major parts:

Coastal Karnataka, which includes: Dakshina Kannada and Uttara Kannada districts.

North Interior Karnataka, which includes: Belagavi, Bidar, Bijapur, Dharwad, Gulbarga and Raichur districts.

South Interior Karnataka, which includes: the remaining districts of Bengaluru Rural, Bengaluru, Bellary, Chikmagalur, Chitradurga, Kodagu, Hassan, Kolar, Mysuru, Mandya, Shimoga and Tumkur districts.

The most famous city of Karnataka is Bengaluru which is best known for its awesome weather and panoramic views. Bengaluru is also known as ‘air-conditioned city’. During

most of the time in year Bengaluru's atmosphere remains pleasant, it's douched with a nice shower, which dissolves a unique jolliness in the air during summers and winters. The coastal regions and highly elevated places reveal uniformity in day and night temperature. Till now the highest recorded temperature is 45.60° C at Raichur in 1928 while the lowest temperature of an individual station was recorded 2.80° C on December 16, 1918 in Bidar.

9.1.3 River System

The Malaprabha River is a tributary of the Krishna River and flows through the state of Karnataka in India. It rises in the Western Ghats at an altitude of 792.4 m (2,600 ft) in the state's Belgaum district. The river joins Krishna River at Kudalasangama in Bagalkot district. Malaprabha River originates in the Sahyadri mountains at an altitude of 792.4 metres (2,600 ft) at Kanakumbi village 16 km (9.9 mi) west of Jamboti village, Khanapur taluka, Belgaum District, Karnataka. Malaprabha flows a distance of 304 km (189 mi) from Kanakumbi-Khanapur-Soundatti (Malaprabha Dam)-Nargund-Pattadkal-Kudalasangam before joining river Krishna at an altitude of 488 metres (1,601 ft) at Kudala Sangama in Bagalkot district.

9.1.4 REAGIONAL GEOLOGY OF STUDY AREA

The complex geological formations can be observed in the Belagavi district. The Schist and Banded Ferruginous Quartzite, the peninsular gneiss by Granite and Gneissic Granites, the Kaladgi formations, Sandstone, Quartzite, Shale and Limestone and Dolomite, Basalt (Deccan Trap) and the Laterite formations are observed in the district. The Geological Succession of Belagavi District as follows:

Laterite, Sand deposits -	Recent.
Deccan Basalt -	Tertiary,
Sand Stone, Dolomite, Limestone -	Kaladagi series,
Schist, Gneiss, Granite -	Archean.

The Archaen Schist is an extension of the Dharawar schist belt. The formation is overlaid by thick cover of shale, the thickness varying from 15 to 25m as observed in many villages of Khanapur and Bailhongal, Belagavi talukas. In few places like, Marihal in Belagavi taluka, Shivanur, Nichanaki villages of Bailhongal taluka, the shale cover extends up to 100 m. The Schist encountered below shale cover is greyish in colour, exhibit well developed platy structures. Individual plates can be easily separated. It is usually weathered up to 25-30 m. It shows a general trend of NW 10-SW 10SE dipping due east. The Schist formation is observed in Bailhongal, Khanapur, Belagavi and Saundatti talukas.

Phyllite is a hard formation, resembling schist by its grey colour, having trend, dip etc similar and occurring adjoining the schist. Joints and platy structures are poorly developed. It is massive in nature, breaking in to irregular, angular fragments or irregular massive

boulders. It shows a trend of NNW-SSE, and occurs parallel to schist. Such formation occupies limited extent in the Central part of Bailhongal taluka and Western parts of Saundatti shallow weathering, and non-porous nature, seepage of water is limited to shallow depth and hence regularly proved to be a poor aquifer. 16 villages of Bailhongal taluka and western part of Saundatti taluka, which are traversed by these formations acute shortage of water.

9.1.5 Seismicity

The project area is located in Belagavi district of Karnataka. As per Seismic Zonation Map of India, the project area lies in Seismic Zone III.

9.1.6 Flora

Depending on phenological conditions and other ecological factors, the forests of Belagavi in Uttara Kannada are broadly divided into two types namely Moist and Dry types. The moist type may be sub-divided into evergreen, semi-evergreen and moist deciduous. The dry type can be divided into dry deciduous and thorny forest. Species flora as *Acacia arabica*, *Albizzia amara*, *Albizzia lebbek, Albizzia odartissima, Artocarpus integrafolia, Azadirachta indica, Arundianaeca* Dowga, *Cassia fistula, Carissa caranda, Ficus species*, *Hardiwickia binate, Inga dulce, Imperata cylindrica,* Elephant grass, *Holoptelia integrifolia, Pongania pinnata, Prosopis juliflora*, *Randia dometorum, Syzigium specieas, Shorea talura, Streblus asper,Terminalia arjuna, Zizyphus species*, etc. whereas ground cover is dominated by shrubs and weeds.

