STANDALONE PUMPED STORAGE COMPONENT OF

PINNAPURAM INTEGRATED RENEWABLE ENERGY PROJECT

FEASIBILITY REPORT

STANDALONE PUMPED STORAGE COMPONENT OF PINNAPURAM IREP

(5 X 200 MW + 2 X 100 MW)

TABLE OF CONTENTS

CHAPTER – 1

EXECUTIVE SUMMARY

1.1 Introduction

India is leading the world's renewable energy revolution and is on track to achieve 175 GW of RE capacity by 2022. Today, Wind & Solar, are the lowest cost source of new energy, however their inherent infirm nature & non-schedulability presents a huge challenge for integrating large RE capacities, while maintaining grid stability. Today, increasing RE capacities coupled with ever changing dynamic demand curves of the States/DISCOMs/STUs are leading to sub-optimal utilization of the existing base-load assets resulting in high fixed cost pass through per kWh and additional burden to the consumers.

Flexible Energy Generation Assets that have a capability to supply both Base Load & Peaking Power efficiently and economically are the need of the future and the necessary solution to address the dynamic evolving energy needs of India. The increasing energy demand of the country can only be met sustainably by developing the much required Flexible Energy Generation Assets immediately.

Wind-Solar-Storage Hybrid Projects present a viable solution to the problem at hand and also for future wherein large RE capacities are being planned to be added to National grid. While battery storage solutions are still evolving, integrating Wind & Solar with time tested and proven Pumped Storage solutions presents an optimal, economically viable & scalable solution to supply Schedulable Power On-Demand (SPOD) with both base load and peak load capabilities to the Nation. Pumped Storage solutions provide the necessary scale (large volume of energy storage) and have a long life cycle resulting in lowest cost of delivered SPOD energy over the life of the projects. Developing such integrated projects in Wind-Solar resource rich locations along with standalone Pumped Storage capacities independently, without impacting the existing natural water systems / irrigation systems is necessary to sustainably power the future needs of our country while maintaining grid stability.

Greenko Group is India's leading clean energy company, with ~3.3 GW operational portfolio across 15 states in India. Greenko Group has an existing asset base of over USD 5 Billion with an equity investment of USD 1.5 Billion. Greenko enjoys strong shareholder support of the world's largest sovereign wealth funds of Singapore (GIC) and Abu Dhabi (ADIA). Greenko Group has an experienced & diverse management team to develop, execute and operate challenging projects with expertise across large-scale Wind,

Solar PV and Hydro projects. The team has recently commissioned one of the World's largest single 816 MW_{DC} Solar PV Plant in Kurnool, Andhra Pradesh within a record time of 6 months.

Greenko Group has over the past 10 years, developed capabilities not just in RE project execution, but also state of the art digital capabilities for efficiently forecasting renewable generation trends in Solar & Wind domains giving it a unique capability to integrate diverse generation streams of energy to lead the creation of a Decarbonized, Digitized future on the Energy sector in India.

Greenko Group has been in the process of evaluating suitable locations for such integrated projects for over 1 year and has identified Pinnapuram, Kurnool District, Andhra Pradesh for the proposed Pinnapuram Integrated Renewable Energy Project (IREP). Pinnapuram IREP has been conceived as the World's First & Largest Gigawatt Scale integrated project with solar, wind and pumped storage components that can supply Schedulable Power On Demand (SPOD) which is Dispatchable & Schedulable Renewable Energy for the first time to consumers across India.

After evaluating the site for over 1 year, assessing the Wind & Solar resources, Greenko Group has approached the Government of Andhra Pradesh (GoAP) for necessary permissions and approvals for the proposed Project. Presently, GoAP has approved the project with 1000 MW Solar, 550 MW Wind & 1200 MW of Standalone Pumped Storage capacities to be developed in Phase I with possibility to enhance capacities in subsequent stages to 3000 MW Solar, 2000 MW Wind & 2400 MW Standalone Pumped Storage depending on technical feasibility, site suitability and associated requirements and demand from various State DISCOMs/STUs and other consumers. GoAP has also allocated 1 TMC of water for establishing the 1200 MW Pumped Storage component with 7 hour storage capacity and process has been initiated to increase the allocation to 1.2 TMC for facilitating 8 hour storage capacity.

All three components of Pinnapuram IREP are in close vicinity of each other and therefore power from all three components will be pooled into common pooling station and will be connected to PGCIL/CTU sub-station at Orvakallu for further supply into the National Grid. The IREP Project is a self-identified project and first of its kind in the world and our country which can meet the dynamic needs of DISCOMs/STUs, through:

1. 24 Hours Round The Clock (RTC) Base Load Energy
2. 18 Hours Base Load Energy as per Demand
3. 12 Hour Peak Load Energy (6 hours + 6 hours)

4 Energy Storage Service, Grid Management, Frequency Management & Ancillary Services

The GoAP has approved the project with First Right of Refusal to utilize the energy from the project, however with no obligation to consume the same.

This PFR is for the standalone Pumped Storage component of IREP of 1200 MW / 9600 MWH storage capacity, located at Kurnool District, Andhra Pradesh. Pinnapuram IREP Standalone Pumped Storage Project will comprise of two reservoirs to be constructed in existing natural depressions with low height embankments of average height 12-14m (with maximum height 35m) to create the desired storage capacity. This Project is standalone in nature and both the reservoirs are located away from all existing natural water systems and have no/negligible catchment area. Water will be lifted one time from existing Gorakallu Reservoir irrigation system and will be stored in the reservoirs to be constructed and used cyclically for energy storage and discharge. Evaporation losses, if any will be recouped periodically.

This Project envisages non-consumptive re-utilization of 1.20 TMC of water for recirculation among two proposed reservoirs. The geographical coordinates of the proposed upper reservoir are at longitude 78°15’13" East & latitude is 15°36’26" North and that of lower reservoir are at 78°15’30" E and 15°37’26" N.

1.2 Scope of Report

The proposed Standalone Pumped Storage Component of Pinnapuram IREP is a self-identified project and this 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 IREP.

1.3 Scope of Works

The Standalone Pumped Storage Component of Pinnapuram IREP envisages construction of upper and lower reservoir near Pinnapuram village in Nandyal Mandal of Kurnool District. The existing Gorakallu balancing reservoir is under operation with a live storage capacity of 12.44 TMC. The one time filling of the proposed Pinnapuram IREP upper reservoir will be taken up from Gorakallu Reservoir.

Proposed Scheme will involve construction Rock fill embankments of average height of around 12m to 14m with maximum of 33m height in lower reservoir and 35m in upper reservoir for very short reach for creation of Pinnapuram IREP reservoirs. Intake structure

and trash rack for Five numbers of independent penstocks and one number of independent penstock bifurcated into two will be taking off from Power block of Pinnapuram IREP upper reservoir. A surface Power House will be located on the downstream of the power block and shall be equipped with five vertical-axis reversible Francis type units composed each of a generator/motor and a pump/turbine having generating/pumping capacity of 200MW/244MW and two units of 100MW/130MW respectively. The individual unit capacity of turbine of 200 MW likely to be changed to 240 MW and also the individual unit capacity of turbine of 100MW likely to be changed to 120 MW and the same will be finalized during DPR stage, provided it is techno economically feasible.

Gas insulated switchgear (GIS) will be provided suitably located nearby area of the Power House. Step up transformers will also be placed, which will be connected to machine hall.

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

The Standalone Pumped Storage Component of Pinnapuram IREP envisages construction of

- Rock fill embankments of average height of around 12m to 14m with maximum of 33m height in lower reservoir and 35m in upper reservoir for very short reach for creation of Pinnapuram IREP upper & lower reservoir with 1.20 TMC live storage capacity
- 45m high RCC Intake structure
- 5 nos. of 760 m long and 7.0m dia. inclined circular steel lined Penstock / Pressure Shaft each for each unit of 200 MW
- 1 no 760m long and 7.0m dia inclined circular steel lined Penstock / Pressure shaft bifurcated into 2 penstocks to feed 2 units of 100 MW
- A surface Power house having an installation of five nos. reversible Francis turbine each of 200 MW capacity (3 units of fixed speed and 2 units of variable speed turbines) and two nos. reversible Francis turbine each of 100 MW capacity (1 unit of fixed speed and 1 unit of variable speed turbines) operating under a rated head of 119.27 m in generating mode and 125.77 m in pumping mode.
- 70m wide concrete lined Tail race channel with FSD of 6.00m and 1300 m long connecting Tail race channel to the lower reservoir.

1.4 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 IREP has been kept in such a way that 1.20 TMC of water will be utilized for the proposed Pinnapuram IREP and one-time filling of the proposed upper reservoir will be taken up from Gorakallu reservoir. The project is a pumped storage scheme and hence, no consumptive utilization of water is required for its operation.

1.5 Installed Capacity

The Standalone Pumped Storage Component of Pinnapuram IREP is proposed with a Storage Capacity of 9600 MWH with Rating of 1200 MWH. This Project is comprising of 5 units of 200 MW each and 2 units of 100 MW each. The installed capacity of a pumped storage scheme is influenced by the requirements of daily peaking power requirements, flexibility in efficient operation of units, storage available in the reservoirs and the area capacity characteristics. The Project will generate 1200 MWH by utilizing a design discharge of 1162.85 Cumec and rated head of 119.27 m. The Pinnapuram IREP will utilize 1480 MW to pump 1.20 TMC of water to the upper reservoir in 8.73 hours.

The Key parameters of Pinnapuram IREP are as follows:

Sl. No.	Parameter	Unit	Value
1	Storage Capacity	MWH	9600
2	Rating	MWH	1200
3	No. of Units	Nos.	7
4	Rated Head in Turbine mode	m	119.27
5	Total Design Discharge	Cumec	1162.85
6	Design Discharge per unit of 200 MW	Cumec	193.81
7	Design Discharge per unit of 100 MW	Cumec	96.90
8	Generation Duration	Hrs	8.00
9	Turbine Capacity – 5 Units	MW	200
10	Turbine Capacity – 2 Units	MW	100
11	Annual Energy Generation	MU	3376
12	Pump Capacity – 5 Units	MW	244
13	Pump Capacity – 2 Units	MW	130
14	Rated Head in Pump mode	m	125.77
15	Pumping Duration	Hrs.	8.73
16	Annual Energy consumption	Mu	4480

The volume of water required for turbine mode of operation is equated to the pumped mode. Annual energy generation by Pinnapuram IREP in Turbine mode is 3376 MU, Annual energy consumption by Pinnapuram IREP in Pump mode is 4480 MU.

1.6 Power Evacuation

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

1.7 Environmental Aspects

Upper and lower reservoir for Pinnapuram IREP will be constructed newly and the onetime filling of the Pinnapuram IREP upper reservoir will be taken up from existing Gorakallu reservoir. There will be submergence of land required for the proposed Pinnapuram reservoir for the Pinnapuram IREP. Also, the land is required for the construction of power house complex and its appurtanent works viz., Intake structure, penstocks, Tail Pool, Tail Race Channel etc. Total land required for the construction of various components is about 714 Ha including submergence by formation of Pinnapuram IREP upper and lower reservoir. The project components of Pinnapuram IREP are in Gani forest under Kurnool Range. Based on assessment of environmental impacts, management plans have to be formulated for compensatory afforestation and other environmental issues like rehabilitation & resettlement. These issues would be addressed during the investigations for DPR.

1.8 Construction Planning & Schedule

It is proposed to construct the project within a period of 3.0 years including infrastructure development which is proposed to be completed within 6 months.

