Greenko

PINNAPURAM INTEGRATED RENEWABLE ENERGY WITH STORAGE PROJECT (IRESP)

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CHAPTER – 1

EXECUTIVE SUMMARY

1 Introduction

Proposed Pinnapuram Integrated Renewable Energy with Storage Project (IRESP) is located in Kurnool Distt of Andhra Pradesh. Pinnapuram IRESP is a 4 GW project i.e. 2 GW of Solar Project and 2 GW of wind project with storage capacity of 1000/ 8000 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 Pinnapuram 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 Orvakallu.

Storage component of Pinnapuram IRESP is a pumped storage project of 1000/8000 MWH storage capacity, located in Kurnool district of Andhra Pradesh. Pinnapuram IRESP-Storage Project will comprise of two reservoirs i.e. Gorakallu Reservoir (already existing) and Pinnapuram Reservoir (to be constructed in natural depression). This project is a one of its kind because both the reservoirs are not located on river course i.e. Gorakallu reservoir (existing) is a balancing reservoir and is located on a canal network and Proposed Pinnapuram reservoir in a natural depression. These reservoirs are far away from any river course.

The Pinnapuram IRESP - Storage Project is located in Kurnool district of Andhra Pradesh. It envisages creation of reservoir near Pinnapuram Village across Muni Madugu which joins into existing Gorakallu Reservoir near village Gorakallu under Nandyal Mandal, about 80 Kms from Kurnool. The Pinnapuram IRESP - Storage Project is proposed in between two reservoirs i.e. Pinnapuram Reservoir as Upper reservoir (to be constructed newly) and the existing Gorakallu (Narasimharaya sagar) Reservoir as Lower reservoir. This scheme envisages non-consumptive re-utilization of 1 TMC of water of the existing Gorakallu reservoir by recirculation. The water in the Gorakallu (existing lower reservoir) will be pumped up and stored in the proposed Pinnapuram reservoir (upper Reservoir) and will be utilized for power generation. The Geographical coordinates of the proposed Pinnapuram reservoir are at longitude 78° 18’ 29.17" East and latitude is 15° 35’ 38.57" North and that of Gorakallu reservoir (existing) are 78° 18’ 18.11" E and 15° 35’ 43.25" N. Proposed Rating of the Pinnapuram Pump storage project is 1000 MWH.

2 Scope of Report

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

3. Scope of Works

The Pinnapuram IRESP - Storage Project envisages construction of upper reservoir across Muni Madugu whereas existing Gorakallu reservoir near Gorakallu village in Nandyal Mandal of Kurnool District will be the lower reservoir. The existing Gorakallu reservoir is under operation with a live storage capacity of 12.44 TMC and Pinnapuram reservoir is proposed for the live storage capacity of 1.00 TMC.

Proposed Scheme will involve construction of 49m high Earthen Dam for creation of Pinnapuram reservoir. Intake structure and trash rack for five numbers of independent penstocks in which One penstock will be bifurcated in to two as hydraulic short circuit to connect two units will be taking off from Pinnapuram reservoir. Underground Power House will be located on the left bank and shall be equipped with four vertical-axis reversible Francis type units composed each of a generator/motor and a pump/turbine having generating/pumping capacity of 200MW/220MW and two units of 100MW/130MW respectively.

Gas insulated switchgear (GIS) will be provided in separate underground cavern suitably located nearby area of the Main Power House cavern. Step up transformers will also be placed in the same Cavern, which will be connected by bus duct galleries to machine hall.

2 nos 400kV quad moose double circuit transmission lines are proposed for the project. 1 no 400 KV quad double circuit transmission line to connect at Pinnapuram IRESP central Pooling station of 12KM and 1 no 400 KV quad moose double circuit transmission line of 20KM to connect at PGCIL 765/400/220kV Substation at Orvakallu. These 2 transmission lines will be used for both evacuation of generated power and input of power during pumping mode.

The Pinnapuram IRESP - Storage Project envisages construction of

- 49 m high Earthen Dam for creation of Pinnapuram reservoir of 1.32 TMC gross storage capacity

- 55m wide concrete lined approach channel with FSD of 6.30m and 1045 m long connecting Pinnapuram reservoir and power intake
- Power Intake Structure
- 4 nos. of 263.130 m long and 6.0m dia. inclined circular steel lined Penstock tunnel / Pressure Shaft each for each unit of 200 MW
- 1 no 263.130m long and 6.0m dia inclined circular steel lined Penstock tunnel/ Pressure shaft bifurcated to 2 penstocks to feed 2 units of 100 MW
- An underground Power house having an installation of four nos. reversible Francis turbine each of 200 MW capacity (2 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 134.0 m in generating mode and 142.75 m in pumping mode.
- 25 m wide typical Tail Tunnel Surge Chamber accommodating Draft tube gates
- 2 nos. each of 3860m long and 12.0m dia. concrete lined tail race tunnel connecting to Tail race channel to carry the power house releases back to the Lower reservoir.
- 55m wide concrete lined Tail race channel with FSD of 6.30m and 2200 m long connecting Tail race channel to the existing Gorakallu reservoir.
- Transformer Hall equipped with 4 nos. 3-Ph, 13.8 KV/400 KV, 250 MVA and 2 nos. 3-Ph, 13.8 KV/400 KV 150 MVA step up/step down transformers and GIS.

4. Hydrology

The total catchment area of the existing Gorakallu Reservoir is 77.70 Sq.Km and the design flood discharge is 848 cumec. The gross storage capacity of the Gorakallu reservoir is 352.26 Mcum (12.44 TMC) and the live storage is 291.38 Mcum (10.29 TMC). Operational pattern of Pinnapuram IRESP - Storage Plant has been kept in such a way that 1.0 TMC of water will be utilized for the proposed Pinnapuram IRESP - Storage Project without affecting the existing commitments at existing Gorakallu Reservoir. The project is a pumped storage scheme and hence, no consumptive utilization of water is required for its operation. The upper reservoir at Pinnapuram is proposed with an live storage of 1.0 TMC to facilitate the pumping operations. The catchment area at the proposed Pinnapuram reservoir is 9.45 Sqkm.

5. Installed Capacity

The Pinnapuram IRESP is proposed with a Storage Capacity of 8000 MWH with Rating of 1000 MWH. This Project is comprising of 4 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 1000 MWH by utilizing a design discharge of 862.50 Cumec and rated head of 134.0 m. The Pinnapuram IRESP will utilize 1140 MW to pump 1.0 TMC of water to the upper reservoir in 9.22 hours.

The Key parameters of Pinnapuram IRESP are as follows:

Sl. No.	Parameter	Unit	Value
1	Storage Capacity	MWH	8000
2	Rating	MWH	1000
3	No. of Units	Nos.	6
4	Rated Head in Turbine mode	m	134.0
5	Total Design Discharge	Cumec	862.5
6	Design Discharge per unit of 200 MW	Cumec	172.50
7	Design Discharge per unit of 100 MW	Cumec	86.25
8	Generation Duration	Hrs	8.00
9	Turbine Capacity – 4 Units	MW	200
10	Turbine Capacity – 2 Units	MW	100
11	Annual Energy Generation	MU	2774
12	Pump Capacity – 4 Units	MW	220
13	Pump Capacity – 2 Units	MW	130
14	Rated Head in Pump mode	m	142.75
15	Pumping Duration	Hrs.	9.22
16	Annual Energy consumption	Mu	3645
17	Cycle Efficiency	%	76.10

The volume of water required for turbine mode of operation is equated to the pumped mode. Annual energy generation by Pinnapuram IRESP in Turbine mode is 2774 MU Annual energy consumption by Pinnapuram IRESP in Pump mode is 3645 MU and the Cycle efficiency is 76.10%

6. Power Evacuation

2 nos 400kV quad moose double circuit transmission lines are proposed for the project. Of these, 1 no 400 KV quad moose double circuit transmission line to connect at IRESP Central Pooling station of 12KM and 1 no 400 KV quad moose double circuit transmission line of 20KM to connect at PGCIL 765/400/220kV Substation at Orvakallu. These 2 transmission lines will be used for both evacuation of generated power and input of power during pumping mode.

7. Environmental Aspects

Upper and lower reservoir for Pinnapuram IRESP will consist of proposed Pinnapuram reservoir (to be constructed newly) and the existing Gorakallu reservoir. There will be submergence of land required for the proposed Pinnapuram reservoir for the Pinnapuram IRESP - storage project. Also, the land required is for the construction of power house complex and its apparent works viz., Intake structure, penstocks, powerhouse, surge Chamber, Tail Race Tunnel and Tail Race Channel etc. All components except Pinnapuram Reservoir, Approach channel of 1.045 KM and Tail race channel of 2.2 KM long are underground. Total land required for the construction of various components is about 380.48 Ha including submergence by formation of Pinnapuram reservoir. The project components of Pinnapuram IRESP are in Gani forest under Kurnool Range. Based on assessment of environmental impacts, management plans have to 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 with in a period of 3.5 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 on the basis of 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 on the basis of 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 Works	2354.38 Cr
2	Cost of Power Plant Electro Mechanical Equipment including Transmission line	1957.42 Cr
3	Total Hard Cost	4311.80 Cr
4	Interest during Construction	517.41 Cr
5	Total cost of the Project	4829.22 Cr

10. Economic Financial Analysis

The economical evaluation of Pinnapuram 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 9.5%.

11. Conclusions

The Pinnapuram IRESP is envisaged to be completed in a period of 3.5 years. The project cost works out to Rs. 4829.22 Crores. The project would generate designed energy of 2774 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**	**Pinnapuram IRESP - Storage Project**
2		**Location**	
	a	Country	India
	b	State	Andhra Pradesh
	c	District	Kurnool
	d	Village near Power House	Pinnapuram
3		**Geographical Co-Ordinates**	
	a	**Pinnapuram IRESP Reservoir - Upper (Now Proposed)**	
		Latitude	15° 35’ 38.57" N
		Longitude	78° 18’ 29.17" E
	b	**Gorakallu Reservoir - Lower (Existing)**	
		Latitude	15° 35’ 43.25" N
		Longitude	78° 18’ 18.11" E
4		**Access To Project Site**	
	a	Airport	Hyderabad
	b	Rail head	Kurnool – 81 Kms
	c	Road	Gorakallu
	d	Port	Krishnapatnam
5		**Project**	
	a	Type	Pumped Storage Project
	b	Storage Capacity	8000 MWH
	c	Rating	1000 MWH
	d	Peak operation duration	8.00 Hours daily

6		**Pinnapuram Reservoir - Upper (Now Proposed)**	Upper Reservoir
	a	Catchment Area	9.45 Sqkms
	b	Max flood discharge	146.94 cumecs
	c	Live Storage	1.00 TMC
	d	Dead Storage	0.32 TMC
	e	Gross Storage	1.32 TMC
	f	Full Reservoir level (FRL)	EL +392.00 m
	g	Min. Draw Down Level (MDDL)	EL +370.00m
	h	Deepest Foundation Level	EL +346.00m
	i	Height of Dam from Deepest foundation level	49.0 m
	j	Total length at the top of dam	510.0 m
	k	Top width of the dam	6.0 m
7		**Gorakallu Reservoir - Lower (Existing)**	
	a	Catchment Area	77.70Sq KM
	b	Max. flood discharge	848cumecs
	c	Live Storage	10.29 TMC (291.38 Mcum)
	d	Dead Storage	2.15 TMC (60.88 Mcum)
	e	Gross Storage	12.44 TMC (352.26 Mcum)
	f	Full Reservoir level (FRL)	EL +261.00 m
	g	Min. Draw Down Level (MDDL)	EL +235.342 m
8		**Approach Channel**	
	a	Type	Trapezoidal Channel – Concrete Lined
	b	Length of the channel	1045 m
	c	Bottom width of the channel	55 m

	d	Full Supply Depth	6.3 m
	e	Bed Slope	1 in 5000m
9		**Power Intake**	
	a	Type	Open Semi Circular
	b	Elevation of Intake center line	EL +357.25 m
	c	Elevation of Sill level of intake	EL +352.50 m
10		**Penstock Tunnel/Pressure Shafts**	
	a	Type	Finished steel lined - circular
	b	Number of Penstocks	4 Nos Independent Penstocks & 1 No Independent Penstock bifurcated in to 2
	c	Diameter of penstock	6.0 m
	d	Length of penstock	263.13 m each
11		**Powerhouse Cavern**	
	a	Type	Underground 'D' Shape
	b	Dimensions	L 270.00m x B 25.00 m x H 49.00 m
12		**Transformer Cavern**	
	a	Type	Underground 'D' Shape
	b	Dimensions	L 173.00m x B 15.00 m x H 26.00 m
13		**Surge Chamber**	
	a	Type	Underground 'D' Shape
	b	Dimensions	L 175.00m x B 25.00 m x H 76.00 m
	c	Expansion Chamber	L 130.00m x B 25.00 m x H 21.00 m
14		**Tail Race Tunnel**	
	a	Tail Race Tunnel - 2 Nos	Twin Tunnels
	b	Type of tunnel	Modified Horse Shoe
	c	Diameter of Tunnel	12.0 m

	d	Length of each Tunnel	3860 m
	e	Bed Slope	1 in 1272
15		**Tail Race Channel**	Trapezoidal Channel - Unlined
	a	Lenth of the channel	2200 m
	b	Bed Width	55 m
	c	Full supply depth	6.30 m
	d	Bed fall	1 in 5000
16		**Tailrace Outlet**	
	a	Type	Open Semi Circular
	b	Elevation of outlet centre line	EL +220.682 m
17		**Hydro-Mechanical Equipment**	
	a	**Intake Structure**	
		Trash Rack	
		No of bays in each trash rack	6 Nos
		Intake Service Gate - 5 Nos	W6.90 m X H6.90 m (Vertical lift fixed wheel)
		Intake Stop log Gate - 5 Nos	W6.90 m X H6.90 m (Vertical lift fixed wheel)
	b	**Draft Tube Gates**	High pressure steel type slide gates
		No of gates per unit	2 per unit - W 6.90 m X H 6.9 m (Vertical lift fixed wheel type)
	c	**Tailrace Outlet Structure**	
		No. of bays in each trash rack	6 Nos
		Tailrace outlet Gate	W 8.0 m X H 12.5 m -2 nos for each tunnel. (Vertical lift fixed wheel type)
18		**Electro Mechanical Equipment**	
	a	**200MW Turbines**	
		Pump Turbine	Francis type, vertical shaft reversible pump-turbine