9.1.7 Fauna

The project area entails acquisition of forest land. The population density is quite low in the area and density of forests is quite good. In such areas, mainly faunal species are reported. Based on the review of secondary data and as per available records, faunal species reported in the district area include Spotted Deer, Bison, Jackal, Wild dog, Hyaena, Langur, Barking etc. The commonly observed birds in the district area and its surroundings include Jungle Bush, Quail, Teal Sparrow, etc.

Wild animals that are found in Karnataka include the elephant, the tiger, the leopard, the gaur, the sambar deer, the chital or spotted deer, the muntjac, the bonnet macaque, the slender loris, the common palm civet, the small Indian civet, the sloth bear, the dhole, the striped hyena and the golden jackal. Some of the birds found here are the great hornbill, the Malabar pied hornbill, the Ceylon frogmouth, herons, ducks, kites, eagles, falcons, quails, partridges, lapwings, sandpipers, pigeons, doves, parakeets, cuckoos, owls, nightjars, swifts, kingfishers, bee-eaters and munias.

9.2 Prediction of Impacts

The environmental impacts of the proposed Saundatti PSP have been predicted and are being forecast in light of the activities that would be undertaken during the construction of various project appurtenances, e.g. Dam, drilling and blasting during tunneling for tunnel, adits, roads, construction of permanent and temporary housing and labour colonies, quarrying for construction material and dumping of muck generated from various project activities. The likely impacts have been considered for various aspects of environment, including physico-chemical, ecological and socio-economic aspects are briefly detailed as below

9.3 Impacts on Land Environment

9.3.1 Construction Phase

Only very few impacts of construction phase are permanent. Majority of the environmental impacts attributed to construction works are temporary in nature, lasting mainly during the construction phase and often little beyond the construction period. However, if these issues are not properly addressed, the impacts can continue even after the construction phase for longer duration. The time required for construction of the project has been assumed as about 3 years.

Tunnelling and foundation works will involve land excavation, filling and concrete works effecting environment by noise and dust pollution. Structural, deployment of machinery, approach roads construction and erection work will also result in dust, noise pollution and vehicular traffic. Material handling and transportation may significantly increase noise pollution.

The labour for various activities during the construction phase shall be engaged from the surrounding villages. Some essential services are also required to be provided. This will have an impact on drinking water supply and sanitary facilities. Economy of the nearby area will be improved due to increased job opportunities with corresponding increase in income. Other associated business activities like transport, hotels, consumer goods etc., will also be benefited. The major environmental parameters likely to be effected during construction phase are noise, dust pollution and sanitation. Water spraying during high dust will minimise the dust level to some extent. A proper temporary housing with water supply and sanitation for workers should be planned. The effect due to construction phase is however, of temporary in nature and has no permanent effect on environment.

9.3.1.1 Environmental degradation due to immigration of labour population

About 400 workers and 100 technical staff are likely to work during the peak construction

phase in the project area. Thus a total of 400 persons along with their families will reside in the project area during peak construction phase. Thus the peak manpower would be around 1200 including their families.

Separate accommodation and related facilities for workers, service providers and technical staff are to be arranged. The volume of labour force is most likely will create problems of sewage disposal, solid waste management and requirement of fuel etc.

9.3.1.2 Quarrying Operations

The course agreegate requirement and construction materials for formation of various roads and buildings of 57.90 lakh Cum will be extracted from the excavated muck from Tunnels and underground Power House. As such no separate quarry is required for production of construction materials.

9.3.1.3 Operation of construction equipment

During construction phase of the project, various types of construction equipment will be brought to the site. These include crushers, batching plant, drillers, earth movers, rock bolters, etc. The siting of these construction equipments would require significant amount of space. Land required will be temporarily acquired, i.e. for the duration of project construction for storage of the material before crushing, crushed material, cement, rubble, etc. Efforts shall be made to select the site for locating the construction equipment in such a way that the adverse impacts on environment are minimal. there are no major habitations in the project area. Thus, no significant impacts are anticipated on this account.

9.3.1.4 Soil Erosion

The runoff from various construction sites, will have a natural tendency to flow towards along with the natural drainage. Thus, the disposal of drainage effluent with such high turbidity levels is bound to affect the water quality, especially in the lean season. The drains/nallahs close to various construction sites are seasonal in nature. However, for the present project proposal no significant drains/nullahs are present. Hence, the increase in turbidity levels are not envisaged to be significant in nature.