1.9 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	2684.76
2	Cost of Power Plant Electro Mechanical Equipme including Transmission line	2263.68
3	Total Hard Cost	4948.44
4	Interest during Construction	519.58
5	Total cost of the Project	5468.02

1.10 Economic Financial Analysis

The economical evaluation of Pinnapuram IREP will be arrived at as part of the Integrated Renewable Energy Project Financial Analysis.

1.11 Reasons for Change of Location of Project

While conducting survey and investigations it was observed that the Underground geology of the proposed alignment comprises of quartzite underlain by thick / flaggy bedded limestones and shales, which geologically is not a very suitable condition for locating the underground power house very near to the reservoir in view of the possibility of movement of the strata under water charged condition and the deformation is high.

Secondly, in case of underground system, power house is not a single cavern alone, it consists of a set of three to four caverns thus increasing the vulnerability of underground complex which in turn impacts the construction time of the project.

Another issue which came to light was that recently there were experiences of failures in caverns in the execution of Kaleshwaram project and some other projects in the state of Telangana, this further strengthened our apprehensions about geology for underground complex.

Since these Pumped storage projects are placed much below the Minimum Draw Down levels because of technical requirement during pumping operations therefore the Main Access Tunnel to Power house becomes very long (around 1.75 KM). With these long MAT and other

tunnels, the overall construction time of project was coming around 54 months and was affecting the financial viability of the project adversely.

Keeping this in view, alternative sites were studied for location of Pumped storage project and it was observed that two more natural depressions exist in the adjoining area where artificial reservoirs can be created in very close vicinity. In this location, both reservoirs were to be constructed anew with low height embankments to create the storage for desired capacity. In this case, this appeared to be the best option technically as in this layout, the total length of water conductor system is only 2 KM long as compared to around 7 KM long in first alternative option, which is the most important requirement for any pumped storage scheme.

All these changes in the layout and capacity have improved the cycle efficiency of the plant which is the most dominant criteria in case of pumped storage projects and impacts the viability of the project directly. Project capacity for this layout is also increasing from 1000MW to 1200 MW.

For this changed layout, total land requirement for the project is about 714.00 Ha, wherein Forest Land is 365 Ha and Non-forest land is 349 Ha.

Another aspect that triggered and necessitated the proposed changes was the reduction in construction period of the project. As Solar and wind projects have very low gestation period, the completion period of this IREP is being controlled by the construction period of the standalone pumped storage project itself. It was imperative to reduce this period to as low as possible so that gap is barest minimum. With this improved layout that objective is also being achieved as the project construction period is reduced to 3 years only.

1.10 Conclusions

The Pinnapuram IREP is envisaged to be completed in a period of 3.0 years. The project would generate designed energy of 3376 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	Standalone Pumped Storage Component of Pinnapuram IREP
2		Location	
	a	Country	India
	b	State	Andhra Pradesh
	c	District	Kurnool
	d	Village near Power House	Pinnapuram
3		Geographical Co-Ordinates	
	a	Standalone Pumped Storage Component of Pinnapuram IREP Reservoir - Upper (Now Proposed)	
		Latitude	15° 36’ 26" N
		Longitude	78° 15’ 13" E
	b	Standalone Pumped Storage Component of Pinnapuram IREP Reservoir - Lower (Now Proposed)	
		Latitude	15° 37’ 26" N
		Longitude	78° 15’ 30" 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	9600 MWH
	c	Rating	1200 MWH
	d	Peak operation duration	8.00 Hours daily
6		Pinnapuram Reservoir - Upper	Upper Reservoir
	a	Live Storage	1.20 TMC
	b	Dead Storage	0.17 TMC
	c	Gross Storage	1.37 TMC
	d	Top of Dam	EL +466.00 m
	e	Full Reservoir level (FRL)	EL +463.00 m
	f	Min. Draw Down Level (MDDL)	EL +441.50m
	g	Height of RCC Intake Structure	45.0 m
	h	Max Height of Embankment	35.0m
	i	Top Width of Embankment	10.0 m
7		Pinnapuram Reservoir - Lower	Lower Reservoir
	a	Live Storage	1.20 TMC
	b	Dead Storage	0.22 TMC
	c	Gross Storage	1.42 TMC
	d	Top of Dam	EL +343.00 m
	e	Full Reservoir level (FRL)	EL +340.00 m
	f	Min. Draw Down Level (MDDL)	EL +321.00 m
	g	Max Height of Embankment	33.0 m
	h	Top Width of Embankment	10.0 m
8		RCC Intake Structure	
	a	Type	Open Semi Circular
	b	Elevation of Intake center line	EL +429.24 m

	c	Elevation of bell mouth bottom	EL +423.71 m
9		Penstock /Pressure Shafts	
	a	Type	steel lined - circular
	b	Number of Penstocks	5 Nos Independent Penstocks and 1 No of Independent Penstock bifurcated in to 2
	c	Diameter of penstock	7.0 m
	d	Length of penstock	760.0 m each
10		Powerhouse	
	a	Type	Surface Powerhouse
	b	Dimensions	L 240.00m x B 24.00 m x H 58.00 m
11		Tail Race Channel	Trapezoidal Channel - Lined
	a	Lenth of the channel	1300 m
	b	Bed Width	70 m
	c	Full supply depth	6.00 m
	d	Bed slope	1 in 5000
12		Tailrace Outlet	
	a	Type	Open Semi Circular
	b	Elevation of outlet centre line	EL +305.70 m
13		Hydro-Mechanical Equipment	
	a	RCC Intake Structure	
		Trash Rack	
		No of bays in each trash rack	6 Nos – 21.0m high
		Intake Service Gate - 6 Nos	W5.77 m X H7.00 m (Vertical lift fixed wheel)
		Intake Stop log Gate - 6 Nos	W5.77 m X H7.00 m (Vertical lift fixed wheel)
	b	Draft Tube Gates	High pressure steel type slide gates
		No of gates per unit	2 per unit - W 6.5 m X H 7.0 m (Vertical lift fixed wheel type)

	c	Tailrace Outlet Structure	
		No. of bays in each trash rack	6 Nos – 18.0m high
14		Electro Mechanical Equipment	
		Pump Turbine	Francis type, vertical shaft reversible pump-turbine
		Total No of units	7 no's (5 X 200MW & 2 X 100 MW)
		Total Design Discharge (Turbine Mode)	1162.85 Cumec
		Rated Head in Turbine mode	119.27m
	a	200MW Turbines	
		Total No of units	5 Units (2 Nos with Variable speed & 3 Nos with Fixed Speed)
		Turbine Design Discharge	193.81 Cumec for each unit
		Pump Capacity	244 MW
		Rated Pumping Head	125.77 m
		Rated Pump Discharge	178.42 Cumecs
		Synchronous speed	136.36 rpm
	i	Generator-Motor	
		Type	Three (3) phase, alternating current synchronous, generator motor semi umbrella type with vertical shaft
		Number of units	5 Units
		Rated Capacity	Generator – 200MW; Pump Input – 244MW
		Rated Voltage	18.0 KV
	ii	Main Power Transformer	
		Type	Indoor, 3-Ph transformers with Off-Circuit tap changer (OCTC)

		Number of units	5 Units
		Rated Capacity of each unit	280 MVA
		Rated Voltage	Primary – 18.0 kV; Secondary - 400 kV adjustable range of the secondary voltage: -10% to +10%(3kV/tap)
	b	100MW Turbines	
		Total No of units	2 Units (1 Nos with Variable speed & 1 Nos with Fixed Speed)
		Turbine Design Discharge	96.90 Cumec for each unit
		Pump Capacity	130 MW
		Rated Pumping Head	125.77 m
		Rated Pump Discharge	94.37 Cumec for each unit
		Synchronous speed	187.5 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	18.0 kV
	ii	Main Power Transformer	
		Type	Indoor, 3-Ph transformers with Off-Circuit tap changer (OCTC)
		Number of units	2 Units
		Rated Capacity of each unit	150 MVA
		Rated Voltage	Primary – 18.0 kV; Secondary - 400 kV adjustable range of the secondary voltage:

			-10% to +10%(3kV/tap)
17		420KV Gas Insulated Switchgear	(GIS)
	1	Type of GIS	Indoor Type
	2	No. of GIS units	One No.
	3	Location	Inside GIS Building above ground
	4	Scheme	Double Busbar Arrangement with bus sectionalise
18		POWER EVACUATION	
	a	Voltage Level (KV)	400 KV
	b	No. of Transmission lines	Two Nos for each connecting point
	e	Conductor	Moose
	h	Total Length	Line 2: 20 Kms to PGCIL 765/400 KV SS near Orvakallu
	i		6 Km up to Central Pooling Substation of IREP
19		Estimated Cost	
	a	Civil Works & Other works	2684.76 Cr.
	b	E & M Works incl transmission	2263.68 Cr.
	c	I DC	519.58 Cr.
		Total Project Cost With IDC	5468.02 Cr.

CHAPTER – 3

PROJECT AREA

3.1 General

Pinnapuram IREP is located in Kurnool district of Andhra Pradesh. It envisages creation of both upper and lower reservoir near Pinnapuram depression which is flowing NW – SE direction. 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 Mandyal Mandal. The Installed capacity of the Project is proposed as 1200 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 Nallamallas 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

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 IREP is located in Kurnool district of Andhra Pradesh, and is proposed between two reservoirs i.e. Pinnapuram IREP upper and lower reservoir (both to be constructed newly) and one time water will be pumped from existing Gorakallu reservoir to fill up the proposed upper reservoir.The project envisages construction of a RCC intake Structure, Penstock, surface Power House and Tail Race Channel. Installed capacity of the Project is proposed as 1200 MW (5x200MW + 2x100MW). 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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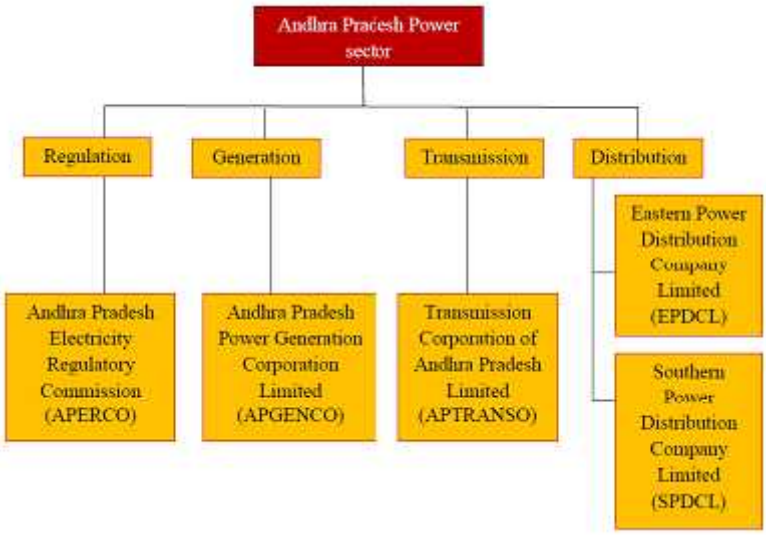


Fig.1 - Andhra Pradesh sector wise breakup

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:

1. Natural Load Growth.
2. 24x7 power supply to all consumers
3. Increase in electrification of households
4. 9 hours supply to agricultural consumers
5. Additional energy requirement for upcoming capital city and associated investments
6. New Industrial corridors
7. New Lift Irrigation schemes.