		Total No of units	4 Units (2 Nos with Varriable speed & 2 Nos with Fixed Speed)
		Rated Pumping Head	142.75 m
		Pump Capacity	220 MW
		Rated Head in Turbine mode	134.00 m
		Turbine Capacity	200 MW
		Turbine Design Discharge	172.50 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	4 Units
		Rated Capacity	Generator – 200MW; Pump Input - 220MW
		Rated Voltage	13.8KV
	ii	**Main Power Transformer**	
		Type	Indoor, 3-Ph transformers with off circuit tap changer (OCTC)
		Number of units	4 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 Varriable speed & 1 Nos with Fixed Speed)
		Rated Pumping Head	142.75 m

		Pump Capacity	130 MW
		Rated Head in Turbine mode	134.0 m
		Turbine Capacity	100 MW
		Turbine Design Discharge	86.25 Cumec for each unit
		Synchronous speed	214.28 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 - 130MW
		Rated Voltage	13.8KV
	ii	**Main Power Transformer**	
		Type	Indoor, 3-Ph transformers with off circuit tap changer (OLTC)
		Number of units	2 Units
		Rated Capacity of each unit	150 MVA
		Rated Voltage	Primary – 13.8 kV; Secondary - 400 kV adjustable range of the secondary voltage: -10% to +10%(3kV/tap)
19		**420KV Gas Insulated Switchgear**	
	1	Type of GIS	Indoor Type
	2	No. of GIS units	One No
	3	Location	Indoor
	4	Scheme	Double Busbar Arrangment
20		**POWER EVACUATION**	
	a	Voltage Level (KV)	400 KV
	b	No. of Transmission lines	Two Nos for each connecting point
	c	Total Length (KM)	Line-1: 12Kms to IRESP Central Pooling Station

			Line-2: 20Kms to PGCIL 765/400/220 KV SS near Orvakallu
	d	Structure	400KV D/C Towers
	e	Conductor	Quad Moose
	h	Terminating at	One Transmission line at PGCIL 765/400/220 KV SS near Orvakallu
	i		Second Transmission line at IRESP Central Pooling Station.
21		**Estimated Cost**	
	a	Civil Works & Other works	2354.39 Cr
	b	E & M Works incl transmission	1957.42 Cr
	c	I DC	517.41 Cr
		Total Project Cost With IDC	4829.22 Cr

CHAPTER – 3

PROJECT AREA

3.1 General

Pinnapuram IRESP - Storage Project is located in Kurnool district of Andhra Pradesh. It envisages creation of a reservoir near Pinnapuram depression which is flowing NW – SE direction, joining the existing Gorakallu reservoir. The project is about 80 km from District headquarters Kurnool via Nannur. Nearest railhead is at Kurnool and Airport is at Hyderabad. The nearest Village to project is Pinnapuram about 2 Km, which comes under Nandyal Mandal. The Storage Capacity of the Project is proposed as 8000 MWH with Rating of 1000 MWH.

Andhra Pradesh is one of the 29 states of India, situated on the country's southeastern coast. The state is the eighth largest state in India covering an area of 160,205 km^2 (61,855 sqmi). As per 2011 census of India, the state is tenth largest by population with 49,386,799 inhabitants.

The state has the second longest coastline of 972 km (604 mi) among all the states of India. It borders Telangana in the northwest, Odisha in the northeast, Karnataka in the west, Tamil Nadu in the south and the water body of Bay of Bengal in the east. A small enclave of 31 km2 (12 sq mi) of Yanam, a district of Pondicherry, lies south of Kakinada in the Godavari delta to the northeast of the state. There are 13 districts with 9 in Coastal Andhra and 4 in Rayalaseema. Visakhapatnam is the largest city and a commercial hub of the state.

Geographically, Andhra Pradesh is bestowed with two mighty river systems of Krishna and Godavari. Its varied topography ranging from the hills of Eastern Ghats and Nallamalas to the shores of Bay of Bengal supports varied ecotypes, rich diversity of flora and fauna. The state has two regions Coastal Andhra and Rayalaseema. The plains to the east of Eastern Ghats form the Eastern coastal plains. The coastal plains are for the most part of delta regions formed by the Godavari, Krishna, and Penna rivers. The Eastern Ghats are discontinuous and individual sections have local names. The Eastern Ghats are a major dividing line in the state's geography. The Kadapa Basin formed by two arching branches of the Eastern Ghats is a mineral-rich area. The Ghats become more pronounced towards the south and extreme north of the coast. Most of the coastal plains are put to intense agricultural use. The Rayalaseema region has semi-arid conditions. Lambasingi (or Lammasingi), a village in the Chintapalli Mandal of Visakhapatnam district is situated at

1000 meters above the sea level. It is the only place in South India which has snowfall and is also nicknamed as Kashmir of Andhra Pradesh. Throughout the year the temperature here ranges from 0 °C to 10 °C

The total forest cover of the state after the bifurcation is left with an area of 22,862 km^2 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

Eastern Ghats region is home to dense tropical forests, while the vegetation becomes sparse as the Ghats give way to the Deccan Plateau, where shrub vegetation is more common. These ghats has rich biological diversity with wide variety of plants, birds and lesser forms of animal life. The vegetation found in the state is largely of dry deciduous type with a mixture of Teak, Terminalias, Dalbergias, Pterocarpus, Anogeissus etc. The State possesses some rare and endemic plants like Cycas beddomei, Pterocarpus santalinus, Terminalia pallida, Syzygium alternifolium, Shorea talura, Shorea tumburgia, Psilotum nudum etc.

The diversity of fauna includes tigers, panthers, hyenas, black bucks, cheetals, sambars, sea turtles and a number of birds and reptiles. The estuaries of river Godavari and Krishna support rich mangrove forests with fishing cats and otters as keystone species

3.2 Gorakallu Reservoir (Existing)

The KWDT in 1973 has allocated 800 TMC (75% dependable flows) of Krishna waters to AP State. Under this award, the state is entitled to make any adjustments and re-allocations within the allotment made specially to the state and also entitled to utilize 11 TMC of regenerated water as its share to irrigate 1,90,000 Acres of Nandyal, Banaganapalli, Koilkuntla Taluks of Kurnool Dist. and Jammalmadugu taluk of Kadapa District.The source of water to the scheme is river Krishna tapped from foreshore of Srisailam reservoir (Now named as N.S.R.S.Project). Water will be drawn from reservoir through Pothidreddy padu head regulator with an approach channel of 3.40 Kms long inside the reservoir and from the head regulator the Sri Sailam Right main canal is aligned cutting across the Mittakandala ridge up to Banakacherla village to enter the Kundu sub-valley. At Banakacherla, a cross regulator complex is constructed and from this point the main canal i.e.,SRMC branches into three canals. The right side canal taking off to feed SRBC scheme with a capacity of 5,000 Cusecs, left canal taking off to feed the TGP and the middle escape channel to feed

K.C.Canal. Thus SRBC starts from Banakacherla cross regulator complex and runs for a length of 198.00 Km and joins in pennar river duly filling two balancing reservoirs one at Goralkallu village and another at owk village.The length of canal in Kurnool district is 141 km. This S.R.B.C Scheme was formulated to irrigate an Ayacut of 1,90,000 Acres to benefit the chronic drought prone areas in 82 villages of Nandyal, Panyam, Banaganapalli, Owk, Koilakuntla, Vuyyalwada and sanjamala mandals of Kurnool district (1,57,422 Acres) and 18 villages of Jammalamadugu mandal of Kadapa district (32,578 Acres).

3.3 Climate

The climate of Andhra Pradesh varies considerably, depending on the geographical region. Monsoons play a major role in determining the climate of the state. Summers last from March to June. In the coastal plain, the summer temperatures are generally higher than the rest of the state, with temperature ranging between 20 °C and 41 °C.

July to September is the season for tropical rains in Andhra Pradesh. The state receives heavy rainfall from the Southwest Monsoon during these months. About one third of the total rainfall in Andhra Pradesh is brought by the Northeast Monsoon. October and November see low-pressure systems and tropical cyclones form in the Bay of Bengal which, along with the Northeast Monsoon, bring rains to the southern and coastal regions of the state. November, December, January, and February are the winter months in Andhra Pradesh. Since the state has a long coastal belt the winters are not very cold. The range of winter temperature is generally 12 °C to 30 °C

3.4 Mineral Resources

Andhra Pradesh is one of the storehouses of mineral resources in India. Andhra Pradesh with varied geological formations, contain rich and variety of industrial minerals and building stones.

Andhra Pradesh is listed top in the deposit and production of mica in India. Minerals found in the state include limestone, reserves of Oil and natural gas, manganese, asbestos, Iron Ore, Ball Clay, Fire Clay, Gold Diamonds, graphite, Dolomite, quartz, Tungsten, Steatitic, Feldspar, Silica Sand. It has about one third of India’s limestone reserves and is known for large exclusive deposits of Barytes and Galaxy granite in the international market.

Mining is identified as one of the growth engines for the overall development of industry and infrastructure. The Tummalapalle Uranium mine in Andhra has confirmed 49,000 tonnes of ore and there are indications that it could hold reserves totaling three times its current size. 700 million tonnes of metal grade Bauxite deposits in close proximity to Visakhapatnam Port.

3.5 Education

Andhra Pradesh has an overall literacy rate of 91.01% (2014). According to the report of Sarva Shiksha Abhiyan (2011–12) and Statistical Abstract (2012–13), 37,45,340 children out of 38,05,791 (98.4%), were enrolled in Primary schools with a teacher/student ratio of 29.3%. 21,01,928 children out of 21,56,577 (97.5%), were enrolled in Upper Primary schools with a teacher/student ratio of 24.6%. Schools in Andhra Pradesh require Telugu to be learned. Apart from thousands of schools ranging from the pre-primary to the senior secondary ones, the state is home to a number of institutes, which impart higher education.

The Ministry of Human Resource Development has sanctioned The Indian Institute of Management (IIM) at Visakhapatnam which will start functioning from the academic year 2015-16. The Government of Andhra Pradesh has established Rajiv Gandhi University of Knowledge Technologies (RGUKT) in 2008 to cater to the educational needs of the gifted rural youth of Andhra Pradesh. The higher education includes many colleges, universities and research institutes providing professional education in the fields of arts, humanities, science, engineering, law, medicine, business, and veterinary sciences, with undergraduate and post-graduation.

3.6 General Features Of The Project

Pinnapuram IRESP - Storage Project is located in Kurnool district of Andhra Pradesh, envisages utilization of water from existing Gorakallu reservoir. The project envisages construction of Dam, approach channel, Intake, Penstock tunnel and a underground Power House. Storage Capacity of the project is proposed as 8000 MWH. There are no monuments of archeological or national importance which would be affected by project activities directly or indirectly.

CHAPTER – 4

POWER SCENARIO

4.1. INTRODUCTION

Power sector is a critical infrastructure element required for the smooth functioning of the economy. An efficient, resilient and financially healthy power sector is essential for growth and poverty reduction. The availability of reliable, quality and affordable power helps in the rapid agriculture, industrial and overall economic development of the state.

The Government of Andhra Pradesh was one of the pioneer states to initiate the power sector reforms in 1998. The erstwhile Andhra Pradesh State Electricity Board (APSEB) was unbundled into six entities to focus on the core operation of Power Generation (APGENCO), Power Transmission (APTRANSCO) and Distribution (APDISCOMS). Significant amount of investments were made for building up generation capacity, strengthening transmission and distribution network, industrial feeder segregation, loss reduction and improving quality of power supply.

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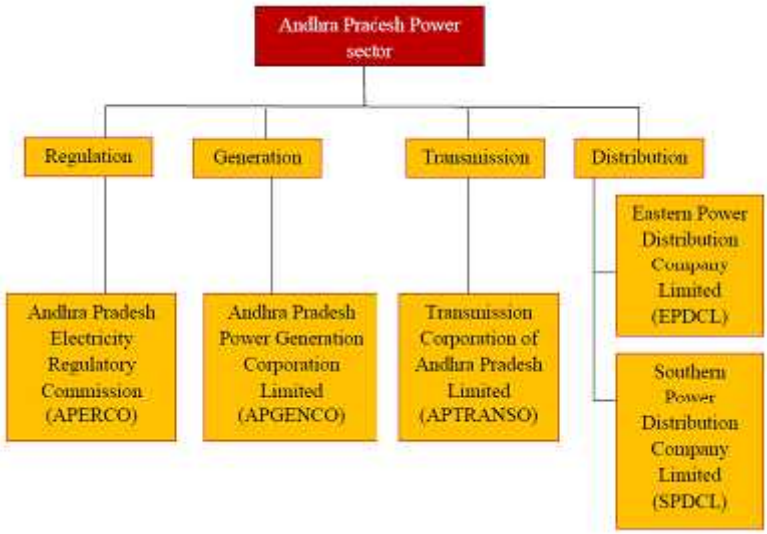


Fig.1 - Andhra Pradesh sector wise breakup

The policy of GoAP is to provide 24 hours power supply to all industries. Government of India & Government of AP have taken joint initiative to provide un-interrupted 24x7 power in the state of AP.