9.3.1.5 Muck Disposal

About 72.15 Lakh cum of muck is expected to be generated as a result of construction of Power house and other appurtenant works. The project proposes to utilize 57.90 Lakh cum of the muck to be generated as construction material in various project structures.

Therefore, 14.24 Lakh Cum muck is proposed to be dumped at pre-identified locations. Out of this quantity, about 10.00 Lakhs Cum is proposed to be dumped in reservoir itself as no river courses are existing and the balance muck is proposed to be dumped in an

environmentally sound manner in pre-identified dumping sites, which are proposed to be rehabilitated subsequently in an environmentally sound manner. Retaining walls will be constructed. After the filling is done, rehabilitation of this site will be done to ensure that neither it flows in to the water stream nor it poses any other environmental threat. Plantation, wherever possible, will also be done on these sites so that these get stabilized over a period of time and do not pose any environmental problem.

9.3.2 Impact identification during operational phase

There would be little environmental and ecological changes during the operational phase. Since, only a small number of O&M staff will reside in the area in a well-designed colony with sewage treatment plant and other infrastructure facilities, problems of water pollution due to disposal of sewage are not anticipated.

9.4 Impacts on Air Environment

Considerable amount of air pollution will be caused during different stages of construction of tunnels, roads and other operations such as excavation, drilling, blasting, loading and transportation of material. Suspended Particulate Matter (SPM) is the main pollutant during construction. Most of the dust arises from drilling, blasting, excavation, crushing and transportation operations. Large quantities of dust become wind borne and are carried away from overburden dumps. The fugitive dust released during the construction activities may cause immediate effect on the construction workers who are directly exposed to the fugitive dust. Vegetation will also be adversely affected as deposition of dust on the leaves will choke the photosynthesis activity, which, in turn, will have adverse effect on the health of the plants. The other sources of air pollution is Pollution due to fuel combustion in various equipment. The operation of various construction equipment requires combustion of fuel. Normally, diesel is used in such equipment. The major pollutant which gets emitted as a result of combustion of diesel is SO2. The SPM emissions are minimal due to low ash content in diesel. The short-term increase in SO2, even assuming that all the equipment are operating at a common point, is quite low. Hence, no major impact is anticipated on this account on ambient air quality.

9.5 Impacts on Noise Environment

The noise will be generated at the time of construction of powerhouse, tunnelling, drilling machines, dumpers, etc. Continuous exposure of workers to high level of noise may result in annoyance, fatigue, and may cause temporary shift of threshold limit of hearing and even permanent loss of hearing. During operational phase, noise level will be increased due trouncing machinery and vehicular movement in the area. However, these impacts are only localized.

9.6 Impacts on Water Quality

The project construction is likely to last for a period of 3 years. As mentioned earlier in about 400 workers and 100 technical staff are likely to work during project construction phase. However, most of the employees/workers during construction phase are likely to be employed from outside the project area. But, the construction phase, also leads to mushrooming of various allied activities to meet the demand of immigrant labour population in the project area. It is recommended to commission units for treatment of sewage generated from labour camps prior to disposal.

During construction phase, one crusher will be commissioned at the muck dumping areas. It is proposed only crushed material would be brought at construction site. Water is required to wash the boulders and to lower the temperature of the crushing edge. About 0.1 m3 of water is required per ton of material crushed. The effluent from the crusher would contain high-suspended solids. The effluent from crushers will be treated by providing settling tank prior to disposal.

9.7 Impacts on Flora and Fauna

There is no vegetation worth its name or any wild life, hence, there will not be any adverse impact. There is no Wild Life Sanctuary or National Park in the Project area. During the detailed study at DPR stage, it is recommended that detailed studies to be conducted to ascertain the ownership status of the lands, i.e. whether the land belongs Forest Department or is it a non-forest government land. Even barren land, could be categorized as forest land, if it is under the jurisdiction of forest department. In such a scenario, compensatory afforestation as per the norms of Forest Conservation Act will have to be done in lieu of entire forest land as per ownership, irrespective of its vegetal status to be acquired for the project. The ownership category of land required for various project appurtenances can be ascertained, once project layout is finalized as a part of DPR preparation. Based on the type of land being acquired for the project, suitable compensatory measures if any can be suggested as a part of Forest conservation act, 1980.