4.3 Present Power Supply Position

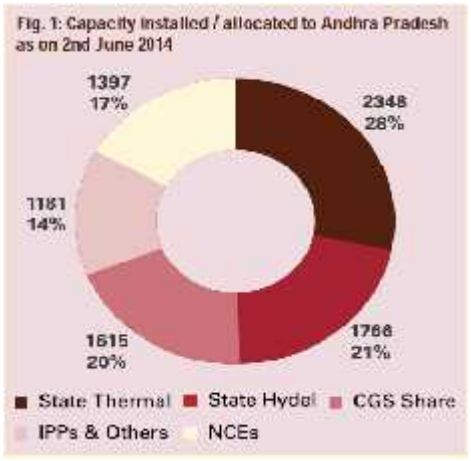
The actual power supply position of Andhra Pradesh as per the CEA report during 2016-17 is as per the table below;

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	1608.87	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	1608.87	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 IREP envisaged with Storage Capacity of 9600 MWH with rating of 1200 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 IREP	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 IREP	4X150	600 MW	Kalahandi, Odisha
23	Pallivasal IREP	-		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

5.2 Topographical Survey

Topographical maps (57 I/2 and 57 I/6) of Survey of India were referred for preliminary investigation, reconnaissance and for finalizing the proposed project layout.

5.3 Reconnaissance Survey

Two offstream reservoirs are proposed to act as lower and upper reservoirs respectively for the proposed Pinnapuram IREP. The water required for the Pumped storage operation will be drawn from Gorakallu Reservoir for onetime filling of the proposed Pinnapuram IREP upper reservoir.

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

5.4 PRIMARY CONTROL BENCH MARKS

A network of control points has been established in the project area, using auto-levels and Differential Global Positioning System (DGPS). Traversing was conducted between the DGPS points by using Total Station.

Height control has been established with respect to the existing bench mark. The bench mark has been carried to site by DCBM method using precision auto levels.

5.5 SECONDARY CONTROL POINTS

To facilitate the detailed survey of remote areas, which are not directly accessible from primary control GPS points, temporary secondary level control points have been established. Several such points were established during detailed survey depending upon the area to be covered and accessibility. A stone pillar, marking on rock or driving a peg into firm ground were the various ways adopted for establishing these temporary bench marks.

All the reference points established were also interconnected elevation wise. The error allowed in these elevations was 12√k mm where k is in kilometers. A double check leveling procedure has been adopted to transfer the level of bench mark. High precision auto levels were used for the entire leveling job.

5.6 DEVELOPMENT OF PLAN

The overall plan of the project site indicating the streams, topographical features like cliffs, rocky outcrops, mounds, ditches, was generated by taking coordinates using total station. Proposed alignment of penstock, power house and tail race channel are indicated in the plan.

5.7 Geological Survey & Investigation

5.7.1 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.

5.7.2 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.

5.7.3 DRAINAGE SYSTEM

The important rivers flowing in the district are the Tungabhadra, its tributaries, the Handri, the Krishna and the 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.

5.7.4 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 belong 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.

5.7.5 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 conglomerates, 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 Cuddapath 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.

5.7.6 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

5.8 GENERAL GEOLOGY OF PROPOSED RESERVOIRS

5.8.1 Lower Reservoir

The proposed reservoir area is located at about 37 km from Kurnool district, which is approximately 3.5km to 4km long in East to West direction and approximately 1.5km wide North to South direction and shielded by isolated small ridges, except few low level areas where few depressions are act as seasonal streams. The slope of the proposed reservoir area is gradually decreased from South to North direction. Towards South direction (from the center of proposed reservoir) there is a straight ridge contineous for more the 4km (fig. 1) and afterwards it is separated by another ridge, which attains its direction NW to SE, similarly towards north west and north east direction from the center of proposed reservoir area all isolated ridges maintain straight pattern for about approximate 4 km surrounding the periphery of proposed reservoir (fig2).

Fig-1 Dense and rugged topography present surrounding the proposed Reservoir area and along southern margin stretching 3 & 4km ridge following East to west trend.

All along and above, the isolated ridge area was unapproachable during the course of present field study. Access along and above the ridges was very difficult and hazardous due

to presence of dense forest and rugged topography (Fig1.) However all efforts were made to access the bottom as well upper part of ridges which were in range of approach had studied and the field data also collected as much as require for analysis. As per the ground level and along with data collection geologists had identified the periphery limit of proposed reservoir are as mention in DWG.

Towards the southern limit between Fig/Dwg – 1 Point Nos 11 to 14 of the proposed reservoir the slope of the ridge is moderate and having a flat bench at top of hill where the top level attains of approximately EL 440m, afterwards it becomes almost flat and maintain gentle to mid slope, whereas towards north western and north eastern limit Fig/Dwg – 1 Point Nos 15 to 16 and 8 to 9 respectively the slope of the ridge is moderately to gentle, which extending up to its top level EL 347m except few areas where the natural depressions were noticed.

Fig-2 Isolated ridges observed all around the proposed Reservoir area and shale outcrops exposed along the center of reservoir.

During the course of traversing, small traverses have been taken along the center of proposed reservoir between Fig/Dwg – 1 all point to points along approach roads, nallahs and all accessible areas. It is was noticed that the area of the proposed reservoir is comprised with the zone of multiple seasonal streams and drains. Among all streams/ depressions Nallas two main seasonal streams have been controlled and gathered all raining water and passing through the valley towards north direction points between drawing points 8 to 9. The both streams flows in between the isolated ridges separately from south to north and north-west direction, however, in which several small seasonal drains are connected from the southern margin of the proposed reservoir area at its initial stage. The minimum ground level ELs are ranging between EL 293m & EL 297m were recorded using hand GPS along the terminal area of streams and at the beginning of these

streams were varies in between El 316m to EL 322m which clearly indicate that the slope of reservoir is south to North.

DETAIL OF STRUCTURES:

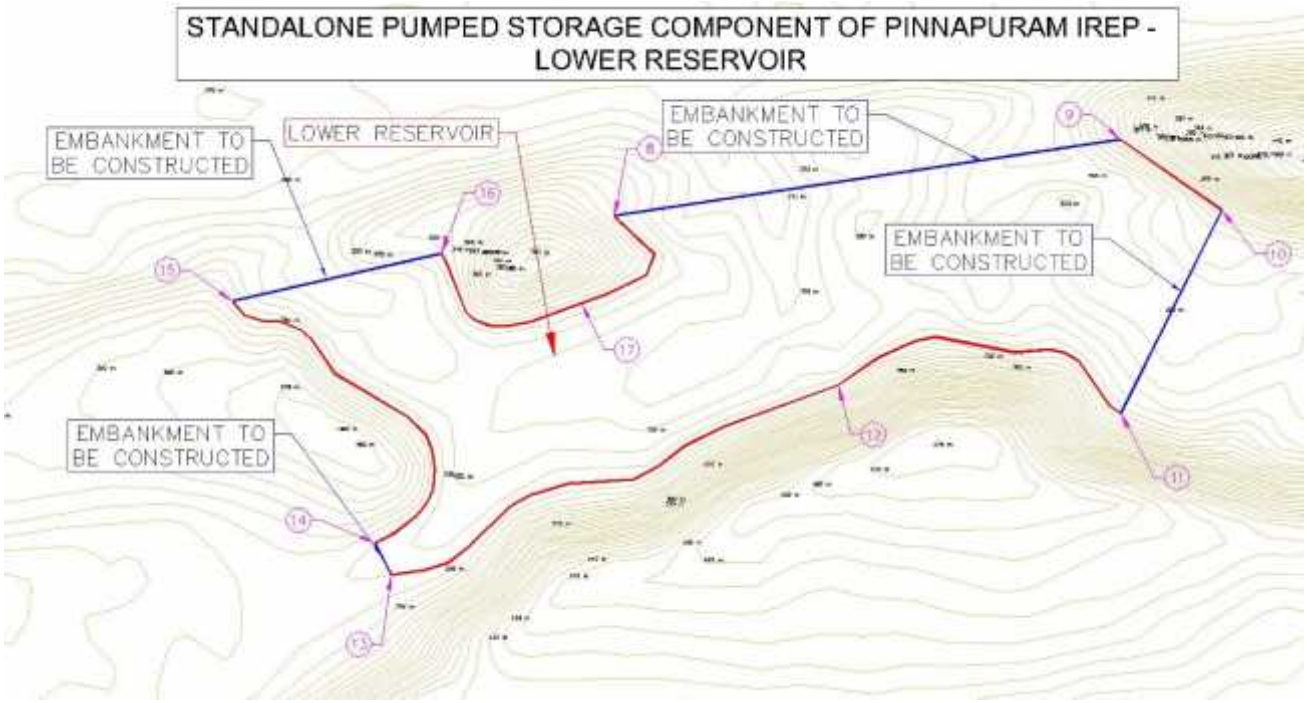
On the basis of aforesaid study embankment structures has been proposed on different locations around the periphery of reservoir area to secure the low level zones. Detailed description of proposed embankment structure has been given below (Dwg – l as below).

Embankment structure between point 14 and 13 (Embankment No 1)

Embankment structure between point 15 and 16 (Embankment No 2)

Embankment structure between point 8 and 9 (Embankment No 3)

Embankment structure between point 10 and 11 (Embankment No 4)



Fig/dwg.1 A general layout plan of proposed lower level reservoir along with its proposed dam structures (1, 2, 3, 4) & Geological X section lines.

Embankment structure between point 14 and 13 (Embankment No – 1): A 143 m long embankment structure has been proposed along 250 m wide open basin which is located approximately 1.2 km downstream of Gumatam Thanda Village and at about 4.0 km from Brahmana Pally Village (fig 3) . The Slope of the basin at the proposed axis is gradually decreases towards North East Direction. On the left bank , the slope of the basin rises gentle to moderate (up to 380m), whereas along right bank the slope rises steeply as compared to left bank (up to 430m). After that, it becomes almost flat to mild. The upper part of hills are comprising with quartzite rocks having low dip angle.

Fig 3- Panoramic view of proposed Embankment 1

Along the right bank in-situ bed rock outcrop is exposed all along the abutment area of proposed dam structure. Although at some places thin veneer of slope wash materials deposited over the in-situ bed rock which are weathering products of shale, whereas the left bank abutment area composed of weak to medium strong shale. The in-situ bed rock of Massive Quartzite is overlying shale at EL.360 m and at the contact of shale & quartzite approximately 30 to 40cm thick conglomerate beds are also noticed & recorded which may sign of discontinuity in lithology succession. During traversing along the both bank of the basin, it is revealed that the contact between weak shale & massive quartzite along the right bank occur at EL.423m.

The slope wash materials are heterogeneous in nature which comprises of sorted to unsorted, rock fragment of weak shale and the pebbles and cobbles of white coloured ,medium grained Quartzite are disseminating over it. The angular to sub angular pebbles & cobbles sized of Quartzite is having size range from 5cm to 30cm.

Fig 4- Shale with bands of sandstone.

Embankment structure between point 15 and 16 (Embankment No 2): A 852 m long and 23.0m high (Above NSL) damming structure (as per dwg) is proposed along 250 m wide open basin which is located approximately 2.7 km downstream of Gumatam Thanda Village and at about 3.0 km from Brahmana Pally Village at the northwestern corner of the proposed lower reservoir, where the slope of the basin at the proposed axis is gradually decreases towards North Western Direction (Fig 5). On the left side , the slope of the basin raises gentle to moderately (up to 380m), whereas along the right side of the slope are raises gently as compared to left side (up to 360m). Multiple ridges are observed during traversing on either sides of the basin. PWD Road connecting Brahmana Pally and Gumatam Thanda passes almost through the center of this Damming structure at elevation 308m. where the occasional bed rocks are exposed in patches along debris of overburden.

Fig 5- Panoramic view of the proposed Embankment 2

In general the rock mass of shale has been exposed along left & right abutment of the proposed embankment structure, although massive quartzite overlying by weak shale at EL.380 m above right bank abutment, whereas along left abutment the contact between shale & quartzite was observed at EL 368 m.