Inter State Transmission System (ISTS), Intra state Transmission System and distribution infrastructure have been reviewed to ensure their adequacy for providing 24x7 power in the states. Works required for strengthening and augmentation of distribution infrastructure

have been identified for supplying uninterrupted power to the consumers. Central Government will supplement the efforts of the State Government through schemes which are being finalized by Ministry of Power for funding of works required for strengthening and augmentation of distribution infrastructure, feeder segregation and 100% metering.

This joint initiative of Government of India and Government of Andhra Pradesh aims to enhance the satisfaction levels of the consumers, improve the quality of life of people and increase the economic activities resulting into inclusive development of the State.

4.2 POWER SUPPLYSCENARIO

The requirement of electricity, i.e. both energy and peak demand are expected to increase significantly in Andhra Pradesh from the present level of demand 54,301MU & 7,969 MW to 82,392 MU and 13,436 MW respectively by FY 2018-19 due to:

- Natural Load Growth.
- 24x7 power supply to all consumers
- Increase in electrification of households
- 9 hours supply to agricultural consumers
- Additional energy requirement for upcoming capital city and associated investments
- New Industrial corridors
- New Lift Irrigation schemes.

4.3 Present Power Supply Position

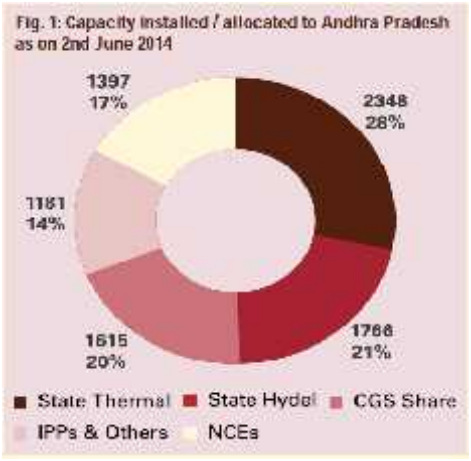
The actual power supply position of Andhra Pradesh as per the CEA report during 2016-17 is as per the table below;

Actual power supply position in terms of Energy Requirement vis-à-vis Energy Availability of during the year 2016-17			
Peak Demand	**Peak Met**	**Surplus(+) / Deficit(-)**	
(MU)	(MU)	(MU)	(%)
54,301	54,257	-44	-0.1

Actual power supply position in terms of Peak Demand vis-à-vis Peak Met of various States/ Systems during the year 2016-17			
Peak Demand	**Peak Met**	**Surplus(+) / Deficit(-)**	
(MU)	(MU)	(MU)	(%)
7,969	7,965	-4	-0.1

4.4 Existing Generation

Capacity allocation for Andhra Pradesh from existing and under costruction projects (Thermal & Hydel) has been considered in the proportion of 46.11% for APGENCO & IPPs and 49.88% for CGS stations and 100% for NCE projects. The total generation capacity of Andhra Pradesh as on 2nd Jun 2014 (on the day of formation of the new state) is 8,307 MW as per power allocation.



As on 31.01.2017, installed capacity (in MW) of power utilities in the state;

State	Ownership/ Sector	Modewise breakup							Grand Total
		Thermal				Nuclear	Hydro (Renewable)	RES (MNRE)	
		Coal	Gas	Diesel	Total				
Andhra Pradesh	State	3085.91	235.40	0.00	3321.31	0.00	1808.87	89.50	5219.68
	Private	3650.00	3074.11	16.97	6741.08	0.00	0.00	3660.99	10402.07
	Central	1540.30	0.00	0.00	1540.30	127.16	0.00	0.00	1667.46
	Sub-Total	**8276.21**	**3309.51**	**16.97**	**11602.69**	**127.16**	**1808.87**	**3750.49**	**17289.22**

4.5 Action points for GoAP / APGENCO

In the current situation, there are a host of measures that are being taken up immediately

by GoAP/APGENCO, while others will be implemented in a phased manner for long term reduction of fuel deficit.

4.5.1 Coal Imports to meet shortfall of Coal from MCL

GoAP has given in-principle approval to APGENCO to import coal for its needs. APGENCO, in view of domestic coal shortfall from MCL, has drawn up the following import plans, for its stations.

Table 6: Coal Import Plan by APGENCO

Coal Imports By APGENCO	**FY 17-18**	**FY 18-19**
Mandatory Imports for Krishnapatnam	1.2	1.2
Imports to meet deficit	4.2	4.2
Total Coal Imports*	5.4	5.4

*Permissible at current domestic coal availability**.**

It has to be noted that, even after importing coal to the maximum technical limits, the PLF will remain in the range of 75% only.

4.6 Necessity of Hydro Power Development

Andhra Pradesh 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.

The most reliable option for energy storage is development of Pumped storage schemes. Pumped hydroelectric energy storage (PHES), is a type of hydroelectric energy storage used by electric power systems for load balancing. The method stores energy in the form of gravitational potential energy of water, pumped from a lower elevation reservoir to a higher elevation. Low-cost surplus off-peak electric power is typically used to run the pumps. During periods of high electrical demand, the stored water is released through turbines to produce electric power. Although the losses of the pumping process makes the plant a net consumer of energy overall, the system increases revenue by selling more electricity during periods of peak demand, when electricity prices are highest.

Pumped-storage hydroelectricity allows energy from intermittent sources (such as solar, wind) and other renewables, or excess electricity from continuous base-load sources (such as coal or nuclear) to be saved for periods of higher demand. The reservoirs used with

pumped storage are quite small when compared to conventional hydroelectric dams of similar power capacity, and generating periods are often less than half a day. Along with energy management, pumped storage systems are also helpful in controlling electrical network frequency and provide reserve energy.

In view of the power scenario described above, the Pinnapuram IRESP - Storage Scheme envisaged with Storage Capacity of 8000 MWH with Rating of 1000 MWH and will help a long way in meeting the projected power demand.

4.7 Pumped Storage schemes in India

Pumped storage schemes in India are commonly used in hydro power projects to meet the peak power demands. There are quite a number of sites in India for development of Pumped storage stations. The reassessment studies by CEA have also identified 56 sites for Pumped Storage Schemes (PSS) with probable total installation of about 94,000 MW.

At present 11 PSS (4504 MW) are under operation, 4 PSS (3290 MW) are under construction. Pumped storage schemes in India is tabulated as below :

S.NO	Name of scheme	Nos. Of units & size	Total Capacity (MW)	State
Schemes in Operation				
1	Ghatghar	2X125	250	Maharashtra
2	Bhira	1X150	150	Maharashtra
3	Nagarajun Sagar	7X100	700	A.P.
4	Srisailam-	6X150	900	A.P.
5	Kadamparai	4X100	400	Tamil Nadu
6	Purulia	4X225	900	W.B.
7	Ujani	1X12	12	Maharashtra
8	Paithon	1X12	12	Maharashtra
9	Kadana Stage I&II	2X60+2X60	240	Gujarat
10	Panchet Hill -D.V.C.	1X40	40	Jharkhand
11	Purulia IRESP	4X225	900	West Bengal

Schemes Under Construction stage				
12	Tehri Stage II	4X250	1000	U.A.
13	Koyana Stage IV	4X250	1000	Maharashtra
14	Sardar Sarovar	6X200	1200	Gujarat
15	Bhivpuri	1X90	90	Maharashtra
Schemes Under Planning stage				
16	Malshej Ghat	700 MW		Maharashtra
17	Humbarli	400 MW		Maharashtra
18	Hathiadah & Durgawati	1600 MW		Bhabhua, Bihar
19	Turga	600 MW		West Bengal
20	Telahar Kund	400 MW		Bhabhua, Bihar
21	Sinafdar	345 MW		Bhabhua, Bihar
19	Kali	600 MW		Yellapur, Karnatak
20	Sharavathi	800 MW		Shimoga, Karnataka
21	Panchgotia	225 MW		Bhabhua, Bihar
22	Upper Indravati	4X150	600 MW	Kalahandi, Odisha
23	Pallivasal IRESP	-		Kerala

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 (57I2 and 57I6) 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 Gorakallu reservoir and proposed Pinnapuram IRESP reservoir to act as lower and upper reservoirs respectively for the proposed Pinnapuram IRESP - Storage Project.

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

5.4 Geological Survey & Investigation

5.4.1 Introduction Of Study Area

Kurnool district is the third largest district in Andhra Pradesh situated between North latitudes 14°35′35″:16°09′36″ and East longitudes 75°58′42″:78°56′06″. It is bounded by Tungabhadra and Krishna rivers and Mahabubnagar district in the north and Prakasam district in the East, Bellary district of Karnataka State in the west and Anantapur and Cuddapah districts in the South. The total geographical area of the district is 17600 sq.km with headquarters at Kurnool and divided into 54 revenue mandals.

5.4.2 Physiography

The Nallamalais and Erramalias constitute the principle hill ranges in the district. The average altitutde ofthe Nallamalais is 600m. The highest point in the range is Manikonda

which is having altitude about 909 m.and the other prominent peak is Durgaonda which is having altitude 851m.

5.4.3 DRAINAGE SYSTEM

The important rivers flowing in the district are the Tungabhadra, its tributaries, the Handri, the Krishna andthe Kunderu. Tungabhadra rises in the Western Ghats and forms the northern boundary between Kurnool and Mahabubnagar district. The Handri drains Pattikonda and Dhone areas and joins Tungabhadra near Kurnool town. Kunderu is a tributary of the river Pennar which rises on the western side of the Erramalais and flows in the southern direction thorough Nandikotkur, Nahdyal, Allagadda and Koilakuntla and enters Cuddapah district. In addition to these, small streams The Sogileru, The Rallavagu, The Munimaduguleru, The Bandrapavagu and The Sudamvagu, Paleru, Gandaleru and Bhavanari drains are flowing in the district.

5.4.4 STRATIGRAPHY OF THE INDIAN PENINSULA

The Proterozoic rocks are present in the northern as well as the southern parts of Indian peninsula. These rock formations of the Cuddapah Supergroup and, its equivalent, were earlier referred to as Purana Formation, including both the Cuddapah and Vindhyan Supergroup. The stratigraphic succession of Indian Peninsula as follows:

It divided in to two main divisions as Upper Purana Group and Lower Purana Group, The Kurnool formation is belongs to Southern Peninsula of the grate Indian Peninsula-

Main division	**Southern Peninsula**	**Northern Peninsula**
Upper Purana	Kumool Group, Bhima	Upper Vindhyan
Group,	Indravati Group	Malani Volcanics,
Sullaria Group		
Lower Purana	Chhattisgarh Group.	Lower Vindhyan
	Cuddapah Supergroup,	Gwalior Group
	Kaladgi Group,	Bijawar Group
	Pakhal Group.	Kolhan Group
		Delhi Super group.

5.4.5 REAGIONAL GEOLOGY OF STUDY AREA

The Kurnool district is situated within the stable shield of Indian Peninsula. The oldest rocks exposed in the district are a group of metamorphic rocks of early Precambrian or Archaean

age. They comprise of quartzites, phyllites, schists, gneisses, migmatites, granites and amphibiolites. These rocks have been highly folded and intruded in to granites. The composite gneisses associated with granites were formed as a result of the injection of granitic magma along weak planes in the pre-existing rocks and reaction between them. Apart from this, there are periods of erosion and non-deposition of sediments known as the Eparchaean interval, followed when there was a termination of earth movement and igneous activity and the country was exposed to denudation.

This prolonged period of dormancy came to a close when in the late Precambrian times a large tract of Landin the district and adjacent districts formed into a sallow sea. Sediments started accumulating in the basin referred to as Cuddapah basin. The sedimentary rocks of the Cuddapah Super group comprises of conglom-erates, quartzites, shales, dolomite, limestones and chert. The floor of the sea was unstable and it sunk periodically. Land conditions appear to have prevailed intermittently in this region before the deposition of the Cuddapah sedimentation was completed. Further, in the early Cuddapah times, there was intermittent volcanic activity, when lavas of basic igneous rocks in the form of sills intruded the cuddapah formations. When the deposition of Cuddapah sediments ended, the region was uplifted and the strata tilted, fractured and exposed to denudation.

With the passage of time, the basin in the west was again submerged beneath a shallow sea and in the upper Precambrian and Cambrian times, the sedimentary rocks of Kurnool group comprising of limestones, shales, quartzites and conglomerates were deposited.

The overlapping nature of the different formations and the lateral variation in the thickness of Kurnool strata suggest that the basin in which the Kurnool sediments accumulated was unstable with frequents oscillations of the sea level. In the post Kurnool times, the Cuddapatl basin was again uplifted and along its eastern margin, the Kurnool and Cuddapahs were folded, the later more severely.