9.8 R&R Aspects

The existing Renukasagar reservoir will be used as a lower reservoir for the project. The upper reservoir at Saundatti shall be constructed new. No dwellings, houses or hamlets will be submerged with the proposed upper reservoir. So, there is no displacement and resettlement is involved. However, for construction of civil structures and other components acquisition of forest land in forest block and private land in various settlements are required. A detailed socioeconomic survey needs to be conducted to ascertain the actual number of

families losing land, as a result of acquisition of land for various project features including reservoir submergence as a part of Social Impact Assessment (SIA) under Land Acquisition, Rehabilitation and Resettlement Act, 2013 based on which, if required suitable Resettlement & Rehabilitation Plan can be formulated.

9.9 Environmental Management Plan

Environmental Management Plan (EMP) aims at the preservation of ecological system by considering certain mitigating measures at the proposed site. The mitigation measures are used to minimize or prevent adverse impacts on environment due to the proposed development activity. Some of the major criteria governing the environmental measures will be adopted, and the same is described below

9.10 Environmental Management

It is expected that the project area shall not be affected much with the proposed activity and likely to get new economic fillip due to power generation, not only for the study area but also for the region as a whole. The majority of the environmental impact pertains to the construction phase. It is planned to take corrective measures to ensure that these effects are kept to bare minimum. The EMP will therefore, be initiated during planning stage itself.

9.10.1 Environmental Management during Construction

Dust emission and solid waste will be generated during initial site preparation activity and there will be slight increase in the noise levels around the site. The environmental impacts during the clearing or clearing for site preparation will be temporary, localised and negligible. Water sprays at appropriate location will be provided for dust suppression, hence reducing the impacts. Solid waste will be disposed off along with the muck at the designated sites.

9.10.2 Air Environment

The construction activities will generate large quantities of dust during drilling, blasting, loading and transportation operations. The following measures are required be taken to mitigate the dust from different operations.

To avoid the dust generation from the drilling operations, wet-drilling methods will be adopted.

Ceasing dust -generating activities during high winds

Covering of vehicles carrying solid waste (muck).

Watering of haul roads and other roads at regular intervals

Plantation near muck disposal places and dumping yards.

9.10.3 Noise environment

The major noise generating sources from the proposed activity are working machinery,

blasting and movement of vehicles. The following control measures are to be undertaken to bring down the noise levels.

Traffic (vehicular movement) to be managed to produce a smooth flow instead of a noisier stop -and start flow.

Ensuring timely preventive maintenance of the equipment involved. Since a well maintained equipment is generally quieter than poorly maintained equipment.

Ensuring usage of personal protective devices i.e., earmuffs and earplugs by workers, working in high noise activity canters.

Plantation in the vicinity of the construction area will further reduce the noise levels.

9.10.4 Water environment

During construction phase the wastewater (sewage) coming from temporary Arrangements like offices, labour camp sheds, canteens etc., and impact due to soil erosion during monsoon period may cause surface water pollution. Some of the control measures adopted for controlling water pollution are as follows:

Establishing septic tanks followed by soak pits to treat the domestic waste water generated from the offices, canteens, labour camp sheds.

9.10.5 Compensatory Afforestation

The loss of vegetal cover can be compensated by compensatory afforestation. The Indian Forest Conservation Act (1980) stipulates:

if non-forest land is not available, compensatory forest plantations are to be established on degraded forest lands, which must be twice the forest area affected or lost, and if non-forest land is available, compensatory forest are to be raised over an area equivalent to the forest area affected or lost.

As per the applicable forest laws in vogue, the cost of compensatory afforestation, the NPV for environment loss as well as cost of trees are also payable as per the applicable norms.

9.10.6 Greenbelt Development

The forest loss due to various project appurtenances has been compensated as a part of compensatory afforestation. However, in addition to compensatory afforestation, it is proposed to develop greenbelt around the perimeter of various project appurtenances, selected stretches along the periphery of water spread area, roads, etc.

CHAPTER – 10

CONSTRUCTION PROGRAMME AND SCHEDULE

10.1 General

Construction of Saundatti IRESP - Storage Project including erection of four generating units is planned to be completed in a period of three (3) years including Pre-constructions works, creation of infrastructure facilities viz. additional investigations, improvement of road network and colonies.

10.2 Main Components of the Project

10.2.1 Main Structure/ Components

The Construction schedule has been detailed for major items of the following main structures/ components.

Civil Works

- Dam
- Power Intake
- Head Race Tunnel
- Surge Chamber
- Penstock Tunnel
- Power House
- Tailrace channel

Electrical Works

- E.O.T cranes
- Supply and erection of T.G sets 7 nos.
- 400 KV G.I.S. equipment
- Main Power Transformers
- Other auxiliary electro-mechanical equipment

Hydraulic equipment

- Intake gates
- Intake trash rack
- Steel liner Penstock
- Penstock Gates
- Draft Tube gates
- Tailrace Outlet gates

10.2.2 Target Schedule

The Total Construction period is scheduled as follows.