During the glance geological mapping along either bank of the basin, it is revealed that at some places few outcrops of basic rock are also found along the slope of the valley at different level, hence these may be Dyke structure or gentle dipping Sill structures of basic rocks as shown in Fig 6.

Fig 6- Isolated outcrops of basic rock (sill/dyke)

The slope wash material is heterogeneous in nature which comprise of sorted to unsorted, rock fragment of weak shale. The exposed shale variegated in nature with colour ranges from greenish grey to chocolaty. Quartz vein is also showing criss cross relationship. Massive quartzite is exposed above the weak shale. The quartzite is medium sized, grey to whitish coloured, strong and hard. Quartz grains are sub-rounded to elliptical. Some conglomeratic beds at quartzite have also been recorded, where the dipping amount of underlying shale is higher than the overlying quartzite. (Fig 7)

Fig 7- Conglomeratic bed at quartzite

Embankment structure between point 8 to 9 & 10 to 11(Embankment no 3&4): A 2034 m long and 35.0m high above NSL dam structure is proposed. The location of proposed dam structure is located at about 2km from existing 500 MW Kurnool Greenko Solar Park. Geological traverse has been taken along the proposed axis, which revealed that few small multiple isolated ridges occupied the area between left & right bank abutment respectively, in-between these ridges in low level area has been incepted by

many small drain. Where all these drain area jointed in main two stream which area flowing from South to north. Rugged topography with dense forest could also be observed during traversing, where the relative elevation was found in the ranges from 305m to 345m.

Fig8- Panoramic view of reservoir from Embankment 3

The slope along both abutments of the proposed dam structure is moderate up to El 395.0m on left bank and up to 460.0 m on right bank and afterwards it becomes almost flat.

OVER ALL APPRAISAL OF AREA:

In general the exposed rock mass of the area comprises of weak to medium strong, light brown to purpled coloured shale which is underlain by grey coloured limestone and hard and massive Quartzites at top of the ridges (up to a 15-35m thick), almost horizontally bedded, widely spaced three sets of Joints which are tight and partly open in nature and medium strong in hardness.

5.8.2 Upper Reservoir

In the continuation of lower level reservoir the upper level reservoir is proposed at about 65 km from Kurnool, neighboring Pinnapuram village. The average height of 12-14m high embankment with rock fill has been proposed as an outer periphery of upper reservoir, which forms a sub-rounded to sub-angular shaped reservoir of about 7 km (Peripheral length) length, where surrounding the proposed reservoir the surface level varies from 430.0 m to 465.0m(south to north). In general, the major slope of the proposed upper level reservoir is almost flat to mild between points 1, 5 & 4 and between points 2 & 3; The slope in between points 4 to 3 and 1 to 2 gradually decrease (from EL 465m to EL430) towards south and south eastern margin of reservoir, where it is terminated against a 15 to 20m high sub-vertical to vertical rock edges. Above and beyond of it a flat bench of in-situ bed rock covers all area and continue for considerable length towards

south east & south west direction. In between points 2 and 3, a seasonal stream of about 230-240m wide has been observed trending South-East to North-west direction (as per fig.9).

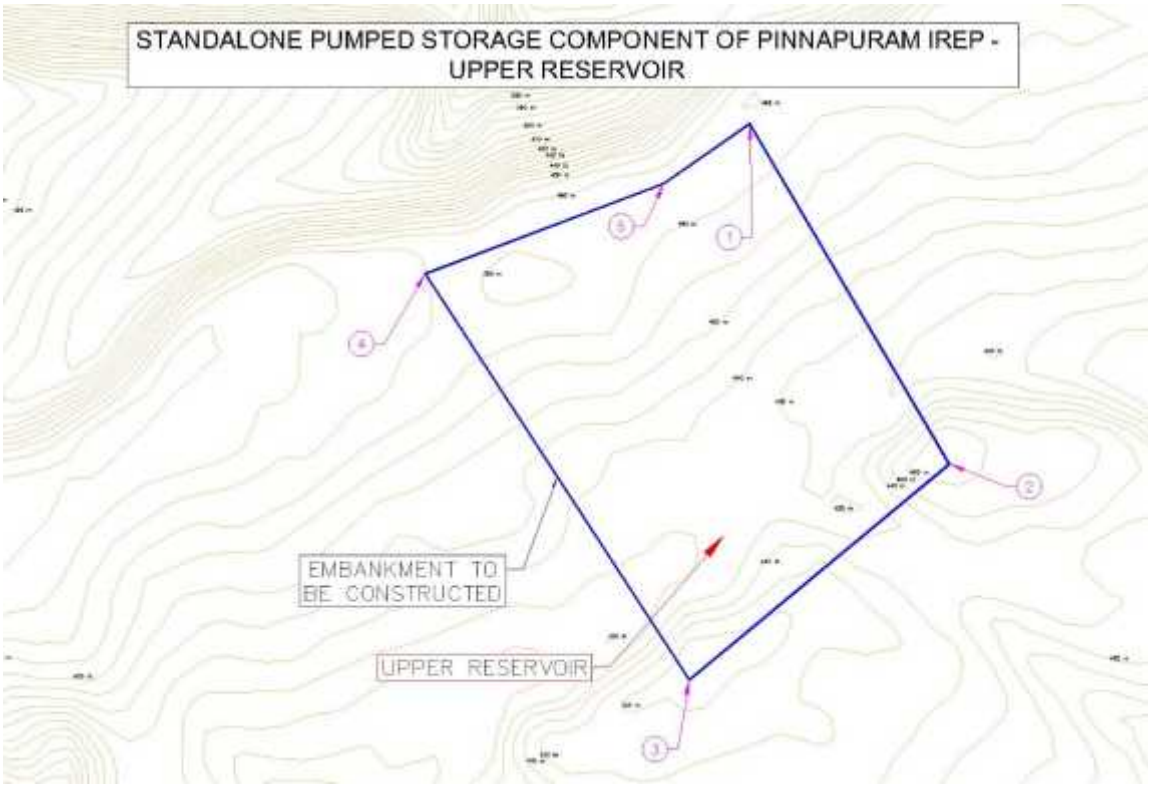


fig.9. General Layout plan of proposed upper reservoir.

Fig-9 A widespread view of proposed upper reservoir, from southern margin

The geological mapping (1:5000) with GPS has been carried out to develop the project layout and to collect detailed information as much as possible, but final detailed Geological mapping of the proposed upper reservoir will be carried out along with Total station for the final detailing. During the course of present field study, traverses have taken between points no 1 to all along the terminal margin of proposed reservoir. It is revealed from it that the overall proposed reservoir area is located in a flat and rocky terrain.

Fig-10. A flat bench of massive quartzite exposed between point 3 and 4 adjacent to Pinnapuram village.

In majority of cases in situ bed rock outcrops are exposed in & around the flat terrain located adjacent to Pinnapuram village (fig-10), although thin layer of silty sand occurring over the in-situ rock mass in the center of the reservoir, where cultivation land is observed (fig-9) and cone shaped sand deposition could also be observed adjacent to rock edge (fig-11). The brown coloured silty sand predominantly consist of sand sized quartz grains. The large size tilted/detached rock blocks of massive quartzites are laying along the 15m to 20m sub vertical to vertical high rock edges continuing for considerable length in east to west direction. (fig-11&12).

Fig-11 cone/fan of sand has been deposited at base of vertical rock edge along southern margin of proposed upper level reservoir

Geological mapping of the proposed reservoir revealed that the litho-units comprising of the rock masses in & around the Pinnapuram village is massive quartzite. At places pinnacle quartzite could also be noticed & recorded occurring along seasonal /periodic nallah. It is anticipated that approximately 20-30m thick deposition of massive quartzite may underlies the Shale & Limestone. However, during traverse along and around the periphery of the proposed reservoir area any contact of shale & quartzite could not be seen along peripheral area of proposed reservoir.

Fig-12 Detached rock mass of quartzite has been accumulated at vertical rock edge along southern margin of proposed upper level reservoir

The exposed Massive Quartzite is, light grey to whitish coloured(see fig-2), hard, very strong, medium grained having high strength. In general the Massive Quartzite is fresh but surficial weathering/staining has been observed & recorded all over the area. In majority of cases, Massive Quartzite is medium grained, well sorted, composed of quartz grains (+90%) and feldspar grains as accessary mineral, the matrix of quartzite is siliceous and calcareous. Therefore at many places solution cavities /holes could be found in Quartzite forming circular and elongated shape. The size of these cavities vary from few cm to 3m and depth of it is increase up to 2 & 3m as observed (fig-13).

Fig-13 Circular and elongated shaped solution cavity /holes at elevation about 400m has been developed in Quartzite.

During geological mapping in between points No. 1, it is revealed that the rock mass has been dissected by three major joints set (S2, S3 & S4), in addition to bedding planes/joints (S0=S1). In which the S2 & S3 joints are more prominent showing high to very high persistence and having spacing of 10-60cm and 60cm-1.5m. At the vertical edge along southern margin of reservoir S2 and S3 becomes opened and gapped enough, which is mainly responsible for the detached/tilted rock mass from the massive quartzite. S2 joints are controlling the all seasonal streams wherever observed. Although, the Seasonal stream between points 3 and 4 are also controlled by it. Generally, RQD varies from 59 to 82%, except at a few places where joints are closely spaced.

The average strike of bedding planes/joints S0=S1 is N81°E-S81°W with very low dip 05° towards S09°E. The average strike of S2 joint planes is S65°E-N65°W with 82°dip towards N25°E. S3 joint planes exhibit average strike as N30°E-S30°W with 85° dip towards N60°W, and S4 joint planes exhibit average strike as N75°E-S75°W with 85° dip towards N15°W.

Table.1 Geotechnical parameter of exposed Rock mass

Joint Se	Attitude		Persistence (m)	Spacing (cm)	Aperture (mm)	Roughness
	Dip Direction	Dip Amount				
S_0/S_1	170-180	004-009	>20m	20-100	Tight to open	RP
S_2	020-030	80-88	>20m	10-60	Tight to open(50mm)	RP
S_3	380-300	79-85	5 to 20m	30-150	Tight to open(20mm)	RP
S_4	345-350	84	2-10m	50-200	Tight to open(5mm)	SRP
*SU- Smooth Undulatory, RP- Rough Planar, SSP-Slightly Smooth Planar						

The slopes within the reservoir are not likely to slide. Mineralization of economic importance could not be observed in the area likely to be submerged due to filling of reservoir area.

As per geological observation it is found the area is suitable for damming structures, there the joints are found tight to partly open and columnar joints are shown widely open in periphery quartzites rocks are still tightly jointed because the joints opening were filled with rain water and it was still there. Some solution for cavities and like pot holes are found in study area are not interconnected also. During study no shearing and faulting signs are

also founded by site geologist team, although a detail Geological mapping will give the more confirmation of Site Suitability.

5.9 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.

The bed rocks are exposed in both sides of RCC intake Structure and its physical property also known with field tests but for chemical property need to test in laboratory hence require testing to be conducted in laboratory at DPR Stage. In-situ test also need to be conducted for foundations.

Engineering geological mapping of Penstock area is to be carried out to cover lithology, discontinuities, any major structural features like faults, folds, etc. 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.

5.10 GEOLOGY OF POWERHOUSE & PENSTOCK:

As per the details collected during surface geological mapping at glance it was confirmed the proposed location is comprising with excellent rocks and suitable for housing powerhouse.

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 in their published documents. The parallel shear may be possible along the proposed power house and Penstock also. Hence the detail investigations are required during detail engineering of project with exploratory drill holes at several intervals so that the alignment of penstock 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).