These rocks occupy the western part of the district exposed in Adoni, Alur, Pattikonda areas. Granites and composite gneisses are the dominant rock types. Amphibolies, hornblende schists, quartzites, phyllites, chlorite schists and mica schists are very much restricted in their extent and confined to small patches. The schists are highly folded. The composite gneisses are grey in colour and show alternate banding of quartz and feldspar with biotite or hornblende. The granites are seen in pink, grey, and with massive, gneissic fine-to-coarse grained and porphyritic texture. The granites are composed of potash feldspar, plagioclase, quartz, biotite and hornblende. Numerous felsite, pegmatites quartz veins and dykes of dolerite have intruded into the granites.

5.4.6 THE CUDDAPAH ROCKS

The rocks of Cuddapah Super group mostly occupy the eastern part of the district, roughly 100 Km long in N-S (roughly) 50 Km wide extending westwards from Nallamalai range. The northern and eastern parts of Atmakur, eastern parts of Nandyal, and east of Allagadda are occupied by Cuddapah formations. They are concealed by the younger Kurnool formations.

The Cuddapah sediments are over 6000 meters in thickness. They are sub divisible as follows-

PAPAGNI GROUP –

Guvalacheruvu quartzites, Vempalli dolomites, The dips are gentle towards ESE or S. In the Veldurthy – Kalva area, the Gulcheruvu and Vempallies have faulted along with Chitravathi Group of rocks. The faults have E-N-E and W-S-W or E-W trends.

CHITRAVATHI GROUP –

Pulivendla qucquartzites and Tadpatri shales, are main Rocks types of group, exposed at around Dhone, Banganapalli areas over a narrow belt.

NALLAMALAI GROUP –

Bairenkonda quartzites, Cumbum shales. Nallamallai Group of rocks are highly folded and intruded by dolorites, prophyritic rocksof alkaline composition, and rocks of probable Kimberlite composition.

KRISHNA GROUP –

THE KURNOOL GROUP ROCKS

The Kurnool Group of rocks are mainly composed of limestones and calcarious shales and attained at thickness of about 600 m. It is divisible into four formations as follows:

- Kundair formaiton
- Paniam formation
- Jammulamadugu formation
- Banganapalli formation

The Banganapalli formation consists of quartzites, sandstones and conglomerates, exposed at Banganmpalli, Nandavaram, Nandyal, Gani, Mithur and Nandikotkur areas. They are horizontal or show gentle dips (<10°). The basal conglomerate is made up of clasts of shale, chert, laser quartzite in a sandy or clayey matrix. Diamonds are picked up from these conglomerate. The quartzites and sandstone are medium to coarse grained, grey in colour.

The Jammalamadugu Group overlies the Banganapalli formation comprises of Narji limestones at the base and Owk shales at the top. They are exposed at Koilakuntla, Dhone, Nandyal, Nandi kotkur and Kurnool. The Narji limestones are massive and variegated in colour intercalated with shale and quartzite bands. The Narji formation contain enormous limestone reserves.

The Panyam Group of rocks which comprises of the plateau quartzites at the bottom and the pinnacle quartzite at the top, constitute the flat topped ridges and plateau to the west of Kundeir plains.

The Kundair formarmations are the youngest of Kurnool Group comprising of Koilakuntla beds at the bottom and the Nandyal shales at the top. They attain a thickness ranging from 60 to 300 m. and exposed in the plains of Kunderu river, south of Allagadda to north of Atmakur. The Koilakuntla consists of grey, massive or flaggy limestones, while the Nandyals are made up of calcareous shale and shaley limestone.

RECENT GEOLOGICAL SUCESSION OF KURNOOL GROUP AS CONFIRMED BY GSI

- Banganapalli Quartzite 10 – 57m
- Narji Limestone 100 – 200m
- Owk shales 10 – 15m
- Panyam Quartzite 10 – 15m
- Koilakuntla Limestone 15 – 50m
- Nandyal Shale 50 – 100m

5.4.7 GENERAL GEOLOGY OF PROPOSED DAM AREA

AAs well described in above section of chapter the Kurnool Group of rocks are mainly composed of various Limestones thickness of 15 – 200m, calcareous shales having 10 – 100m and various Quatrzites having 10 – 57 m thickness at places. Hence the cumulative thickness of Kurnool group varying between 185 – 440m.

The Banganapalli quartzites are oldest quartzites which are having vertical to sub vertical jointing system along with very low dip bedding joints it can be seen at road sections near Banganapalli village, Nandavaram, Nandyal, Gani, Mithur and Nandikotkur of Kurnool district. It is underlined by Narji limestones which are well exposed at the banks of Gaurikulla reservoir. The thickness of Narji Limestone thickness are varying between 100 to 200m, it is dissected with N60W – S60E main Joints which is having massive shearing

along itself at places. The Narji limestone can be seen at Koilakuntla, Dhone, Nandyal, Nandi kotkur and Kurnool. The Narji Limestone is intersect almost perpendicular to Gorikulla Reservoir with a prominent Fault which is aligned EW direction. The uplift section of the Narji limestone can be exhibited at tale of Gaurikulla Reservoir as well as some canal regulators works are under progress. Owk Shales are not most prominent at our study area. The Panyam Quartzite are overlaid on Owk Shale which are not exposed in surrounding areas although Koilakuntla limestones are well exposed at Gaurikulla Reservoir tale having thickness up to 50m the thickness of Panyam Quartzites are varying between 3-5ms at places as confirmed by GSI through nos of exploratory drill holes did during the exploration of Gaurikulla Dam. The Gaurikulla Dam has constructed almost perpendicular to a massive fault line which is trending E – W directions and massive shearing along it at places. This fault is a part of Ganni Kalwa fault which are resulting many depressions in area which are acting as a valley who is carrying runoff water. Near The Prinapuram village using the depressions of rocks and valleys where it is slightly narrow (almost U Shape) and ridges of hills/ plateau are covered with Plateau Quartzites of Panyam series of Kurnool group, is comprising with 03 major sets of joints which are vertically to sub vertical in disposition along with low dip angle of bedding Joint are as follows viz

Jointing System of Study Area

Set No Attitude of Discontinuity Persistence along strike (m) Spacing (cm) Aperture (mm) Roughness Infilling

Jointing System of Study Area:

Set No	Attitude of Discontinuity		Persistence along strike (m)	Spacing (cm)	Aperture (mm)	Roughness	Infilling
	Dip Direction	Dip Amount					
J1	185°-210°	5°-10°	4.0 – 10.0	15-60	Tg-2	RP	Nil
J2	210°-225°	80°-85°	2.0 – 7.0	30-100	Tg	RU	Nil
J3	330°-345°	70°-80°	1.0 – 4.5	100-400	T-20	RP	Gauge
J4	015°-020°	65°-75°	1.0 – 2.5	20-60	Tg-1	RP	Nil

Based upon survey and surface geological mapping of area a complete geological plan has been made as Annexure – I, in this plan several sections have been made and studied, based upon site suitability the section DA – 9 (Annexure – II) was found for suitable for housing a rock fill dam and geological setting also placed and fond that at this location the valley width is about 475m and banks are comprising with exposed rock abutments and the base of valley is also almost horizontal where the agriculture farming was going on.

Based upon surface geology the approximate overburden may be 12-14m in center of bed, but need to verify with exploratory drill holes which may be 20 – 25m in rocks. Some more drill holes also require for delineating the bedrock conditions and in-situ test i.e. SPT in Overburden horizon, and permeability in overburden and rocks also need to check. Apart from these general tests laboratory tests also require to do in advance stage of project. slightly narrow and The proposed dam axis area comprising with a U shaped valley where the bed width is about 175m covered 5 – 10 m deep overburden of sandy soil and gritty material. Need to confirm with at least 3 rows of ERT before deciding the finial axis of dam. Some dense shrub and herbs forest also covered the bed area along with ground nut and cotton agriculture field.

The crest of both banks of valley are covered with jointed rock mass of quartzites and shale. At the top of valley the horizontal width may within 600 to 650m (Annexure – I). Hence the location may suitable for housing a 45 – 50m high Rock fill dam or Earthen Dam also keeping alignment of axis as N48°E – S48°W with a 5° – 7° variation as per suitability of site. The require construction materials are i.e rock debris for preparing aggregates and earthen dam material as well as the core material for using in earthen dam and rock fill dam are available nearby the proposed area.

5.4.8 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 with all 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 shears as well as minor weak zones of area.

For confirming the valley bed before doing the exploratory drill holes at least 03 lines across the valley of Electric Restivity Test of ERT need to be done for optimization of lowest thickness of overburden and week zones beneath the valley bed. Based upon the results of ERT the dam axis has to be finalized. The bed rocks are exposed in both banks of Dam abutments and its physical property also known with field tests but for chemical property

need to test in laboratory hence require testing to be conduct in laboratory at DPR Stage. In-situ test also need to conduct in dam foundations i.e plate load test for optimization of load bearing capacity of bed and bed rocks. Deformation modulus and shearing of rock to rock and rock to concrete, Modulus deformation Test, bearing test also require because beddings are almost horizontally laid at both banks of proposed dam locations.

Tail Race Tunnels and Penstocks area 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.

5.4.9 GEOLOGY OF POWERHOUSE AND TUNNELS:

As per the details collecting during surface geological mapping at glance it was confirmed the both banks of proposed location is 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 craven based upon results of hydro-fracture tests and shearing tests.

For making any size of tunnels the adjacent rock outcrops are very suitable excepts some minor faults and shear joints may negotiate during construction of tunnels. The housing of Power house has to be limited between multiple shear joints which are trending NW – SE at about 100 – 250m spacing as reflect on Topo sheet and confirming by GSI also at their published documents. The parallel shear may be possible along the proposed power house and TRTs also. Hence the detail investigations are required during detail engineering of project with exploratory drill holes at several intervals so the alignment of tunnels can be optimized accordingly. The tunneling media is good enough and may categorized in Class II (Good Rock Mass Class) to III (fair rock Mass Class) except some pockets of Poor rock Mass Class (IV). Although the tunneling media is good enough hence the 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 occurred frequently if support of rocks may not provide on time although in TBM tunneling pre cast support are provided along with excavation of phase.

5.4.10 GEOLOGY OF RIM AREA:

Along the valley bed a complete traverse was taken towards 3.5 – 4 KM up stream of proposed dam axis along with depression bed and observations were recorded. The both banks of valley are well 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. Mineral exploration also not doing by any one agency just because there are probability of mineral founding are very less hence no economic mineral may occurred during project execution and project submergence area.

5.5 Construction Material

The excavated material from the tunnels, underground structures may be sorted, crushed, tested and utilized for the construction activities.

5.6 Further Studies for Survey & Geotechnical Investigation

Detailed topographic survey shall be carried out for the proposed Pinnapuram 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.

5.7 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 Gorakallu reservoir. i.e balancing reservoir in existing canal network. Secondly since these two reservoirs are not located across any stream, 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 Pinnapuram IRESP - Storage Project is proposed to utilize the water available in the existing Gorakallu reservoir located near Gorakallu Village of Nandyal Mandal of Kurnool 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 49 m from the deepest foundation level. An approach channel which is located on left side of upper reservoir starts from reservoir and ends at power Intake structure and independent penstock tunnels/Pressure shafts starts from the power intake structure conveys the water up to the powerhouse. The water from power house out fall is conveyed through a tail race tunnel and is let back to the existing Gorakallu reservoir through Tail Race Channel.

Since the proposed scheme is a pumped storage scheme and envisages to utilize 1.0 TMC of water from existing Gorakallu Reservoir, no modification in the operating levels are needed. Moreover, only recycling of water is proposed for Pinnapuram IRESP operation. As such hydrological study is required to the extent to see the required inflow into reservoir

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

Sl. No.	Parameter	Unit	Value
1	Full Reservoir Level (FRL)	m	EL 392.00
2	Minimum Draw Down Level (MDDL)	m	EL 370.00
3	Live Storage	TMC	1.00
4	Dead Storage	TMC	0.32
5	Gross Storage	TMC	1.32
6	Height of Dam	m	49.00

7	Catchment Area of Reservoir	Sq. Km	9.45
8	Design Flood Discharge	Cumecs	146.94

The Key parameters of Existing Gorakallu Lower Reservoir are as follows:

Sl. No.	Parameter	Unit	Value
1	Catchment Area of Reservoir	Sq. Km	77.70
2	Design Flood Discharge	Cumecs	848
3	Full Reservoir Level (FRL)	m	EL 261.00
4	Minimum Draw Down Level (MDDL)	m	EL 235.342
5	Live Storage	TMC	10.29
6	Dead Storage	TMC	2.15
7	Gross Storage	TMC	12.44
8	Length of Dam	m	1731
9	Height of Dam	m	48.50

6.1 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 Pinnapuram IRESP is envisaged to utilize 1.0 TMC of water to be pumped from the existing Gorakallu reservoir to the proposed upper Pinnapuram reservoir in 9.22 hours. The project is a pumped storage scheme and hence, no consumptive utilization of water is required for its operation.

6.2 Gorakallu Reservoir (Existing)

The existing Gorakallu reservoir is utilised to enable Pinnapuram IRESP to operate as a peak station. The FRL & MDDL of Existing Gorakallu reservoir is at EL 261.00 m & EL 235.342 m respectively. The live storage capacity of existing reservoir is 10.29 TMC. Water will be pumped to the proposed upper reservoir through TRC and TRT.

The FRL and MDDL of the proposed Pinnapuram reservoir are at EL 392.00m & 370.00m respectively. The live storage of the proposed reservoir is kept for 1.00 TMC. The water from Pinnapuram reservoir, after generation, passes through a 3860 m long tail race tunnel. A tail race channel of approx. 2200m will discharge the flows in to existing Gorakallu reservoir.