Preconstruction Period	:	6 months
Construction Period (Main Works)	:	2.5 Years
Total Construction Period	:	3 Years

10.3 Infrastructure Facilities

The Saundatti IRESP - Storage Project, however creation of additional infrastructure facilities or Renovation of existing infrastructure facilities will be taken up in the first year. Construction/improvement of project roads and improvements/ upgrading of access roads will be taken up and completed on priority basis. The construction of office and residential buildings will be started and completed in the 1st year. The facilities for workshop and stores etc. are also included.

10.3.2 Dam

Excavation of dam area will be started from the 3rd month of year 1 immediately after the completion of partial filling at coffer dam and will be completed by 12th month of year 2.

10.3.3 Power Intake

Excavation of intake structure may start from 5th month of year 1and will be completed by 4th month of year 2. The concreting of intake may take place from 7th month of year 2 and will be completed by 6th month of year 3.

10.3.4 Penstock Tunnels

Adit to penstock tunnel will be started in the 7th month of year 1 and will be completed within 3 months. Excavation in penstock tunnels will be taken up in the 10th month of year 1 and will be completed by the end of 12th month of the 2nd year. The Lining & erection of steel liners will be start from 1st month of year 3 and will be completed by the end of 5th month of year 3.

10.3.5 Powerhouse

Excavation of the power house cavern will be taken up in the 6th month of the 1st year and will be completed by 2nd month of year 2. The concreting will be taken up in the 2nd month of the second year and will take 8 months for completion along with the trash rack structure.

10.3.6 Electro-Mechanical Works

Action for procurement of EOT cranes is proposed to be initiated in the 1st year itself. The

entire process of inviting the tender, placing orders, manufacture, supply, erection and testing is planned to be carried out in the 1st year to end of the 3rd year.

Pre-manufacture activities such as preparation of specifications, inviting and evaluation of tender etc. can be completed within the 1st year so that the supply orders are placed by the end of the 1st year. The model tests and approval to the supplier's drawings will require nine more months. Installation period for each pump/turbine and generator/motor has been considered as 12 months.

CHAPTER - 11

COST ESTIMATE

11.0 General Description Of The Project

The Saundatti IRESP - Storage Project envisages utilization of water of the existing Renuka sagar reservoir. Upper and lower reservoir for Saundatti IRESP will be made up respectively by the proposed Saundatti IRESP reservoir and the existing Renuka sagar reservoir.

11.1 Cost Estimates

The Civil Cost Estimates of the project has been prepared as per "Guidelines for preparation of estimates for the river valley projects" issued by CWC and Indian Standard IS: 4877 "Guide for Preparation of Estimate for River Valley Projects".

Rates of major items of works have been prepared based on SSR of Karnataka & local prevailing rates are adopted for the items not covered by the SSR wherever quantification has not been possible at the present stage of design, lumpsum provisions have been made based on judgement / experience of other projects.

The estimates of the Hydro Electric Scheme has been divided under the following account heads:

A. Direct Cost

I. Works

A - Preliminary

B - Land

C - Works

J - Power Plant Civil Works

K - Buildings

M - Plantation

O - Miscellaneous

P - Maintenance during construction

Q - Special T&P R - Communications

S - Power Plant and Electro-Mechanical system

X - Environment and Ecology

Y - Losses on stock

Total I-Works

Establishment

Tools and Plants

Suspense

Receipt and Recoveries

Total (A) - Direct Cost

B. Indirect Cost

Capitalization of Abatement of Land Revenue

Audit and Account Charges

Consultancy Charges

Upfront fee for loan

Total (B) - Indirect Cost

Total Cost (A+B)

11.2 Preparation Of Estimates

The capital cost of the project includes all costs associated with investigations, design, construction and maintenance during construction period of the project.

For preparation of cost estimates of civil works, the unit costs of labor, materials and equipment necessary to perform the work designated in the various pay-items for the proposed construction are determined based on Schedule of Rates for the year 2017-18 of Karnataka Irrigation and Command Area Development and for items for which the rates are not available, the accepted schedule of rates of similar ongoing/recently executed projects adopted. The rates of major items have been worked out by rate analysis.

The quantities of Civil Works are estimated based on designs and drawings prepared for various components of the project. The Daily wage rates have been taken as per Karnataka I&CAD Schedule of Rates for the year 2017 - 18.

Provision for contingencies are considered at 3% of the works cost and are provided in the detailed works estimates prepared on the heads of item rates and quantities of works to be executed. These percentage provisions are not considered on lump-sum items.