5.11 Seismicity

The project area is in Kurnool district of Andhra Pradesh. As per Seismic Zonation Map of India, the project area lies in Seismic Zone II. No earthquake of any significance intensity has been reported in the project area as well as in the surrounding areas.

5.12 Construction Material

A few quarry sites are identified close to the project area. As the proposed site is a hard rocky terrain, excavated material from the project sites will also be used for the construction purpose depending on their suitability. However, after locating the suitable quarry sites, the engineering and mineralogical properties for the various rock types will be determined to know their suitability as coarse aggregate of concrete for wearing and non-wearing surfaces.

The following tests shall be carried out for extracted rock core samples.

Natural Density	IS 13030-1991
Dry Density	IS 13030-1991
Wet Density	IS 13030-1991
Water Absorption	IS 13030-1991
Specific Gravity	IS 13030-1991
Porosity	IS 13030-1991
Unconfined Compressive Strength	IS 9143-1979
Tensile Strength [Brazilian Method]	IS 10082- 1981
Point Load Strength Index	IS 8764- 1998
Triaxial Shear [c & ø]	IS 13047- 1991
Poisson's Ratio with Modulus of Elasticity (2 specimen-for average)	IS 9221- 1979
Slake Durability	IS 10050 -1981

Excavated material shall be tested for suitability of coarse aggregate as listed below:

Sieve Analysis	IS 2386 Pt-1 1963
Flakiness & Elongation Index	IS 2386 Pt-1 1963
Specific Gravity & Water Absorption	IS 2386 Pt-3 1963

Voids Ratio	IS 2386 Pt-3 1963
Bulk Density	IS 2386 Pt-3 1963
Aggregate Impact Value	IS 2386 Pt-4 1963
10% Fine Value	IS 2386 Pt-4 1963
Deleterious Materials	IS 2386 Pt-2 1963
Crushing Value	IS 2386 Pt-4 1963
Los Angles Abrasion value	IS 2386 Pt-4 1963
Alkali Aggregate Reaction (By Chemical method)	IS 2386 Pt-7 1963
Soundness [By MgSO4 or Na2SO4]	IS 2386 Pt-5 1963
Petrographic Analysis with coloured micro photograph	IS 2386 Pt-8 1963

Excavated material shall be tested for suitability of fine aggregate as listed below:

Grain Size Analysis	IS 2386 Pt-1 1963
Fineness Modulus	IS 2386 Pt-1 1963
Silt Content	IS 2386 Pt-1 1963
Specific Gravity & Water Absorption	IS 2386 Pt-3 1963
Bulk Density	IS 2386 Pt-3 1963
Soundness [By MgSO4 or Na2SO4]	IS 2386 Pt-5 1963
Alkali Aggregate Reaction (By Chemical method)	IS 2386 Pt-7 1963
Organic Impurities	IS 2386 Pt-2 1963
Bulking of Sand	IS 2386 Pt-3 1963
Petrographic Analysis with coloured micro photograph	IS 2386 Pt-8 1963

Identified quarries shall be tested for suitability as core material and below mentioned tests shall be carried out.

1) Classification tests	
a) Grain size distribution tests by Hydrometer Analysis	IS 2720 Part-4

b) Atterberg's limits	IS 2720 Part-5
2) Permeability by Variable head test	IS 2720 Part-17
3) Compaction Properties	
a) Optimum Moisture Content & Maximum Dry density by Heavy Compaction test	IS 2720 Part-8
4) Physical Properties	
a) Unit weight	IS 2720 Part-3
b) Moisture Content	IS 2720 Part-2
c) Specific Gravity	IS 2720 Part-3
d) Voids ratio	IS 2720
e) Porosity	IS 2720
f) Degree of Saturation	IS 2720
5) Shear properties	
a) Cohesion & Angle of internal friction	IS 2720 Part-12
6) Swell pressure	IS 2720 Part-41

5.13 Further Studies for Geotechnical Investigation

Large scale contour plans shall be prepared to bring out the detailed geological and structural features of the project components and also to delinate any weak fetures like shear zones or fault zones.

The Geotechnical explorations and required soil and rock mechanics tests shall be taken up for the assessment of foundation strata as per the design requirements. The pattern of drilling, spacing and the minimum depth of boreholes shall be carried out in accordance with the Guidelines for preparation of DPR for Irrigation & Multi purpose projects vide Annexure – 1 (b). The number of boreholes proposed for the structures shall be as follows

RCC Intake Structure	Two vertical boreholes to be drilled in intake area
Upper & Lower Reservoir Embankment	Five bore holes each to be drilled equal to the height of the embankment or 5.0m in to the hard rock whichever is higher.

Penstock/Pressure Shaft	One vertical drill hole at penstock area
Power House	Three vertical drill hole at power house area

The following tests shall be carried out:

1. Standard Penetration Test shall be conducted in 150mm dia of boreholes using split spoon sampler (SPT). Test shall be conducted in boreholes at intervals of 1.5m. Test shall be discontinued when the blow count is equal to 100 or drilling 3m into hard strata whichever is earlier. Test shall conform to IS 2131-1963 for Dam & Power House

2. Permeability tests in rock using calibrated pressure and water meters at every 3m interval or as directed by geologist/engineer, using double packer system, applying pressures in cyclic order, and including arrangement of necessary clean water for testing and giving permeability values in lugeons as per IS standards for Dam Location

3. Shear strength parameters of soil/rock mass

CHAPTER – 6

HYDROLOGY & POWER POTENTIAL STUDIES

6.1 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.

The Pinnapuram IREP is proposed between two reservoirs i.e. Pinnapuram IREP upper and lower reservoir (both to be constructed newly) and one time water will be pumped from existing Gorakallu reservoir to fill up the proposed upper reservoir. 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 water in between these two reservoirs.

The Pinnapuram IREP is proposed to utilize the water available in the existing Gorakallu reservoir located near Gorakallu Village of Nandyal Mandal of Kurnool district. The two reservoirs are formed to have a live storage capacity of 1.20 TMC. The lower and upper reservoir comprises of max 33.0m and 35.0m high rockfill embankment respectively with clay core for short reach and the average height of embankment for both upper and lower reservoir are around 12 to 14m. An RCC Concrete Structure is proposed in upper reservoir with power block of 200m long comprising of six power intake structure and six independent steel lined penstock starts from the RCC intake structure for conveying water to powerhouse. The water from power house out fall is let back to the lower reservoir through Tail Race Channel.

Since the proposed scheme is a pumped storage scheme and envisages to utilize 1.20 TMC of water, no modification in the operating levels are needed. Moreover, only recycling of water between these two reservoirs are proposed for Pinnapuram IREP operation. As such hydrological study is required to the extent to see the required inflow into reservoir.

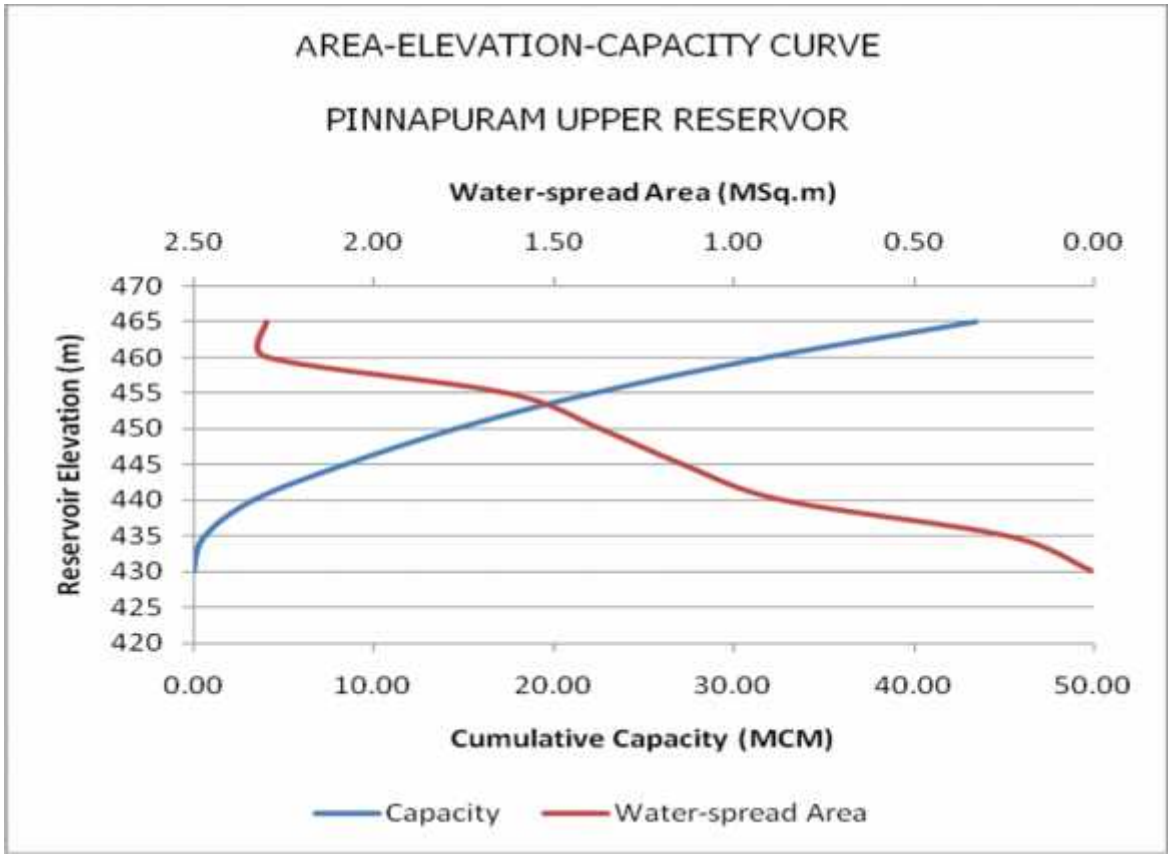
The Key parameters of proposed Pinnapuram IREP Upper Reservoir are as follows:

Sl. No.	Parameter	Unit	Value
1	Full Reservoir Level (FRL)	m	EL 463.00
2	Minimum Draw Down Level (MDDL)	m	EL 441.50
3	Live Storage	TMC	1.20
4	Dead Storage	TMC	0.17

5	Gross Storage	TMC	1.37
6	Height of RCC Intake Structure	m	45.0
7	Max Height of Rock Fill Embankment	m	35.0

The area capacity table for the proposed upper reservoir is given in the table below

Pinnapuram IREP - Upper Reservoir Capacity							
Sl.No	Elevation	Area in Sqm	Water-spread Area in M.Sqm	Capacity in Cum	Capacity in MCum	Cumulative Capacity in Mcum	Cumulative Capacity in TMC
1	425	0	0.00	0.00	0.00		
2	430	2918	0.00	4863.33	0.00	0.00	0.00
3	435	236403	0.24	212626.75	0.21	0.60	0.02
4	440	867894	0.87	803917.73	0.80	3.35	0.12
5	445	1140837	1.14	1113431.18	1.11	8.37	0.30
6	450	1374390	1.37	1350967.40	1.35	14.66	0.52
7	455	1626798	1.63	1601490.90	1.60	22.16	0.78
8	460	2297269	2.30	2229885.88	2.23	31.97	1.13
9	465	2297269	2.30	2297269.00	2.30	43.46	1.53