6.3 Operation Of Pinnapuram IRESP - Storage Project

The Pinnapuram IRESP is proposed with a Storage Capacity of 8000 MWH with Rating of 1000 MWH. This project is comprising of 4 units of 200 MW each and 2 units of 100 MW each. The Project will generate 1000 MWH by utilizing a design discharge of 862.50 Cumec and rated head of 134.00m. The Pinnapuram IRESP will utilize 1140 MW to pump 1.0 TMC of water to the upper reservoir in 9.22 hours.

The Key parameters of Pumped Storage Operation are as follows:

Sl. No.	Parameter	Unit	Value
1	Storage Capacity	MWH	8000
2	Rating	MWH	1000
3	No. of Units	Nos.	6
4	Rated Head in Turbine mode	m	134.00
5	Total Design Discharge	Cumec	862.50
6	Design Discharge per unit – for 200 MW	Cumec	172.50
7	Design Discharge per unit – for 100 MW	Cumec	86.25
8	Generation Duration	Hrs.	8.00
9	Annual Energy Generation	Mu	2774
10	Pumping Head	m	142.75
11	Pumping Duration	Hrs.	9.22
12	Annual Energy consumption	Mu	3645
13	Cycle Efficiency	%	76.10

The volume of water required for turbine mode of operation is equated to the pumped mode. Annual energy generation by Pinnapuram IRESP in Turbine mode is 2774 MU and Annual energy consumption by Pinnapuram IRESP in Pumping mode is 3645 MU and the Cycle efficiency is 76.10%

6.4 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 Pinnapuram reservoir is at EL+392.00 m and MDDL is at EL+370.00 m. The normal tail water level is the level at the tail race outlet corresponds to design discharge flow of 862.50 Cumec passing

through the turbine considering all machines running at full plant load. Normal tail water level corresponding to above design discharge is EL +234.842m. The bed level of the tail race Channel is kept at EL + 228.542m.

CHAPTER – 7

DESIGN FEATURES OF MAJOR COMPONENTS

7.0 Introduction

The Pinnapuram IRESP - Storage Project is located in Kurnool district of Andhra Pradesh. It envisages creation of reservoir near Pinnapuram across Muni madugu which joins into existing Gorakallu Resesrvoir.

The scheme will involve construction of 49m high Dam for creation of Pinnapuram reservoir of 1.32 TMC capacity, and the Pinnapuram IRESP - Storage Project is proposed in between two reservoirs i.e. Pinnapuram Reservoir as Upper reservoir (to be constructed newly) and existing Gorakallu Reservoir as Lower reservoir (existing). Water will be let out from the Pinnapuram reservoir through Approach channel of 1045m long upto Power Intake and penstocks of 263.13m long to feed the Pinnapuram IRESP, having an Storage Capacity of 8000 MWH with Rating of 1000 MWH. This project is comprising 4 units of 200 MW and 2 units of 100 MW each. The water after power generation will be conveyed through 3860m long and 2 nos. of 12m dia. Tail Race Tunnels followed by a 2.20 Km long Tail Race Channel to discharge water in to Lower reservoir of existing Gorakallu reservoir. General Layout of the proposed scheme is enclosed in the drawing AA/POWER/2154/01.

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

Sl. No.	Parameter	Unit	Value
1	Top of bund	m	EL +395
2	Full Reservoir Level (FRL)	m	EL +392
3	Minimum Draw Down Level (MDDL)	m	EL +370
4	Live Storage	TMC	1.00
5	Dead Storage	TMC	0.32
6	Gross Storage	TMC	1.32
7	Deepest Foundation Level (m)	m	EL +346
8	Height of Dam from Deepest foundation level	m	49.00
9	Catchment Area	Sqkm	9.45
10	Design flood discharge	Cumec	146.94

Pinnapuram Reservoir - Area Capacity							
EARTH BUND AT DA – 9							
ELEVATION (m)	Depth (m)	AREA (M.sq.m)	Sqrt Area	Sqrt(A1 * A2)	Capacity (MCM)	Cum.capacity (MCM)	Cum.capacity (TMC)
349	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
350	1	0.0600	0.2449	0.0000	0.0200	0.0200	0.0007
355	5	0.3000	0.5477	0.1342	0.8236	0.8436	0.0298
360	5	0.5300	0.7280	0.3987	2.0479	2.8915	0.1021
365	5	0.6900	0.8307	0.6047	3.0412	5.9327	0.2095
370	5	0.8700	0.9327	0.7748	3.8913	9.8241	0.3469
375	5	1.0300	1.0149	0.9466	4.7444	14.5684	0.5145
380	5	1.2200	1.1045	1.1210	5.6183	20.1867	0.7129
385	5	1.3900	1.1790	1.3022	6.5204	26.7071	0.9432
390	5	1.5500	1.2450	1.4678	7.3464	34.0535	1.2026
395	5	1.8200	1.3491	1.6796	8.4160	42.4695	1.4998

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

Sl. No.	Parameter	Unit	Value
1	Catchment Area	Sq. Km	77.70
2	Design Flood Discharge	Cumecs	848
3	Full Reservoir Level (FRL)	m	EL 261.00
4	Minimum Draw Down Level (MDDL)	m	EL 235.342
5	Live Storage	TMC	10.29
6	Dead Storage	TMC	2.15
7	Gross Storage	TMC	12.44
8	Length of Dam	m	1731
9	Height of Dam	m	48.50

7.1 Approach Channel

An approach channel of 1045m long will convey the water from Pinnapuram reservoir. A trapezoidal channel of 55m wide with FSD of 6.3m is provided on the left bank of the reservoir. The total design discharge for the Approach channel is 862.50 Cumecs. The side slopes are provided as 0.5 H : 1.0 V

7.2 Intake Structure

The intake structure of Pinnapuram IRESP will be constructed on the left side of Pinnapuram reservoir. The Intake structure will have 5 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 Penstock tunnel/Pressure Shaft. There is a provision of service gate and Stop log gate with vent size 6.9m x 6.9m. The total design discharge for the Penstock tunnel/Pressure shaft is 862.50 Cumecs.

The center line of the pressure tunnel emerging from the trash rack is EL +357.25m and the trash rack is proposed to rest on rock at around EL +352.50m. Radius of the trash rack is 14.6 m.

7.2 Penstock Tunnel / Pressure Shaft

Four independent pressure shaft / penstock tunnels of 6.0 m diameter are proposed to provide supply of water to feed four 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 263.13m. Flow through the penstocks shall be controlled through the gates provided at the Intake 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 172.50 Cumec for each unit.

7.3 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 134.0m. The Pumped storage plant comprises of 6 units.

The Key parameters of Storage Operation are as follows:

Sl. No.	Parameter	Unit	Value
1	Storage Capacity	MWH	8000
2	Rating	MWH	1000
3	No. of Units	Nos.	6
4	**Turbine Capacity – 4 Units**	**MW**	**200**
5	**Turbine Capacity – 2 Units**	**MW**	**100**
6	Rated Head in Turbine mode	m	134.0

7	**Design Discharge per unit of 200 MW**	**Cumec**	**172.50**
8	**Design Discharge per unit of 100 MW**	**Cumec**	**86.25**
9	Total Design Discharge	Cum	862.50
10	Generation Duration	Hrs.	8.00
12	Annual Energy Generation	Mu	2774
13	**Pump Capacity – 4 Units**	**MW**	**220**
14	**Pump Capacity – 2 Units**	**MW**	**130**
15	Pumping Head	m	142.75
16	Pumping Duration	Hrs.	9.22
17	Annual Energy consumption	Mu	3645
18	Cycle Efficiency	%	76.10

Pumping operation is proposed at 9.22 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 8.00hours/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, a surface power house is not feasible as it requires deeper excavation, intricate supporting arrangements for the cut slopes involving cable anchors etc., Also it required to construct Surge shaft above NGL by about 100m height which may lead to construction difficulties and operational problems. Keeping in view the disadvantages of surface powerhouse, an underground powerhouse considered to be the preferred option for the Pinnapuram IRESP. Other aspects favoring an underground powerhouse are its suitability for the large installed capacity and size of powerhouse of the PSS, least length of pressure shaft, compactness, ease of approach through access tunnel, remoteness from the reservoir for water tightness and fairly good geological conditions. Keeping in view the above fact, an underground power house with underground transformer hall cavern has been proposed. Also, underground 420 KV Gas Insulated Switchyard has been proposed keeping in view the terrain and reliability of the system. The approach to power house and transformer hall cavern has been proposed through 8.5m D-shaped main access tunnel. The machine hall and transformer hall are proposed in underground parallel cavities at suitable spacing. The control room is

proposed in power house cavity while the SF6 switchgear is proposed in transformer hall cavity. A cable cum ventilation gallery/tunnel is proposed, which will initially be used for carrying out excavation and providing support system in the crown portion of power house and transformers hall cavities.

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

7.4 Machine Hall

The internal dimensions of power house cavity have been proposed with length 170m and width 25.00m. The units have been kept at about 25.00m spacing while the erection bay and control bay have been proposed 30m and 40m long respectively. Necessary support system to be provided in crown portion of cavity with grouted rock anchors at suitable spacing, shotcreting with welded wire mesh etc. will be studied in detail at the time DPR preparation. Cavern for housing control room and various auxiliaries/offices, 4 nos. floor have been proposed. The main inlet valve is proposed to be housed in power house cavity 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.

7.5 Transformer Hall

The size of transformer hall cavity has been proposed as 175m long and 15m wide. The clear spacing between power house cavern and transformer cavern has been kept at 40m. In addition to main generator transformers, space for spare transformers and station transformer has also been provided in the cavern. The transformer hall cavern will be connected to erection bay by 8.5m D-shaped gallery for carriage of transformers at erection stage and for repairs. NG rail track is proposed between transformer hall and erection bay for transportation of transformers. The transformer hall will be connected by 6 nos. bus duct galleries of 4.00m D-shaped.

7.6 Downstream Surge Chamber And Tail Race Tunnel

The outflow from the end of draft tube will be taken through 6 nos. separate tunnels which will be entering into a chamber. This chamber will act as an expansion chamber for minimizing the downstream surge effect and shall also accommodate the draft tube gate. 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 TRT, it is

proposed to provide expansion chambers at right angle to the flow. The Surge Chamber shall be provided with adequate rock support system and a reinforced concrete lining of 500 mm thickness up to maximum surge level. Thereafter, provision of rock support system consisting of rock bolts and shotcreting will be studied in detail at the time DPR preparation. Vertical lift gates have been proposed in all the Draft tubes for facilitating repair in turbines. Downstream of this chamber will be joined to two nos 12.00m dia main Tail race tunnel. Total length of each Tail race tunnel has been proposed as 3860m. The flows from the tail race tunnel shall be carried through a tail race channel of 2.20 Km long.

7.7 Main Access Tunnel & Construction Adits

One no. of 8.5m dia. D Shaped main access tunnel is provided to approach Power house Service bay and Transformer hall on the left side of power house. Additional tunnel of 6.5m dis. D Shaped tunnel is provided to approach Power House crown from the right side of power house. Another tunnel of 6.5m dia. D shaped is provided for cable cum ventilation tunnel. Construction adits in suitable numbers are provided to facilitate construction activities for Surge chamber, Tail race tunnel etc. The details of the adits along with the lengths are shown in the General Layout drawing.

7.8 Muck Disposal

By constructing a 3860m long twin tunnel and Power house complex, Surge chamber, Transformer cavern, Pressure shaft etc. the quantity of muck to be generated is estimated to be about 73.40 lakh Cum. It is expected that about 37.71 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 18.00 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 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 off circuit tap changer along with control and protective gear and breakers etc.
- One nos 420KV Gas Insulated switch-gear (GIS) units is proposed for connecting to two different sources separated by bus sectionalize.
- 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).

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 200/220 MW (4No’s) & 100/130MW (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&75kArms for 3 s
c)	Rated current of bus bars	-	12,000A & 8000A

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 4 nos 3-Ph 250 MVA & 2 Nos 3-Ph 150MVA 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	-	250.0 MVA and 150MVA
(c)	Cooling Method	-	OFWF (Oil Forced and Water Forced)
(d)	13.8KV connection	-	Delta
(e)	400KV connection	-	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:

One no 420KV Gas Insulated switch-gear (GIS) units are proposed for for the project.