PREPARATION OF DETAILED ESTIMATES OF COST (I-WORKS)

11.2.1 A - Preliminary

The provision under this head covers the works relating to various Investigations, Surveys, Model tests, Ecological studies etc. Provision for preliminary expenses is provided not to exceed 2% of total cost of I-Works.

11.2.2 B – Land

The provision under this head covers Acquisition of Land, Rehabilitation & Resettlement

including compensation for property, Interest charges, Solatium charges, demarcation & measurement charges, etc. have been made as per actuals. A provision of 69.64 Crore has been made under this head.

11.2.3 C - Works

The provisions under this head covers the costs of Earth dam, Approach channel, Intake structure, Penstocks, Power House, Surge Chamber, Tail Race Tunnel and Tail Race Channel.

Important items considered under this head are

11.2.4 J - Power plant civil works

Important items to be considered under this head are

Intake Structure & Head Race Tunnel

- Excavation
- Foundation treatment
- Cement concrete for foundation, piers and abutments
- Masonry/concrete for guide walls of approach channel
- Concrete for trash racks including raking arrangement
- Tunnel lining
- Gates with auxiliary equipment's
- Reinforcement Steel
- Instrumentation etc.,

Surge Chamber

- Excavation
- Concrete
- Shortcreting

Penstock

- Excavation
- Cement concrete for
- Bed
- Anchor blocks
- Intermediate supports
- Stiffener, Reducers, Bends, Penstock valves, Instrumentation

Power House

- Excavation
- Concrete for foundation, sub-structure, super-structure and supports for turbines

and generators.

- Masonry/concrete for super-structure and other necessary items for building work.
- Scroll casing / Generator barrel
- Draft tube
- Bulkhead gates, crane and hoisting equipment
- Power-house crane
- Miscellaneous items such as anchor bolts, grouting etc.
- Instrumentation

Tail Race channel

- Excavation
- Embankment
- Lining with cement concrete in bed and sides with drainage pipes and valves
- Pucca works
- Cross Drainage(s)
- Escape(s)
- Bridge(s)
- Instrumentation

11.3 K – Buildings

The provisions under this head covers the Residential / Nonresidential buildings, office buildings, Stores, Testing laboratories, Workshops, Other Service Buildings, Community Centre etc. A provision of 2% of C- Works and J-Power plant civil works is made under this head.

11.4 M – Plantation

The provisions under this head covers the plantation program including Gardens etc. required for beautification which is considered necessary at downstream of Weir and around Power House and other important structures. A provision of Rs. 125.80 Lakhs is made under this head.

11.5 O – Miscellaneous

The provision under this head covers the capital cost & maintenance of Electrification, Water supply, Sewage disposal and drainage works, Recreation, Medical, Firefighting equipments, Inspection vehicles, School bus, Pay van, visit of dignitaries, welfare works etc. A provision of around 2% of C- Works & J-Power plant civil works is made under this head.

11.6 P - Maintenance during Construction

The provision under this head covers the cost of maintenance of all works during the construction period. A provision of around 1% of C-Works & J-Power plant civil works is made under this head.

11.7 Q - Special Tools & Plants

The provisions under this head covers the Drilling & Grouting equipment's, Transport, Compaction, Electrical equipment's, Construction Plant & Earth Moving equipment's and other Miscellaneous equipment's. A provision of Rs.251.60 lakhs has been made under this head. As the project works have been planned for construction through contractors, and it is expected that the contractors will procure their own equipment's for work.

The project estimates therefore do not provide for purchase of heavy earth moving equipment and concreting equipment by the department.

11.8 R – Communication

The provisions under this head covers the construction of main approach roads, quarry roads, temporary or permanent river crossing, railways, bridges and connecting roads.

11.9 S - Power plant and Electro - Mechanical System

The provision under this head cover the Electro-Mechanical equipment for the power plant and associated substation. The cost of the Electro-Mechanical equipment is arrived at based on the preliminary size and compared with recent projects. Cost of transmission line is also included in the project cost.

11.10 X - Environment and Ecology

Under this head provisions for items like, compensatory afforestation, catchment area treatment, establishment of fuel depot, salvage / rehabilitation of any rare or endangered species of flora and fauna, control of aquatic weeds, public health measures to control water or soil borne diseases, Restoration of land, seismological measures etc., are considered as per their requirements. A provision of around 2% of C-Works & J-Power plant civil works is made under this head

11.11 Y - Losses On Stock

The provision under this head has been made at 0.25% of the total cost of C Works, J - Power Plant Civil Works and K – Buildings.