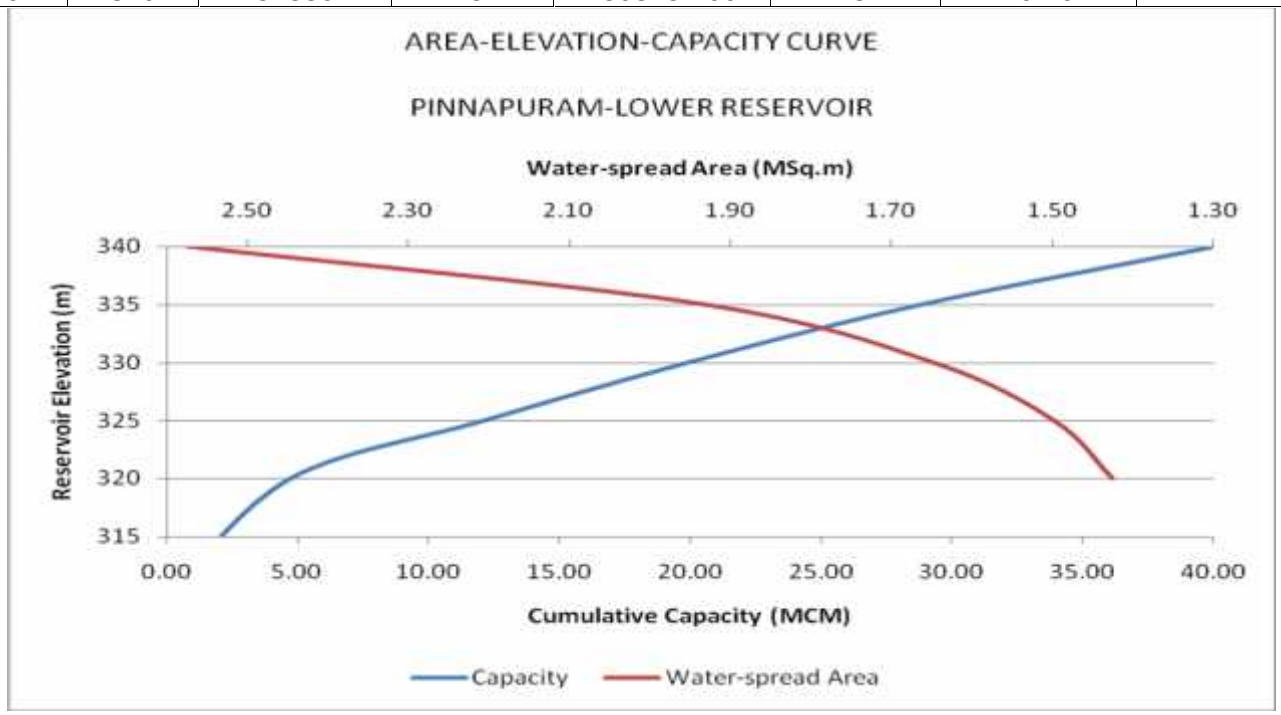
The Key parameters of proposed Pinnapuram IREP Lower Reservoir are as follows:

Sl. No.	Parameter	Unit	Value
1	Full Reservoir Level (FRL)	m	EL 340.00
2	Minimum Draw Down Level (MDDL)	m	EL 321
3	Live Storage	TMC	1.20
4	Dead Storage	TMC	0.22
5	Gross Storage	TMC	1.42
6	Max Height of Rock Fill Embankment	m	33.0

The area capacity table for the proposed Lower reservoir is given in the table below

PINNAPURAM IREP - LOWER RESERVOIR

Sl.No	Elevation	Area in Sqm	Water-spread Area in M.Sqm	Capacity in Cum	Capacity in MCum	Cumulative Capacity in Mcum	Cumulative Capacity in TMC
1	310	0	0.00			0.00	
2	320	1425228	1.43	4750760.00	4.75	4.75	0.17
3	325	1496489.4	1.50	7303569.19	7.30	12.05	0.43
4	330	1646138.34	1.65	7853598.44	7.85	19.91	0.70
5	335	1930020.75	1.93	8930993.25	8.93	28.84	1.02
6	340	2573361	2.57	2508752.00	2.51	40.10	1.42



The Key parameters of Existing Gorakallu 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

6.2 Water Availability - 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).

6.3 Evaporation Loss

The annual evaporation from the reservoirs are calculated based on the actual monthly evoporation data of Kurnool IMD station. The annual evaporation loss from the reservoirs

works out to 7.85 Mcum. The loss in evaporation will be compensated by pumping water from Gorakallu Reservoir.

6.4 Installed Capacity

The installed capacity of Pinnapuram IREP is proposed based on the operating levels of the upper and lower reservoir with a rated capacity of 1200 MWH.

6.5 Operation Of Pinnapuram IREP

The Pinnapuram IREP is proposed with a Storage Capacity of 9600 MWH with Rating of 1200 MWH. This project is comprising of 5 units of 200 MW each and 2 units of 100 MW each. The Project will generate 1200 MWH by utilizing a design discharge of 1162.85 Cumec and rated head of 119.27m. The Pinnapuram IREP will utilize 1480 MW to pump 1.20 TMC of water to the upper reservoir in 8.73 hours.

The Key parameters of Pumped Storage Operation are as follows:

Sl. No.	Parameter	Unit	Value
1	Storage Capacity	MWH	9600
2	Rating	MWH	1200
3	No. of Units	Nos.	7
4	Rated Head in Turbine mode	m	119.27
5	Total Design Discharge	Cumec	1162.85
6	Design Discharge per unit – for 200 MW	Cumec	193.81
7	Design Discharge per unit – for 100 MW	Cumec	96.90
8	Generation Duration	Hrs.	8.00
9	Annual Energy Generation	Mu	3376
10	Pumping Head	m	125.77
11	Pumping Duration	Hrs.	8.73
12	Annual Energy consumption	Mu	4480

The volume of water required for turbine mode of operation is equated to the pumped mode. Annual energy generation by Pinnapuram IREP in Turbine mode is 3376 MU and Annual energy consumption by Pinnapuram IREP in Pumping mode is 4480 MU.

6.6 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 upper reservoir is at EL+463.00 m and MDDL is at EL+441.50 m. Full reservoir level at Pinnapuram lower

reservoir is at EL+340.00 m and MDDL is at EL+321 m. The total head loss in the system is arrived as 2.90m. Thus, the rated head of 119.27m is considered for the proposed project. The normal tail water level is the level at the tail race outlet corresponds to design discharge flow of 1162.85 Cumec passing through the turbine considering all machines running at full plant load. Normal tail water level corresponding to above design discharge is EL +320.76m. The bed level of the tail race Channel is kept at EL + 314.76m.

CHAPTER – 7

DESIGN FEATURES OF MAJOR COMPONENTS

7.1 Introduction

The Pinnapuram IREP is located in Kurnool district of Andhra Pradesh. It envisages creation of offstream reservoirs near Pinnapuram village.

The scheme will involve construction of rock fill embankment of average height of around 12m to 14m with the maximum height of 35m for short reach for creation of Pinnapuram IREP upper reservoir of 1.37 TMC gross capacity. The lower reservoir is formed with rock fill embankment with the average height of around 12m to 14m with the maximum height of 33m for short reach with 1.42 TMC gross capacity. The Pinnapuram IREP is proposed in between two reservoirs i.e. Pinnapuram IREP Upper & Lower Reservoirs (both to be constructed newly) and one time water will be pumped from existing Gorakallu Reservoir to fill up the proposed Upper reservoir. The total design discharge for the proposed scheme is 1162.85 Cumec with the rated head of 119.27 m.

The proposed layout of the project has been finalized after considering various alternatives from techno-economic considerations. The proposed Pinnapuram IREP envisages construction of

Embankment for formation of upper & lower reservoir

RCC intake Structure

Penstock / Pressure shaft

Surface Power House

Tail Pool & Tail Race Channel

Pothead yard

7.2 Pinnapuram Upper & Lower Reservoir

The upper reservoir site is proposed at Latitude 15° 36’ 26" N and Longitude 78° 15’ 13" E. The lower reservoir offtake site is proposed at Latitude 15° 37’ 26" N and Longitude 78° 15’ 30" E. An RCC Intake structure proposed at this location envisages construction of 45.0m high Concrete Gravity Intake structure for 200m long and non over flow rock fill embankment of average height around 12m to 14m with maximum height of 35m for short reach for formation of upper reservoir. The lower reservoir is formed with rock fill embankment of average height around 12m to 14m with maximum height of 33m for short reach. The gross storage capacity of the upper reservoir at this location is 1.37 TMC with a

live storage of 1.20 TMC keeping the FRL and MDDL at EL + 463.0m and EL + 441.50 m respectively. The gross storage capacity of the lower reservoir at this location is 1.42 TMC with a live storage of 1.20 TMC keeping the FRL and MDDL at EL + 340.0m and EL + 321.0 m respectively. The one time filling of upper reservoir is taken up by pumping the water from existing Gorakallu Reservoir.

7.3 Project Layout

Six power intakes have been provided in the RCC intake structure with six independent steel lined pressure penstocks of 760m long and 7.0m dia to convey water to the surface powerhouse. Five penstocks will be feeding 5 units of 200 MW and one penstock bifurcated in to two will be feeding 2 units of 100 MW each. The General Layout plan is shown in drawing no. AA/PSP/POWER/2154/001

The L/H ratio of the proposed alignment is 6.3 and no separate surge shaft is provided in this layout. The water after power generation will be conveyed through 1300m long Tail Race Channel to discharge water in to Lower reservoir.

After considering the above factors, this layout is found to be technically feasible and the same is adopted considering the following.

1. It is easier and faster to construct at lesser cost.
2. The sites are suitable for formation of reservoir.
3. The length of the penstock / pressure shaft is short in this case.
4. A surface powerhouse can be suitably located.
5. All the project components are easily accessible.

As the proposed project is a part of integrated renewable energy scheme, the construction time for the project shall be in line with the solar and wind power developments. Considering the economics of the cost for the integrated project, the scheme is more viable.

The details of project layout are explained in the following paragraphs.

7.4 Pinnapuram Embankment (Upper & Lower Reservoir)

The upper reservoir is formed by constructing a 45.0m high RCC intake structure for housing the power blocks along with non over flow rock fill embankment of average height around 12m to 14m with maximum height of 35m for short reach. The lower reservoir is formed with rock fill embankment of average height of around 12m to 14m with maximum height of 33.0m for short reach.

The top width of RCC intake structure is 8.0m. The d/s slope of the intake structure has been proposed as 0.6H: 1V and u/s slope as 1H:5V.

According to IS.1843, the location of proposed structures is falling within Zone-II for which a seismic factor 0.02 will be adopted. No seismic activity is reported from the area and taking the project site with respect to seismo tectonic setting, an importance factor 3.0 has been provided in the design. Accordingly, the horizontal seismic co-efficient works out to 0.06 α, which is considered adequate. The vertical seismic co-efficient where applicable has been taken as half of the horizontal co-efficient. No earthquake of any significance intensity has been reported in the project area as well as in the surrounding areas. Hence, no site specific seismic design parameter study is required. However, if required the seismic parameters adopted in the design of Gorakallu dam will be verified and adopted in the design of Pinnapuram IREP.

The stability analysis of the RCC Intake Structure shall be carried out in accordance with IS 6512-1984 and earthquake loading in accordance with IS 1893-1984. Tentative proposals for curtain grouting, consolidation grouting and drainage arrangements have been provided. The curtain grouting depth is taken as 2/3 H. The consolidation grouting is taken as H/4. Depth of grouting may be modified if necessary in consultation with geologist after opening the foundation.

The most important cause of failure of an embankment structure is sliding. A portion of the Rock fill embankment will slide downwards and outwards with respect to remaining part, generally along a well defined slice surface. The failure is caused when the average shearing stress exceeds the average shearing resistance along the sliding surface due to various loading conditions. Simplified Bishops method is used to assess the stability of slopes under the following loading conditions

1. Construction condition (u/s and d/s slopes).
2. Reservoir partially full (u/s slope).
3. Sudden Drawdown (u/s slope).
4. Steady seepage (d/s slope).
5. Steady seepage with sustained rainfall (d/s slope).
6. Earthquake condition (u/s and d/s slopes).