Indoor metal-enclosed phase segregated type SF6 gas insulated switchgear system rated for 420 kV, 3 phases, 50 Hz consisting of following major items:

i) 3150A SF6 gas insulated metal enclosed bus bars complete in all respects, comprising of:

(1) Individual bus bars enclosures running the length of the switchgear,

(2) Single-phase surge arrestors,

(3) Single-phase, 2-core voltage transformers,

(4) Single-phase disconnector complete with manual and motor driven operating mechanisms, for isolation of voltage transformer,

(5) Single-phase safety earthing switches complete with manual and motor driven operating mechanisms, with each single-phase disconnector.

ii) Bus-coupler & bus sectionalize bay modules, each comprising of:

a) 3-pole SF6 gas insulated circuit breaker, complete with dedicated operating mechanism,

b) 4-core, multi ratio, 3-pole current transformers,

c) 3-phase, single-pole group-operated disconnector complete with manual and motor driven operating mechanisms,

d) 3-phase, single-pole group-operated safety earthing switches complete with manual and motor driven operating mechanisms,

Local control cubicle for control of coupler bay, bus bar VT and disconnector including bay controller.iii) Generator bay modules, each comprising of:

a) 3-pole SF6 gas insulated circuit breaker, complete with dedicated operating mechanism for each pole,

b) 5-core, multi ratio, 3-pole current transformer,

c) Single-phase surge arrestors,

d) 3-phase, single-pole group-operated disconnector, complete with manual and motor driven operating mechanisms,

e) 3-phase, single-pole group-operated safety earthing switches, complete with manual and motor driven operating mechanisms,

f) SF6 / SF6 bushings,

g) Local control cubicle for control including bay controller.

iv) Transmission line bay modules, each comprising of:

a) 3-pole SF6 gas insulated circuit breaker, complete with individual operating

mechanism,

b) 5-core, multi ratio, 3-pole current transformer,

c) 3-phase, single-pole group-operated disconnectors, complete with manual and motor driven operating mechanisms,

d) 3-phase, single-pole group-operated safety earthing switches, complete with manual and motor driven operating mechanisms,

e) 3-phase, single-pole group-operated high-speed earthing switch, complete with manual and motor driven operating mechanism,

f) SF6 / air bushings for outdoor connections,

g) Local control cubicle for control including bay controller.

v) Gas insulated bus duct (GIB) for interconnection between GSU transformers and respective unit bays of GIS,

vi) All necessary terminal boxes, SF6 gas filling, interconnecting power and control wiring, earthing connections, gas monitoring equipment and piping support structures etc.,

vii) Continuous on-line monitoring and diagnostic systems to monitor gas density, gas pressure, leakage, moisture (offline) etc., operating parameters such as current, voltage, temperature etc. complete with sensors, control/processor units, wiring/cabling in all respect and integration of the systems with plant SCADA system,

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 replacement with minimum disturbance of the remaining pressurized switchgear.

Metal enclosed Bus bar

The bus bars shall be single-phase segregated metal-enclosed type. The enclosure design shall essentially be based on following considerations

a) Temperature and solar radiations,

b) Thermal cycling, vibration, shock and seismic,

c) Design Pressure on normal and abnormal conditions.

Conductors and live part shall be mounted on moulded epoxy resin insulators specially made for the EHV application. The conductors shall be made of tubular aluminium. Silver plated finger contacts at the ends of conductor or mounted on support insulators shall be provided to form sliding contact permitting the conductor to expand axially on a temperature rise, without imposing any mechanically stresses on the supporting insulators. Metal bellows compensators shall be provided on enclosure for permitting longitudinal expansion. The enclosure shall be dimensioned for the full return current. Compensators shall be bypassed by copper straps.

Circuit breakers

The circuit breaker shall be designed to minimize switching over voltages and also to be suitable for out-of-phase switching. The specified arc interruption performance must be consistent over the entire operating range, from line-charging currents to full shortcircuit currents. The complete contact system (fingers, clusters, jets, SF6 gas) shall be designed to withstand at least twenty (20) operations at full short-circuit rating without the necessity to open the circuit breaker for service or maintenance.

The interrupter and operating drive should be simple and sturdy conforming to C2 & M2 class complying with T100 & L75 without maintenance respectively as per IEC 62271-100.

The operating mechanism shall be spring / spring or hydraulic / spring type.

The circuit breakers shall comprise three single-phase metal clad breakers poles. The circuit breaker shall have double break interrupter unit per pole. Each pole shall consist of the operating mechanism, interrupter unit and the enclosure with basic supporting structure. The mechanism shall be trip free mechanically or electrically with anti pumping device. Grading capacitors shall be provided to ensure uniform voltage distribution between interrupting elements. SF6 circuit breakers shall conform to IEC- 62271-100. Auxiliary contacts of the breakers shall be provided for the local and remote indications, the performance of various control and protection schemes and the interlocking scheme. Alarm and cut-off contacts for mechanism faults and gas pressure loss shall also be provided. The circuit breaker shall be capable of being operated locally or from remote.

Current transformers

The current transformers shall be of single phase inductive type and shall have multi core with multi ratio, which shall be changeable by means of taps on secondary side. Independent cores shall be used for different purposes of protective relaying and metering diagram.

Voltage transformers

The voltage transformers shall be of single phase inductive type with secondary windings. Independent cores shall be used for different purposes of protective relaying and metering diagram.

The voltage transformer shall be located in a separate module and shall be connected phase to ground to the phase buses.

Disconnector

The three-phase disconnector shall comprise of three separate pole and all the three poles shall be mechanically coupled via robust mechanical link. All three poles shall be group-operated manually as well as through motor driven mechanisms.

The disconnector shall have provision for visual indication of switching position. Disconnector shall conform to IEC 62271-102. Sufficient auxiliary contacts shall be provided for indications (local and remote), interlocking schemes and the performance of various control and protection schemes.

Earthing switch

The 3-phase earthing switch shall comprise of three separate pole and all the three poles shall be mechanically coupled via robust mechanical link. All three poles shall be group-operated manually as well as through motor driven mechanisms.

Each earthing switch shall be electrically and mechanically interlocked with its associated disconnector and circuit breaker. Sufficient auxiliary contacts for indications and interlocking shall be provided. Inspection window shall be provided in the enclosure.

High speed earthing switch

The three-phase high-speed make-proof type-earthing switch shall comprise of three separate pole and all the three poles shall be mechanically coupled via robust mechanical link. All three poles shall be group-operated manually as well as through motor driven mechanisms. It shall be used to discharge the respective charging current in addition to their safety earthing functions.

Each earthing switch shall be electrically and mechanically interlocked with its associated disconnector and circuit breaker. Sufficient auxiliary contacts for indications and interlocking shall be provided. Inspection window shall be provided in the enclosure.

Surge arrestor

The surge arrestor shall be of gap-less heavy-duty station type and the live part shall comprise of non-linear metal oxide resistors without spark gap. Provision shall be made for measurement of leakage current and connection of discharge counter. The arrestors shall be either the plug in construction or the disconnect link type and be attached to the GIS in such a manner that they can be readily disconnected during the dielectric tests. The metal housing of the arrestor should be connected to the metal enclosure of the GIS through the flanged or bolted joints.

Earthing

The enclosures of all the GIS shall be grounded at several points so that there shall be a grounded gauge around all live parts. All conduits and cables sheaths shall be connected to the ground bus, to be provided, in the control cubicles and the marshalling boxes. All steel structures shall be grounded.

All wirings to GIS shall be shielded and grounded at both ends.

Subassembly to subassembly ground conductors shall be provided to assure safe voltage gradients.

The gas shall generally conform to IEC 60376 – 2005 edition but for following

Water	<	5 ppm by weight
Carbon Tetra Fluoride	<	250 ppm by weight
Air	<	250 ppm by weight

On-line monitoring

Continuous on line monitoring system shall be provided to monitor conditions such as gas density, gas pressure, gas leakage, moisture (offline) etc. and operating parameters such as current, voltage, temperature etc. of GIS for smooth operation and detection of any changes in insulation at an early stage during normal operation to take appropriate remedial action.

Each system shall be complete with sensors, input/output module, control/processor unit, relays, junction boxes, cabling and associated accessories for measuring, monitoring and data acquisition of intended parameters to be monitored.

Gas monitoring system

Each gas-filled compartment shall have its own SF6 gas density / pressure monitoring system, each comprising of a temperature compensated SF6 gas density monitoring unit and pressure gauge having alarm/trip contacts.

Gas pressure and density shall be continuously monitored and displayed by a suitable temperature compensated instrument, which will provide an alarm signal in case of pressure drop before the allowable minimum pressure is reached.

Local control cubicle

The Local control cubicle shall contain all the equipment required for controlling and monitoring the bay. Each bay's local control cubicle shall have at least the following main function:

The mimic diagram with control switches for electrically operated circuit breakers, disconnector and earthing switches as well as the position indication of all components provided with auxiliary switches,

Alarm facia with indicating lamps for monitoring of gas density,

Trip circuit healthiness,

Electric interlocking between devices,

Interface between central control and the switchgear,

Interior lighting, safety shrouding, heating to prevent condensation etc.

All the switchgear bay module shall be supplied with a local control cubicle of the floor standing type. The cubicle shall have full height, hinged, gasket lockable double doors. One door shall have safety glass window through which various controls can be viewed without opening the door. The cubicle shall be utilized as both the switchgear bay local control module and as the terminating centre for all power supply, control, annunciation and supervisory wiring interfacing with the system. Adequate no. Of potential free contact shall be made available for providing necessary input/output interface.

Implemented technology for control shall be digital and local control cubicle shall incorporate bay control unit for integration to plant SCADA system through local control Board for GIS.

8.3.4 400KV Outdoor Connection:

Four incomers of 1CX1000Sqmm XLPE Cu cables from 420KV GIS are connected to two nos separate 400KV D/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.

II) Station Transformers

HT station power will be derived by providing **1 nos 20/25.0 MVA**, 400/13.8KV Station Transformer through **3 nos 35.0 MVA & 2nos 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.

III) SFC Equipments:

The static frequency converter for fixed machines and AC excitation for variable machines is a modular multilevel direct converter. 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.

IV) 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%

V) Unit Auxiliary Transformers

415 V Unit auxiliary power will be derived by providing **6 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.

VI) 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

VII) 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:

Two (2) numbers 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:

- Start/Stop of the turbine and generator/pump in sequence control.
- Monitoring, recording & trending of the temperature inputs from RTD's
- Monitoring of the alarm inputs from the turbine and generator/pump protection system.
- Monitoring, recording & trending of all electrical and analog parameters through suitable transducers
- 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:

- Continuous UTC reference, +5.30 hours offset (IST)
- IRIG B Time Code output
- RS 232 & 485 serial port interface
- SNTP & NTP Ethernet Output
- Pulse Output
- BCD Output
- DCF77 Output
- Large size Time display
- All weather water proof antenna
- Synchronization software for Server /PC
- Hot Redundant GPS / Master clock with comparator
- Redundant power supply with Diode O-ring
- 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:

- Backup Impedance (21)
- Over Excitation (24)
- Under Voltage/ Over Voltage (27/59)
- Reverse power (32)
- Under Power (37)
- Loss of Field/ excitation (40)
- Negative phase sequence (46)
- Thermal Over Loading (49)
- Breaker Failure (50BF)
- Voltage Restrained Over current (51V)
- PT fuse failure (60FL)
- 100% Stator earth fault (64G)
- Under/ Over frequency (81O/U)
- Generator Differential (87G)
- Annunciator (30)
- Rotor Earth Fault (64F)
- Master Trip relay (86G)
- Trip Circuit Supervision (95)
- Split phase based inter turn protection
- Overall differential protection with 3 winding inputs (Generator, GT HV, and

Generator Tap off).

Turbine Protections

The following protections will be provided:

- Under/ Over Speed (12/14)
- Governor Failure Relay (33/63)
- Bearing Temperature (38T)
- Oil pressure Failure (96.2 OPU)
- Oil levels
- Shear pin
- vibrations etc

Auxiliary Transformer Protections

The following protections will be provided:

- Under Voltage (27)
- Instantaneous O/C & E/F (50/50N)
- IDMTO/C & E/F (51/51N)
- Master Trip (86)

Step-Up Generator Transformer Protections:

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

- Transformer Over Fluxing (49)
- Instantaneous O/C & E/F (50/50N)
- IDMT O/C & E/F (51/51N)
- Transformer Differential (87GT)
- Restricted earth fault (64Ref)
- Annunciator (30)
- Oil temperature, Alarm/Trip Aux (49OA/OT)
- Winding temperature, Alarm/Trip Aux (49 WA/WT)
- Buchholz/ Alarm/Trip Aux (63 A/T)
- High Speed Tripping (Master) (86T)
- Trip Circuit Supervision (95)

- Low Oil Level Alarm (LOLA)
- Oil Surge Trip (OSR-T)
- Pressure Relief Device Trip Aux. (PRD-T)
- Apparatus thermal device (26)
- 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:

1. Impedance (21)
2. Over/ under voltage (27/59)
3. AC Directional over current (67/67N)
4. Frequency (81)
5. Master Trip (86)
6. Trip Circuit Supervision (95)
7. AC Reclosing Relay / Auto Reclose (79)
8. Instantaneous Overcurrent Relay (50)
9. Phase Angle Measuring or Out-of-Step Protective Relay (78)
10. Bus Differential (87B)
11. Overvoltage Relay (59)
12. 400KV reactor protection
13. 400KV bus bar protection
14. 400KV cables protection
15. 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	250 lux
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:

The most feasible option for power evacuation is to establish 2 nos. separate 400KV D/C quad moose transmission lines, which will be connected to two separate substations at PGCIL 765/400/220KV Substation at ORVAKALLU and IRESP central pooling station.

CHAPTER – 9

ENVIRONMENTAL ASPECTS

9.0 Introduction

The Project is envisaged as a Pumped Storage Project being developed near existing Gorakallu Reservoir. The project is located in Kurnool district of Andhra Pradesh. The Project involves creation of upper reservoir near Pinnapuram Village across Muni Madugu which joins into existing Gorakallu Reservoir near village Gorakallu under Nandyal Mandal, about 80 Kms from Kurnool. 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 Pinnapuram IRESP - Storage Project is proposed in between two reservoirs i.e. Pinnapuram Reservoir as Upper reservoir (to be constructed new) and the existing Gorakallu (Narasimharaya sagar) Reservoir as Lower reservoir. This scheme envisages non-consumptive re-utilization of 1.0 TMC of water of the existing Gorakallu reservoir by recirculation. The water in the Gorakallu (Existing lower reservoir) will be pumped up and stored in the proposed Pinnapuram reservoir (upper Reservoir) and will be utilized for power generation. The Geographical co - ordinates of the proposed Pinnapuram reservoir are at longitude 78° 18’ 29.17" East and latitude is 15° 35’ 38.57" North and that of Gorakallu reservoir (existing) are 78° 18’ 18.11" E and 15° 35’ 43.25" N.