11.12 Establishment

The provision under this head has been made in the corresponding items of the work.

11.13 Tools & Plants

Provision for ordinary tools and plants is made at 1.0% of I - Works less land.

11.14 Suspense

The net provision under this minor head is "NIL", as all the outstanding suspense accounts are expected to be cleared by adjustment to appropriate heads.

11.15 Receipts & Recoveries On Capital Account

Provision is made under this head towards estimated recoveries by way of resale at 15% of the total cost incurred towards Q-Special tools and plants.

11.16 Indirect Charges

A provision of 0.25% of I - Work cost is made for Audit and Account.

11.17 Project Cost

The total project cost has been estimated at 4985.80 Crore at March 2018 price level as given below:

Cost of Civil Works	2609.94 Crores
Cost of E&M work including	
Transmission line	1841.67 Crores
Interest During Construction	534.19 Crores
Total project cost	**4985.80 Crores**

CHAPTER – 12

FINANCIAL AND ECONOMIC ANALYSIS

12.0 Introduction

The economic viability of a project is determined by comparison with the alternative sources at the same place considering therein all elements such as cost of transmission/distribution etc., In isolated areas, it is often compared with diesel or other sources available for affording the same energy benefits. The economics of the project, where existing facility is required to meet the demand could be computed considering system requirements and the ability of the scheme for meeting the demand. When a Hydro Project is to be developed by an Independent producer, he would have to consider returns to him considering all factors such as rate offered to him by third party sale or captive consumption or sale to state electricity boards, any subsidies and concessions available for funding or otherwise.

12.1 General Description Of The Project

The Saundatti IRESP has been conceived on Renuka Sagar reservoir, in the state of Karnataka

12.2 Generation

In a year, the planned power generation will be 3329 MU considering the rate of 8 hours per day for 365 days operation @ 95% installed capacity.

12.3 Annual Requirement Of Pumping Energy

The pumping will have to be carried out for 3190 hours per year i.e 9.20 hours for 365 days operation @ 95% capacity. The energy required for pumping works out to 4338 MU per annum. The ratio of generation to pumping energy works out to 76.74%.

Optimization studies with actual parameters of Pump Turbine, Generator Motor and other equipment’s as obtained from the manufacturers shall be carried out at the time of preparation of DPR in line with the latest international practice and guidelines issued by CEA.

12.4 Means Of Finance

The project is proposed to be financed through term loans from financial institutes and balance through equity participation or as in practice of Corporation.

Equity: The developer will provide Equity to the extent of 30% of the project cost based on the estimates by adopting a debt equity ratio of 70:30 is borrowed.

Debt: The term loan to the extent of 70% of the project cost (including IDC) based on the estimates will be obtained from the financial institutions.

The analysis has been carried out, considering the rate of interest equal to 9.5% on term loan. As per CERC Terms & Conditions of Tariff Regulations, 2014 (in short, "**CERC Tariff Regulations 2014**"), repayment of loan has been considered equal to the depreciation allowed under these regulations, until the loan is fully paid off. Interest charges have been computed based on average of opening and closing amount of outstanding loan.

12.5 Cost Of Project

Estimated cost of the project is Rs.4985.80 Crore (including IDC) based on year 2017-2018 prices. The actual cost, till the completion of the project is higher due to interest charges during construction. Construction work is assumed to take 36 months and the power station is expected to be commissioned in 3.0 Years.

12.6 Interest During Construction

Interest charges during construction would depend on phasing of expenditure. IDC has been considered for scheduled completion period of 36 months. The Interest during Construction period is expected to be Rs.534.19 Crore.

12.7 Depreciation Provision

As per CERC Tariff Regulations 2014, Depreciation is considered @5.28% p.a. for the initial period of 12 years and the remaining depreciation to cover 90% depreciable value shall be spread over balance useful life of 35 years of the project.

Land is not a depreciable asset; hence depreciation is to be provided on total cost of the project other than Land.

12.8 Viable Tariff

Following assumptions are made to arrive at the viable tariff, as per CERC Tariff Regulations 2014.

Operation and maintenance O & M Expenses @ 2.5% of the project cost, escalated @ 6.64% per annum.

Interest on working capital has been arrived as follows: The total working capital is arrived at by considering sum of 15.00% on maintenance of spares, 1-month O&M cost, and 2-months Receivables.

Discount Factor for the purpose of calculating levelized tariff has been considered at 9.15% based on CERC Renewable Tariff Regulations 2017.