The water from the upper reservoir will be let out through penstocks of 760m long to feed the Pinnapuram IREP Power House, having an Storage Capacity of 9600 MWH with rating of 1200 MWH. This project is comprising 5 units of 200 MW and 2 units of 100 MW each.

The water after power generation will be conveyed through 1300m long Tail Race Channel to discharge water in to Lower reservoir. General Layout plan and L – Section of the proposed scheme is enclosed in the drawing AA/PSP/POWER/2154/02 & 03.

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

Sl. No.	Parameter	Unit	Value
1	Top of bund	m	EL +466.00
2	Full Reservoir Level (FRL)	m	EL +463.00
3	Minimum Draw Down Level (MDDL)	m	EL +441.50
4	Live Storage	TMC	1.20
5	Dead Storage	TMC	0.17
6	Gross Storage	TMC	1.37
7	Height of intake structure	m	45.00
8	Max Height of Rock Fill Embankment	m	35.00

The Key parameters of proposed Pinnapuram IREP Lower Reservoir are as follows:

Sl. No.	Parameter	Unit	Value
1	Top of Bund	m	EL +343.00
2	Full Reservoir Level (FRL)	m	EL +340.00
3	Minimum Draw Down Level (MDDL)	m	EL +321.00
4	Live Storage	TMC	1.20
5	Dead Storage	TMC	0.22
6	Gross Storage	TMC	1.42
7	Max Height of Rock Fill Embankment	m	33.0

The Key parameters of the Existing 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

7.5 RCC Intake Structure

The intake structure of Pinnapuram IREP will be constructed in the upper reservoir. The Intake structure with bell mouth openings will have 6 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 into the penstock. The intake structure comprises 7 panels of trash racks, each 2.5 m wide and 21.75 m high. The total area of intake opening is 450 Sqm. The velocity of flow through the trash rack for the design discharge of 193.81 Cumec with net area of 157.5 m2 (assuming 50% of area is occupied by trash rack bars) works out to 1.23 m/s which is considered within acceptable limit. There is a provision of service gate and Stop log gate with vent size 5.77m x 7.0m. The total design discharge for the penstocks is 1162.85 Cumec. The center line of the pressure tunnel emerging from the trash rack is EL +429.24m and the trash rack is proposed to rest at around EL +423.71m. Radius of the trash rack is 9.30 m.

The design of intake structure has been carried out with minimum losses and adequate water cover above the MDDL to prevent vortex formation and entry of air.

7.6 Penstock / Pressure Shaft

Five independent pressure shaft / penstock of 7.0 m diameter are proposed to provide supply of water to feed five units of 200 MW. One penstock of 7.0m dia. bifurcated into 2 will feed 2 units of 100 MW each. The length of the penstock up to powerhouse location shall be 760.0m. The pressure shaft is designed to withstand the internal pressure from water and external pressure from rock. Rock participation factor is considered in the design of pressure shaft. The pressure shaft consists of 460.0m horizontal segments followed by 90.0 m vertical and 210.0m horizontal segment. The steel lined pressure shaft will be backfilled with concrete. 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 7.00m has been adopted to carry the design discharge of 193.81 Cumec for each unit.

7.7 Power House

It has been proposed to have power house and all associated components on the surface. As the proposed power house involves little deeper excavation, intricate supporting arrangements for the cut slopes involving anchors etc., are provided. The control room is

proposed on the downstream of machine hall above the Draft tubes.

The project envisages the utilization of the Rated head of 119.27m. The Pumped storage plant comprises of 7 units.

The Key parameters of Storage Operation are as follows:

Sl. No.	Parameter	Unit	Value
1	Storage Capacity	MWH	9600
2	Rating	MWH	1200
3	No. of Units	Nos.	7
4	Turbine Capacity – 5 Units	MW	200
5	Turbine Capacity – 2 Units	MW	100
6	Rated Head in Turbine mode	m	119.27
7	Design Discharge per unit of 200 MW	Cumec	193.81
8	Design Discharge per unit of 100 MW	Cumec	96.90
9	Total Design Discharge	Cum	1162.85
10	Generation Duration	Hrs.	8.00
12	Annual Energy Generation	Mu	3376
13	Pump Capacity – 5 Units	MW	244
14	Pump Capacity – 2 Units	MW	130
15	Pumping Head	m	125.77
16	Pumping Duration	Hrs.	8.73
17	Annual Energy consumption	Mu	4480

Pumping operation is proposed at 8.73 hours/day. 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.

7.8 Machine Hall

The internal dimensions of power house have been proposed with length 240m and width 24.00m including control room. The units have been kept at about 23.00m spacing while the erection bay have been proposed as 30m long. For housing control room and various auxiliaries/offices, 4 nos. floor have been proposed on the D/s side of Power house over the draft tube. The main inlet valve is proposed to be housed in power house just u/s of turbine. 2 Nos EOT crane of 400/60 tons capacity has been proposed in erection bay and unit bay to facilitate erection and repair of heavy equipment including main inlet valves.

The machine floor is designed to carry load of machines, live load and thrust transferred through turbines, generators and other machinery. The machine floor is designed as an RCC raft with adequate openings as required for equipment foundations and cable trenches etc.

7.9 Tail Pool and Tail Race Channel

The tail water from the machines, is led back to the lower reservoir through a tailrace channel. Each turbine is provided with gated draft tube. Water from the draft tube of each of the machines will enter in to a tail pool constructed with RCC walls on three sides. The downstream wall of the powerhouse completes the tail pool structure. The tail pool is connected to a tail race channel that conveys the water into the Lower Reservoir.

CHAPTER – 8

ELECTRO - MECHANICAL EQUIPMENTS

8.1 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, SFC, Cooling system, Electrical and mechanical 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 LOAD TAP changer along with control and protective gear and breakers etc.
- One no. 420KV Gas Insulated switch-gear (GIS) unit with bus sectionalize is proposed for connecting to two different sources.
- Auxiliary Power supply system consisting of unit auxiliary transformers, station auxiliary transformer, D.G Set for alternative emergency supply and station/ unit auxiliary boards for station auxiliaries, unit auxiliaries.
- Control supply system consisting of station battery, charger and its distribution system.
- The station auxiliaries like EOT crane, D.T crane, Air Compressor system, Dewatering and Drainage system, firefighting equipment, Air conditioning, Ventilation system, Public addressing 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 trunnions 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 and transmitters 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. Type of cooling water system i.e. whether Common or individual shall be decided during detailed engineering.

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 room. 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 room, Power house and other areas. Air Handling units are to be placed in transformer room. 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 850 (recommended practice for Fire Protection for Hydroelectric Generating Plants).

Fire protection system design and drawings enclosed.

VI) Air Compressor System

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

8.3 ELECTRICAL EQUIPMENT:

The Electrical scheme showing the major system, such as the Generator and its connections to 420KV GIS switchgear for Power evacuation to near by substations, 18KV Switchgear and 415V Auxiliary Power distribution.

8.3.1 Generator/Motor:

The synchronous generator/Motor will be 200/244 MW (5 Nos.), & 100/130 MW (2No’s), 18KV, 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 both Electrical braking and mechanical braking to bring the rotor parts of the generator and turbine to stop from 80% of rated speed with electrical braking and mechanical brakes applied at 15% 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 18KV LAVT Cubicle:

The power generated will be fed to 18KV side of the each transformer through respective Lightning Protection Voltage Transformer (LAVT) cubicle, CT's 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 18KV LAVT Cubicle.

The main electrical parameters of the switchgear will be:

a)	Rated voltage	-	18KV
b)	Rated short circuit current	-	120kArms & 75kArms for 3 sec
c)	Rated current of bus bars	-	10,000 A & 5500 A

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

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

8.3.3 Step-up Transformers:

Power generated at 18kV will be stepped up to 400KV by means of 5 nos 3-Ph 280MVA & 2 Nos 3-Ph 150MVA 18/400KV oil filled transformers. These Step-up transformers will be installed in Transformer room. 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	-	18KV/400KV, 3 phase, 50 Hz
(b)	Rating	-	280 MVA and 150 MVA
(c)	Cooling Method	-	OFWF (Oil Forced and Water Forced)
(d)	18KV connection	-	Delta

(e) 400KV connection - Star with neutral solidly earthed.

(f) OFF load tap changer - In the range of +/-10.0% in step of 2.5% as per IS 10028 (part – I)

The 18KV terminals (Primary) will be suitable for Bus Duct connection and 400KV terminals for connection to GIS.

8.3.4 420KV GIS (1 No.):

One number 420KV Gas Insulated switch-gear (GIS) units are proposed. Each GIS unit is connected on the secondary side of 3-phase transformer each.

Standards

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

Sl. No.	Standards	Description
1	IEC 62271(All Parts)	"High voltage switchgear and control gear",
2	IEEE C37.122-1993	IEEE Standard for Gas-Insulated Substations (GIS)
3	IEEE C37.123-1996	IEEE Guide to specifications for Gas- Insulated, Electric Power Substation Equipment
4	IEC 60694 1996 Edition	Common Clauses for high-voltage switchgear and control gear standards
5	IEC 60376 – 2005 Edition	Specification of technical grade sulphur hexafluoride (SF6) for use in electrical equipment

Arrangement and assembly

The arrangement shall be single-phase enclosed. The assembly shall consist of completely separate pressurized sections designed to minimize the risk of damage to personnel or adjacent sections in the event of a failure occurring within the equipment. Rupture diaphragms shall be provided to prevent the enclosures from uncontrolled bursting and suitable deflectors provide protection for the operating personnel. In order to achieve maximum operating reliability, no internal relief devices shall be installed because adjacent

compartments would be affected. Modular design, complete segregation, arc-proof bushings and “plug-in” connection pieces shall allow ready removal of any section and

8.3.5 400KV Outdoor Connection:

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

8.3.6 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 room. Based on the manufacturer design, this may change to unit wise in 18kV level.

I) Station Transformers

HT station power will be derived by providing 2 nos 20/25.0 MVA, 400/18KV Station Transformer through 2 nos 20MVA 18/18KV SFC (Static Frequency Converter) Transformers. These transformers will be connected to their respective 18kV bus through SFC Equipment’s, Starter Panel and necessary switchgear.

II) SFC Equipments:

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

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

working stages are divided into pulse commutation stage and load commutation stage.

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

III) Station Auxiliary Transformers

415V station power will be derived by providing 2 nos 2.5 MVA, 18KV/415V Station Transformers. These transformers will be connected to the 18kV 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	-	18KV/415V, 3 phase, 50 Hz
(b)	Rating	-	2 X 2.5 MVA
(c)	Type	-	Dry Type (CRT)
(d)	Primary connection	-	Delta
(e)	Secondary connection earthed.	-	Star with neutral solidly
(f)	Off circuit Tap Changer (OCTC)	-	+/- 5% in step of 2.5%

IV) 415V Switchgear:

Station Auxiliary Board (SAB)

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

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

2. Two nos ACB controlled incomer feeders from Station auxiliary transformers.
3. ACB controlled Outgoing feeders to Unit auxiliary boards
4. Outgoing feeders to battery chargers / lighting panels with MCCB.
5. Motor feeders fitted with MPCB, DOL / Star- Delta Starter, thermal overload relays etc., are of draw out type

6. 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.

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

The main electrical parameters of the switchgear will be:

a) Rated Voltage – 415V

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

c) Rated bus bar current – 2000 A

V) Power Station Auxiliary Services:

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

a) Motors - 415V, 3 phase AC supply

b) Lighting and space heaters - 230V, 1 phase AC supply

c) Power receptacles - 415V, 3 phase AC supply

d) Control circuits - 110V, 1 phase grounded AC supply for

AC control circuits.