9.1.2 Climate

The climate of Andhra Pradesh varies considerably, depending on the geographical region. Monsoons play a major role in determining the climate of the state. Summers last from March to June. In the coastal plain, the summer temperatures are generally higher than the rest of the state, with temperature ranging between 20 °C and 41 °C.

July to September is the season for tropical rains in Andhra Pradesh. The state receives heavy rainfall from the Southwest Monsoon during these months. About one third of the total rainfall in Andhra Pradesh is brought by the Northeast Monsoon. October and November see low-pressure systems and tropical cyclones form in the Bay of Bengal which, along with the Northeast Monsoon, bring rains to the southern and coastal regions of the state. November, December, January, and February are the winter months in Andhra Pradesh. Since the state has a long coastal belt the winters are not very cold. The range of

winter temperature is generally 12 °C to 30 °C

CLIMATOLOGICAL TABLE				
Month	Mean Temperature(oC)		Mean Total Rainfall (mm)	Mean Number of Rainy Days
	Daily Minimum	Daily Maximum		
Jan	17.9	**31.7**	4	0.3
Feb	20.3	**34.8**	2.2	0.2
Mar	23.8	38.2	9.8	0.7
Apr	26.7	40.1	26.4	1.6
May	27.5	40.5	50.4	2.7
Jun	25.5	36.2	93.6	5.7
Jul	24.5	33.6	121.4	7.6
Aug	23.9	32.5	143.4	9
Sep	23.8	32.9	145	7.7
Oct	22.8	32.5	114.1	5.2
Nov	20.1	31.2	23	1.9
Dec	17.8	30.5	3.9	0.3
Annual	22.9	34.6	737.2	43

9.1.3 Gorakallu Reservoir (Existing) system

The KWDT in 1973 has allocated 800 TMC (75% dependable flows) of Krishna waters to AP State. Under this award, the state is entitled to make any adjustments and re-allocations within the allotment made specially to the state and also entitled to utilize 11 TMC of regenerated water as its share to irrigate 1,90,000 Acres of Nandyal, Banaganapalli, Koilkuntla Taluks of Kurnool Dist. and Jammalmadugu taluk of Kadapa District.The source of water to the scheme is river Krishna tapped from foreshore of Srisailam reservoir (Now named as N.S.R.S.Project). Water will be drawn from reservoir through Pothidreddy padu head regulator with an approach channel of 3.40 Kms long inside the reservoir and from the head regulator the Sri Sailam Right main canal is aligned cutting across the Mittakandala ridge up to Banakacherla village to enter the Kundu sub-valley. At Banakacherla, a cross regulator complex is constructed and from this point the main canal i.e.,SRMC branches into three canals. The right side canal taking off to feed SRBC scheme with a capacity of 5,000 Cusecs, left canal taking off to feed the TGP and the middle escape channel to feed K.C.Canal. Thus SRBC starts from Banakacherla cross regulator complex and runs for a length of 198.00 Km and joins in pennar river duly filling two balancing reservoirs one at Goralkallu village and another at owk village.The length of canal in Kurnool district is 141 km. This S.R.B.C Scheme was formulated to irrigate an Ayacut of 1,90,000 Acres to benefit the chronic drought prone areas in 82 villages of Nandyal, Panyam, Banaganapalli, Owk, Koilakuntla, Vuyyalwada and sanjamala mandals of Kurnool district (1,57,422 Acres) and

18 villages of Jammalamadugu mandal of Kadapa district (32,578 Acres).

9.1.4 REAGIONAL GEOLOGY OF STUDY AREA

The Kurnool district is situated within the stable shield of Indian Peninsula. The oldest rocks exposed in the district are a group of metamorphic rocks of early Precambrian or Archaean age. They comprise of quartzites, phyllites, schists, gneisses, migmatites, granites and amphibiolites. These rocks have been highly folded and intruded in to granites. The composite gneisses associated with granites were formed as a result of the injection of granitic magma along weak planes in the pre-existing rocks and reaction between them. Apart from this, there are periods of erosion and non-deposition of sediments known as the Eparchaean interval, followed when there was a termination of earth movement and igneous activity and the country was exposed to denudation.

This prolonged period of dormancy came to a close when in the late Precambrian times a large tract of Landin the district and adjacent districts formed into a sallow sea. Sediments started accumulating in the basin referred to as Cuddapah basin. The sedimentary rocks of the Cuddapah Super group comprises of conglom-erates, quartzites, shales, dolomite, limestones and chert. The floor of the sea was unstable and it sunk periodically. Land conditions appear to have prevailed intermittently in this region before the deposition of the Cuddapah sedimentation was completed. Further, in the early Cuddapah times, there was intermittent volcanic activity, when lavas of basic igneous rocks in the form of sills intruded the cuddapah formations. When the deposition of Cuddapah sediments ended, the region was uplifted and the strata tilted, fractured and exposed to denudation.

With the passage of time, the basin in the west was again submerged beneath a shallow sea and in the upper Precambrian and Cambrian times, the sedimentary rocks of Kurnool group comprising of limestones, shales, quartzites and conglomerates were deposited.

The overlapping nature of the different formations and the lateral variation in the thickness of Kurnool strata suggest that the basin in which the Kurnool sediments accumulated was unstable with frequents oscillations of the sea level. In the post Kurnool times, the Cuddapatl basin was again uplifted and along its eastern margin, the Kurnool and Cuddapahs were folded, the later more severely.

These rocks occupy the western part of the district exposed in Adoni, Alur, Pattikonda areas. Granites and composite gneisses are the dominant rock types. Amphibolies, hornblende schists, quartzites, phyllites, chlorite schists and mica schists are very much restricted in their extent and confined to small patches. The schists are highly folded. The composite gneisses are grey in colour and show alternate banding of quartz and feldspar

with biotite or hornblende. The granites are seen in pink, grey, and with massive, gneissic fine-to-coarse grained and porphyritic texture. The granites are composed of potash feldspar, plagioclase, quartz, biotite and hornblende. Numerous felsite, pegmatites quartz veins and dykes of dolerite have intruded into the granites.

9.1.5 Seismicity

The project area is located in Kurnool district of Andhra Pradesh. As per Seismic Zonation Map of India, the project area lies in Seismic Zone II.

9.1.6 Flora

The floral diversity of this Kurnool district is incredible, which covers 353 species of plants including trees, herbs, shrubs, climbers, grasses. The forest present in this district area is abode to medicinal plants. The plants like Madhuca longifolia, Dillenia Pentagyna, Aristolochia indica, Terminalia arjuna, Pithecolobium dulce, Adina cordifolia, Terminalia tomentosa, T.bellerica, Chloroxylon swietenia, Boswellia serrata, Teak and Vanda spp. etc; are there.

Kurnool District has two major forest Nallamalais and Yerramalais forest. Yerramalis forest are the eastern ghat extensions. The Gani Reserve forest is a dry deciduous forest. Forest comes under the Sothern thorn forest. The vegetation is varied depending upon the climate and edaphic factors. Apparently there are signs of forest becoming degraded from moist deciduous and to scrub type dominated by thorny. Succulent and xerophytic bushes. The forest is luxuriant in vegetation and enriched with many medicinal, rare, endemic and threatened categories of plants.

9.1.7 Fauna

The invertebrate life is enthralling with an over hundred species of Butterflies, Over 50 species of moths, and a huge diversity among other insects. East Asian tree frog, narrow mouthed frog, Indian cricket frog etc, represent the 18 species of amphibians, while their reptilian counterparts include snakes like Russell's viper, common cobra, Indian rock python along with other reptiles such as marsh crocodile, monitor lizard, star tortoise, etc. 200 species of birds like wood sand piper, Temminck's stint, lesser golden backed wood pecker, Gray horn bill, Brown fish owl, wigeon, Vultures etc. Mammals like leopard, Indian wolf, wild dog, Jackal, Striped hyena, Spotted deer, sambar, Barking deer, chinkara, chowsingha, Nilgai, Honey badger etc. are present in Kurnool District.

9.2 Prediction of Impacts

The environmental impacts of the proposed Pinnapuram IRESP 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 4 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 31.71 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 73.40 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 37.71 Lakh cum of the muck to be generated as construction material in various project structures.

Therefore, 35.69 Lakh Cum muck is proposed to be dumped at pre-identified locations. Out of this quantity, about 18 Lakh Cum is proposed to be dumped in upper reservoir itself (to be constructed newly) 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 4 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 Gorakallu reservoir will be used as a lower reservoir for the project. The upper reservoit at Muni madugu 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 Pinnapuram IRESP Storage Project including erection of four generating units is planned to be completed in a period of three and half (3.5) 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

a) Dam

b) Approach channel and Power Intake

c) Penstock Tunnel/Pressure shaft

d) Underground powerhouse and transformer cavern including pothead yard/cable tunnel and access tunnel.

e) Underground Surge Chamber and adits.

f) Tailrace Tunnels

g) Tailrace outlet structure

h) Tailrace channel

Electrical Works

a) E.O.T cranes

b) Supply and erection of T.G sets 6 nos.

c) 400 KV G.I.S. equipment

d) Main Power Transformers

e) Other auxiliary electro-mechanical equipment

Hydraulic equipment

a) Intake gates

b) Intake trashrack

c) Steel liner Penstock

d) Draft Tube gates

E) Tailrace Outlet gates

10.2.2 Target Schedule

The Total Construction period is scheduled as follows.

Preconstruction Period	:	6 months
Construction Period (Main Works)	:	3.0 Years
Total Construction Period	:	3.5 Years

10.3 Infrastructure Facilities

The Pinnapuram 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 approach roads, office and residential buildings will be started and completed in 3 months. The facilities for workshop and stores etc. are also included.

10.3.1 Coffer Dam

Excavation of coffer dam will be started from the 2nd month of year 1 immediately after the completion of Preconstruction works and award of work. Partial filling and construction of guide bunds may start from 3rd month of year 1

10.3.2 Dam

Excavation of dam area will be parallelly started from the 3rd month of year 1 immediately after the completion of partial filling at coffer dam and will be completed by 11th month of year 2.

10.3.3 Approach Channel

Excavation of Approach channel may start from 8th month of year 1 and will be completed by 8th month of year 2. The concreting of channel may take place from 4th month of year 1 and will be completed by 8th month of year 2 respectively.

10.3.4 Power Intake

Excavation of intake structure may start from 8th month of year 1 and will be completed by 8th month of year 2. The concreting of intake and gate shaft may take place from 11th & 12th month of year 1 and will be completed by 10th month and 11th month of year 2 respectively.

10.3.5 Penstock Tunnels

Adit to penstock tunnel will be started in the 3th month of year 1 and will be completed within 9 months. Excavation in penstock tunnels will be taken up in the 4th month of year 1 and will be completed by the end of 1sh month of the 2nd year. The Lining & erection of steel liners will be start from 2nd month of year 2 and will be completed by the end of 6th month of year 3.

10.3.6 Underground Powerhouse/Transformer Caverns

Access tunnel to powerhouse will be done by 7th month of first year and then the excavation of the power house cavern will be taken up in the 8th month and will be completed by 6th month of year 2. The concreting will be taken up in the 10th month of the third year including all the second stage grouting works.

10.3.7 Tailrace Tunnel/Outlet/Tailrace Channel

Adit to Tailrace tunnel will be started from 4th month of year 1 and completed by 8th month of year 1. Tailrace channel & tunnel works will start simultaneously and completed within 24 months. The construction of outlet tunnel may take place independently and will be completed within 8th month of year 3.

10.3.8 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 9 months.

CHAPTER - 11

COST ESTIMATE

11.0 General Description Of The Project

The Pinnapuram IRESP - Storage Project envisages utilization of water of the existing Gorakallu reservoir. Upper and lower reservoir for Pinnapuram IRESP will be made up respectively by the proposed Pinnapuram reservoir and the existing Gorakallu 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 Andhra Pradesh & 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 Andhra Pradesh 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 Andhra Pradesh 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 75.00 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

Approach channel & Intake Structure

- 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
- Gates with auxiliary equipment's
- Reinforcement Steel
- Instrumentation etc.,

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

Surge Chamber

- Excavation
- Concrete
- Shortcreting

Tail Race Tunnel and 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% C – Works & 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. 114.23 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% C-Works, J-Power plant civil works and K-Buildings 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% C-Works, J-Power plant civil works and K-Buildings 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.228.50 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 and 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 4829.22 Crore at March 2018 price level as given below:

Cost of Civil Works	2354.38 Crores
Cost of E&M work including	
Transmission line	1957.42 Crores
Interest During Construction	517.42 Crores
Total project cost	4829.22 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 Pinnapuram IRESP has been conceived on existing Gorakallu reservoir, in the state of Andhra Pradesh

12.2 Generation

In a year, the planned power generation will be 2774 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 3197 hours per year i.e 9.22 hours for 365 days operation @ 95% capacity. The energy required for pumping works out to 3645 MU per annum. The ratio of generation to pumping energy works out to 76.10%.