The above analysis is only for the purpose of arriving at the stand-alone viable tariff for the Saundatti IRESP - Storage Project, and the viability analysis for Saundatti IRESP will be carried out separately. Accordingly, the input cost of power in this project, which is dynamic and will vary as per actual conditions from time to time, has not been captured in this analysis.

TOPO SHEET NO. 48 I / 13 & M/1

52° 30'' 52° 30''

D SAUND ATTI A

839 RF

RESERVED FORE

FOREST

Open scrub

Fairly dense scrub

Cave

Spring

Falls 24 m

INTAKE STRUCTURE

HEAD RACE TUNNEL

SAUNDATTI DAM

POT HEAD YARD

EXPANSION CHAMBER

SURGE TANK

ADIT TO SURGE CHAMBER BOTTOM

PENSTOCK

POWER HOUSE

Rocky knobs

TAIL RACE CHANNEL

BM 654·9

Kāralkatti Tānda

Dargāh

Yekkundi

BM 648·9

Annual fair (Feb)

Market (Tue)

(Homeopathic)

Covered tank

Primary Health Centre

(Low level)

Aqueduct

Kagihā Tānda

Murgod 5½ km

Shāwār 5½ km

Mallūr

Dhūpdāl

Kāralkatti

Āladkatti

RENUKA SAGAR RESERVOIR

N

CLIENT:	GREENKO SOLAR ENERY PVT. LTD
PROJECT:	SAUNDATTI IRESP-STORAGE PROJECT
TITLE:	PROJECT LAYOUT
CONSULTANTS:	aarvee associates architects engineers &consultants pvt.ltd. Ravula Residency, Srinagar Colony Main Rd., Hyderabad-82, India Tel: +91 -40-23737633; Fax: +91 -4023736277 e-mail: power@aarvee.net; web:www.aarvee.net
DATE: 30.03.2018	AA/PSP/POWER/2153/004 REV.

PLAN

FOR PRE-FEASIBILITY REPORT PURPOSE ONLY

CLIENT: GREENKO SOLAR ENERGY PVT. LTD

PROJECT: SAUNDATTI IRESP - STORAGE PROJECT

TITLE: GENERAL LAYOUT - PLAN

CONSULTANTS: aarvee associates
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Ravula Residency, Srinagar Colony Main Rd., Hyderabad-82, India
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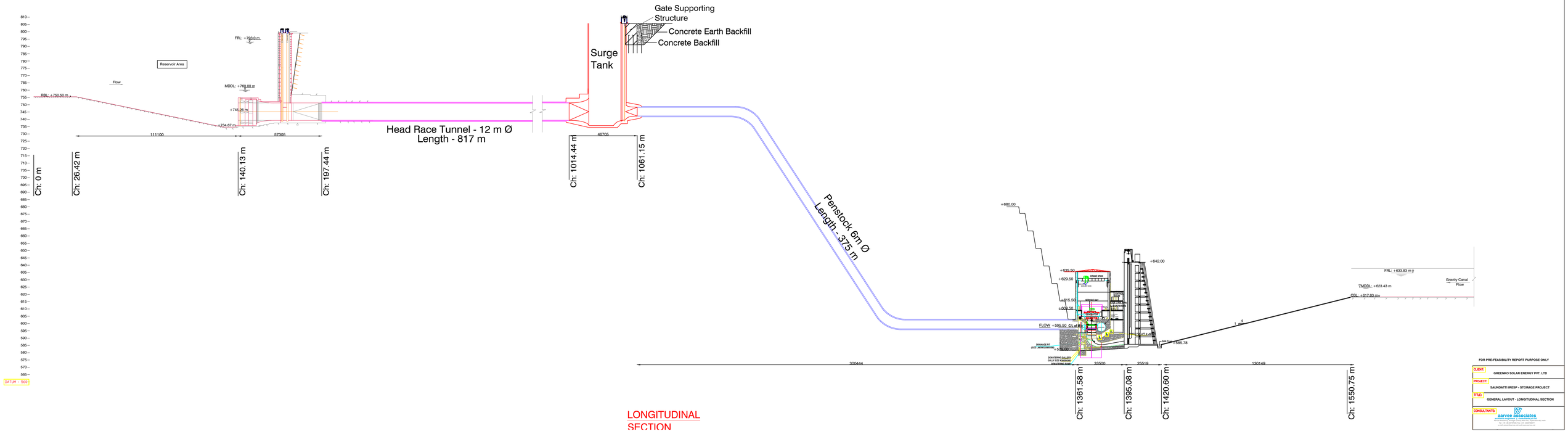
e-mail: power@aarvee.net; web:www.aarvee.net

DATE: 30.03.2018 | AA/POWER/2153/002 | REV.



LONGITUDINAL SECTION