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.4829.22 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 42 months and the power station is expected to be commissioned in 3.5 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 42 months. The Interest during Construction period is expected to be Rs.517.42 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.

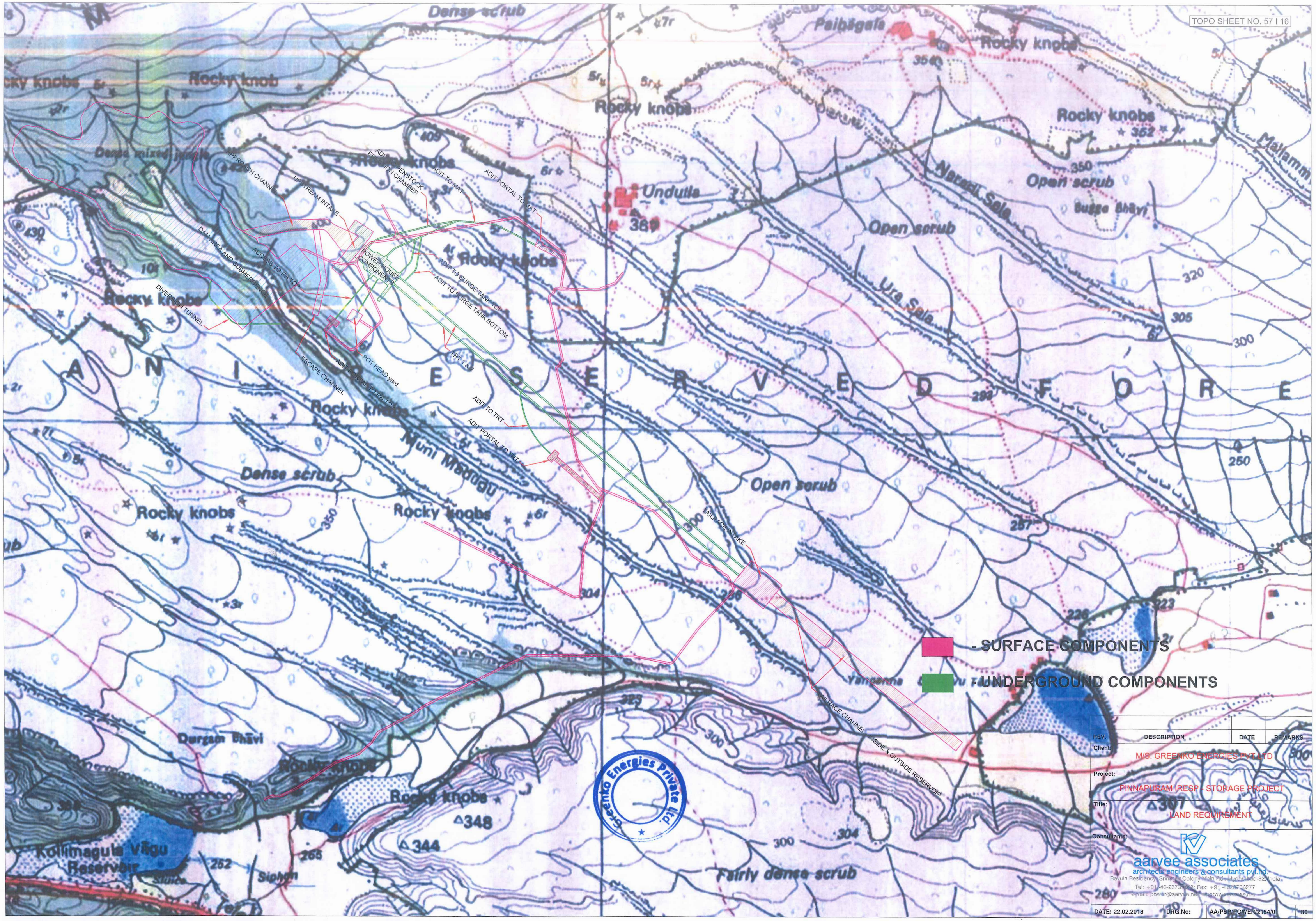
Operation and maintenance O & M Expenses @ 2.5% of the project cost, escalated @

6.64% per annum.

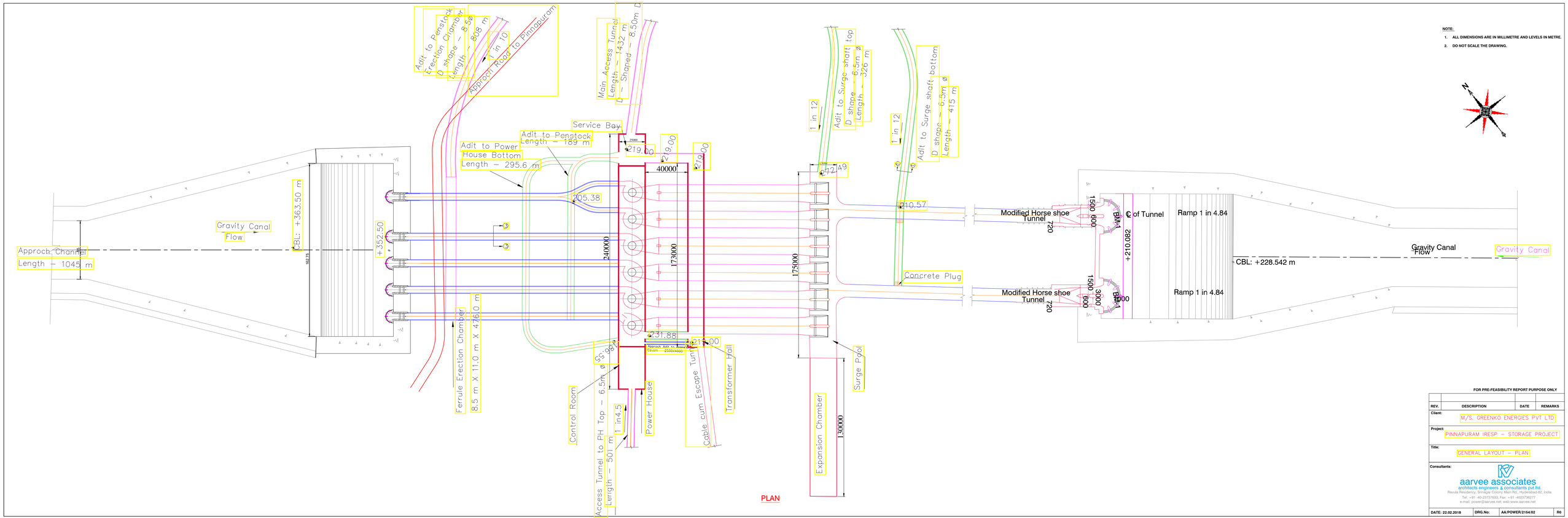
Interest on working capital has been arrived as follows: The total working capital is arrived at by considering sum of 15.00% on maintenance of spares, 1-month O&M cost, and 2-months Receivables.

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 Pinnapuram IRESP - Storage Project, and the viability analysis for Pinnapuram 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. 57 I 16
Dense scrub
Rocky knobs
Rocky knob
Dense mixed jungle
APPROACH CHANNEL
UPSTREAM INTAKE
ADIT TO MAT
ADIT PORTAL TO MAT
POWER HOUSE COMPONENTS
ADIT TO SURGE TANK TOP
ADIT TO SURGE TANK BOTTOM
DIVERSION TUNNEL
ESCAPE CHANNEL
POT HEAD yard
ADIT TO TRT
ADIT PORTAL TO TRT
TAILRACE INTAKE
TAILRACE CHANNEL INSIDE & OUTSIDE RESERVOIR
Paibāgala
Undulla
Open scrub
Bugge Bhāvi
Ura Sala
Muni Madugu
Durgam Bhāvi
Kollimagula Vāgu Reservoir
Siphon
Yerrgenna
Fairly dense scrub
- SURFACE COMPONENTS
- UNDERGROUND COMPONENTS
Greenko Energies Private Ltd.
REV.
DESCRIPTION
DATE
REMARKS
Client:
M/S. GREENKO ENERGIES PVT LTD
Project:
PINNAPURAM IRESP - STORAGE PROJECT
Title:
LAND REQUIREMENT
Consultants:
aarvee associates
architects engineers & consultants pvt.ltd.
DATE: 22.02.2018
DRG.No:
AA/PSP/POWER/2154/01
R0



NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETRE AND LEVELS IN METRE.
2. DO NOT SCALE THE DRAWING.

FOR PRE-FEASIBILITY REPORT PURPOSE ONLY

REV.	DESCRIPTION	DATE	REMARKS

Client: M/S. GREENKO ENERGIES PVT LTD

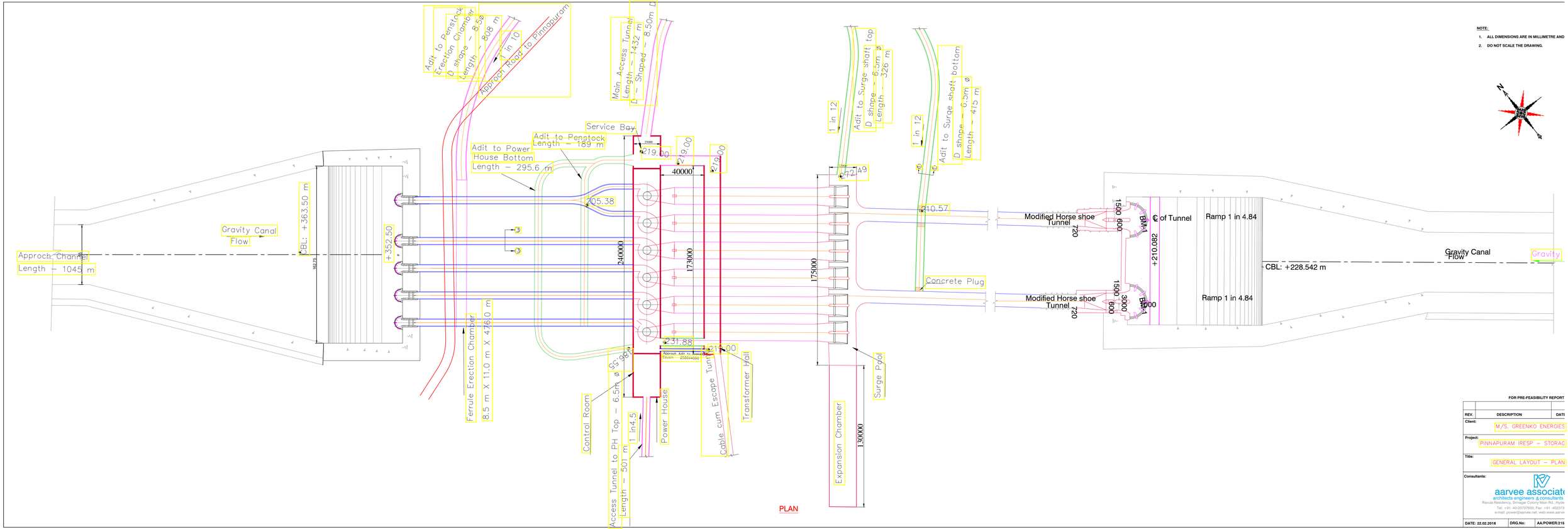
Project: PINNAPURAM IRESP – STORAGE PROJECT

Title: GENERAL LAYOUT – PLAN

Consultants:

aarvee associates
architects engineers & consultants pvt.ltd.
Ravula Residency, Srinagar Colony Main Rd., Hyderabad-82, India
Tel: +91-40-23737833, Fax: +91-40-23736077
e-mail: power@aarvee.net; web:www.aarvee.net

DATE: 22.02.2018	DRG.No:	AA/POWER/2154/02	R0


Approach Channel
Length – 1045 m
Gravity Canal
Flow
CBL: +363.50 m
182.75
+352.50
Adit to Penstock
Erection Chamber
D shape – 8.5m
Length – 8.58 m
1 in 10
Approach Road to Pinnapuram
Main Access Tunnel
Length – 1432 m
D – Shaped – 8.50m D
Service Bay
Adit to Penstock
Length – 189 m
Adit to Power
House Bottom
Length – 295.6 m
219.00
40000
205.38
240000
173000
231.88
Approach Adit to Transformer Cavern – 25000x9000
Ferrule Erection Chamber
8.5 m X 11.0 m X 47.60 m
Control Room
Power House
Access Tunnel to PH Top – 6.5m ø
Length – 501 m
1 in 4.5
Cable cum Escape Tunnel
Transformer Hall
1 in 12
Adit to Surge shaft top
D shape – 6.5m ø
Length – 326 m
Adit to Surge shaft bottom
D shape – 6.5m ø
Length – 415 m
210.57
175000
Concrete Plug
Surge Pool
Expansion Chamber
130000
Modified Horse shoe Tunnel
1500
600
720
BM1
℄ of Tunnel
+210.082
Ramp 1 in 4.84
3000
6000
CBL: +228.542 m
Gravity Canal
Flow
Gravity
N
NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETRE AND
2. DO NOT SCALE THE DRAWING.
PLAN
FOR PRE-FEASIBILITY REPORT
REV.
DESCRIPTION
DATE
Client:
M/S. GREENKO ENERGIES
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PINNAPURAM IRESP – STORAGE
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Consultants:
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architects engineers & consultants
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Tel: +91-40-23737605, Fax: +91-4023737
e-mail: power@aarvee.net; web:www.aarvee.net
DATE: 22.02.2018
DRG.No:
AA/POWER/215