- 220V ungrounded DC supply for control, indication and Instrumentation & Control system.

8.3.7 Emergency Power System:

I) Diesel Generator Set:

One number of 1.0 MVA, 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 1.0 MVA, 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.

8.3.8 Control, Instrumentation & Protection Systems:

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

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

Each Turbine-Generator control cubicle shall contain the following:

Measuring & Indicating instruments comprising of the following:

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

(One main and check meters on the HT side of the GT

One meter on the LT side of the GT

One meter on the 11 KV tap off of the generator bus.

One main and check meters on the HT side of the ST.

One main and check meters on the 400KV feeder.)

- Indicating lamps for ON/OFF/ Trip - 1 set
- Controls comprising of the following:
- Start control switch with relays - 1 set
- Stop control switch with relay - 1 set

- Alarm annunciator - I set
- Master protection relays -1 set
- D.C. Failure
- Synchronizing scheme with auto synchronizer - 1 set
- One set of acknowledge, reset and test push button
- One hooter and blinking relay.
- Programmable logic controller (PLC) - 1 set

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

Programmable Logic Controller (PLC) System:

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

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

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

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

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

e) Man Machine interface unit

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

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

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

II) Local Instrumentation:

The following instruments shall be mounted locally:

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

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

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

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

III) Communication system:

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

- Control room
- Switchgear room
- Turbine pit
- Machine hall
- Unloading/erection bay
- Drainage/ dewatering motor starter panel
- Transformer room
- Outdoor yard
- Staff quarters
- Pump house
- 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:

a. Continuous UTC reference, +5.30 hours offset (IST)

b. IRIG B Time Code output

c. RS 232 & 485 serial port interface

d. SNTP & NTP Ethernet Output

e. Pulse Output

f. BCD Output

g. DCF77 Output

h. Large size Time display

i. All weather water proof antenna

j. Synchronization software for Server /PC

k. Hot Redundant GPS / Master clock with comparator

l. Redundant power supply with Diode O-ring

m. 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:

a) Over / Under Speed (12/14)

b) Governor Failure Relay (33/63)

c) Bearing Temperature (38T)

d) Oil pressure Failure (96.2 OPU)

e) Oil levels

f) Shear pin

g) 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:

- Impedance (21)
- Over/ under voltage (27/59)
- AC Directional over current (67/67N)
- Frequency (81)
- Master Trip (86)
- Trip Circuit Supervision (95)
- AC Reclosing Relay / Auto Reclose (79)
- Instantaneous Overcurrent Relay (50)
- Phase Angle Measuring or Out-of-Step Protective Relay (78)
- Bus Differential (87B)
- Overvoltage Relay (59)
- 400KV reactor protection
- 400KV bus bar protection
- 400KV cables protection
- Bus coupler protection

V) Safety Earthing & Lighting protection system:

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

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

VI) Fire detection and Alarm System:

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

8.3.9 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 18/0.415KV, 3-phase, 4 wire transformer connected to 415V distribution system. Detailed design enclosed.

II) Direct Current Emergency Lighting system:

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

These would be fed from the station 220V DC system and would be off when the normal AC power supply is available. These would be automatically switched on when the normal AC supply fails.

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

AREA	Illumination Level
Control Room	300 lux
Switchgear/MCC room	250-300 lux
TG building	260lux

Outlying areas	30-40 lux
Switch yard	25-35 lux
stores	100-150 lux
Battery Room	100 lux
Administration building and Office rooms	300 lux
Roads	20 lux

8.3.10 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 18KV power cables – 18KV (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.

8.3.11 Power Evacuation & Transmission Lines:

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

CHAPTER – 9

ENVIRONMENTAL ASPECTS

9.1 Introduction

The Project is envisaged as a Pumped Storage Project being developed near existing Gorakallu Reservoir. The project is in Kurnool district of Andhra Pradesh. The Project envisages creation of upper and lower reservoir near Pinnapuram Village, about 80 Kms from Kurnool. This chapter broadly covers the impacts likely to occur during construction and operation of the project.

9.2 Description of the Environment

9.2.1 Upper & Lower Reservoirs

The upper reservoir site is proposed at Latitude 15° 36’ 26" N and Longitude 78° 15’ 13" E. The lower reservoir offtake site is proposed at Latitude 15° 37’ 26" N and Longitude 78° 15’ 30" E. The RCC intake structure is proposed at upper reservoir location and envisages construction of 45.0m high Concrete Gravity Structure with non over flow rock fill embankment of average height of around 12m to 14m with maximum height of 35m for short reach for formation of upper reservoir. The lower reservoir is formed with rock fill embankment of average height of around 12m to 14m with maximum height of 33m for short reach. The gross storage capacity of the upper reservoir at this location is 1.37 TMC with a live storage of 1.20 TMC keeping the FRL and MDDL at EL + 463.0m and EL + 441.50 m respectively. The gross storage capacity of the lower reservoir at this location is 1.42 TMC with a live storage of 1.20 TMC keeping the FRL and MDDL at EL + 340.0m and EL + 321.0 m respectively. The onetime filling of the reservoir is taken up by pumping the water from existing Gorakallu Reservoir.

9.2.2 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

9.2.3 Gorakallu Reservoir 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).

9.2.4 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.

9.2.5 Seismicity

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

9.2.6 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.

9.2.7 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.

9.3 Prediction of Impacts

The environmental impacts of the proposed Standalone Pumped Storage Component of Pinnapuram IREP 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 excavation of pressure shafts, 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

9.4 Impacts on Land Environment

9.4.1 Construction Phase

Only very few impacts of construction phase are permanent. Majority of the environmental impacts attributed to construction works are temporary in nature, lasting mainly during the construction phase and often little beyond the construction period. However, if these issues are not properly addressed, the impacts can continue even after the construction phase for longer duration. The time required for construction of the project has been assumed as about 3.0 years.

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 affected 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.

9.4.1.1 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.

9.4.1.2 Quarrying Operations

The coarse aggregate requirement and construction materials for formation of embankment, various roads and buildings of 73.40 lakh Cum will be extracted from the excavated muck from various project components. However a separate quarry is being identified to meet the balance requirement of construction materials.

9.4.1.3 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.

9.4.1.4 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/nallahs are present. Hence, the increase in turbidity levels are not envisaged to be significant in nature.

9.4.1.5 Muck Disposal

About 85.30 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 73.4 Lakh cum of the muck to be generated as construction material in various project structures.

Therefore, 11.90 Lakh Cum muck is proposed to be dumped at pre-identified locations. The 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.

9.4.2 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.

9.5 Impacts on Air Environment

Considerable amount of air pollution will be caused during different stages of construction of pressure shafts, 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.

9.6 Impacts on Noise Environment

The noise will be generated at the time of construction of powerhouse, pressure shafts, 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.

9.7 Impacts on Water Quality

The project construction is likely to last for a period of 3.0 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.

9.8 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.

9.9 R&R Aspects

The Pinnapuram IREP is proposed between two reservoirs i.e. Pinnapuram IREP upper and lower reservoir (both to be constructed newly) and one time water will be pumped from existing Gorakallu reservoir to fill up the proposed upper reservoir. 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 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.

9.10 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

9.11 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.

9.11.1 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.

9.11.2 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.

9.11.3 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.

9.11.4 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.

9.11.5 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.

9.11.6 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 IREP including erection of seven generating units are planned to be completed in a period of 36 months including Pre-constructions works, creation of infrastructure facilities viz. additional investigations, improvement of road network and colonies.

Two shift working is considered economical for surface works. Opting 25 working days in a month, shift wise scheduled working hours annually are adopted as follows:

For Surface Works

Two Shift Work = 25x12x10 hrs. = 3000 hrs.

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

- Embankment for forming upper and lower reservoir
- Head Race Channel
- RCC intake Structure
- Penstock / Pressure shaft
- Surface Power House
- Tail pool and Tailrace channel

Electrical Works

a) E.O.T cranes

b) Supply and erection of T.G sets 7 nos.

c) 400 KV G.I.S. equipment

d) Main Power Transformers

e) Other auxiliary electro-mechanical equipment

Hydraulic equipment

- Intake gates
- Intake trash rack
- Steel liner Penstock
- Draft Tube gates
- Trash Rack at Tail pool

10.2.2 Target Schedule

The Total Construction period is scheduled as follows.

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

10.3 Infrastructure Facilities

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

10.3.1 Head Race Channel

Excavation of Head Race channel may start from 2nd month of year 1 and will be completed by 7th month of year 1.

10.3.2 Embankment for Upper & Lower Reservoir

Excavation of embankment area will be started from the 3rd month of year 1 utilisng the muck generated from approach channel and will be completed by 12th month of year 2.

10.3.3 RCC intake Structure

Excavation of intake structure may start from 5th month of year 1 and will be completed by 4th month of year 2. The concreting of intake may take place from 5th month of year 2 and will be completed by 9th month of year 2.

10.3.4 Penstock / Pressure shaft

Excavation in penstock / Pressure shaft will be taken up in the 8th month of year 1 and will be completed by the end of 6th month of the 2nd year. The Lining & erection of steel

liners will be started from 7th month of year 2 and will be completed by the end of 12th month of year 2.

10.3.5 Powerhouse

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

10.3.6 Tail pool and Tailrace Channel

Excavation of Tail pool and Tailrace Channel will be taken up in the 3rd month of the 2nd year and will be completed by 9th month of year 2. The concreting will be taken up in the 10th month of the second year and will be completed by 2nd month of 3rd year.

10.3.7 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 2nd 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 six months. Installation period for each pump/turbine and generator/motor has been considered as 12 months.

CHAPTER - 11

COST ESTIMATE

11.1 General Description Of The Project

The Pinnapuram IREP is proposed between two reservoirs i.e. Pinnapuram upper and lower reservoir (both to be constructed newly) and one time water will be pumped from existing Gorakallu reservoir to fill up the proposed upper reservoir.

11.2 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)

11.3 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)

11.3.1 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.

11.3.2 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.

11.3.3 C - Works

The provisions under this head covers the costs of Rockfill embankment, Head Race Channel, RCC intake structure, Penstocks/Pressure Shaft, Power House, Tail Pool and Tail Race Channel.

Important items considered under this head are

11.3.4 J - Power plant civil works

Important items to be considered under this head are

Embankment, Head Race Channel & Intake Structure

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

Penstock / Pressure Shaft

- Excavation
- Cement concrete for
- Bed

- Anchor blocks
- Intermediate supports
- Stiffener, Reducers, Bends, Penstock valves, Instrumentation

Power House

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

Tail Pool 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

11.4 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% J-Power plant civil works is made under this head.

11.5 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. 100 Lakhs is made under this head.

11.6 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% J-Power plant civil works is made under this head.

11.7 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% J-Power plant civil works is made under this head.

11.8 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.200.00 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.

11.9 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.

11.10 S-Power plant and Electro - Mechanical System

The provision under this head cover the Electro-Mechanical equipment for the power plant and associated substation under the sub-head as indicated in Annexure – S for "Abstract of Cost Estimates of Electro-Mechanical Equipment's". 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.

11.11 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% J-Power plant civil works is made under this head

11.12 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.

11.13 Establishment

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

11.14 Tools & Plants

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

11.15 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.

11.16 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.

11.17 Indirect Charges

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

11.18 Project Cost

The total project cost has been estimated at 5468.02 Crores at March 2018 price level. The cost works out to Rs. 4.56 Crore per MW including IDC.

CHAPTER – 12

FINANCIAL AND ECONOMIC ANALYSIS

12.1 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.

12.2 General Description Of The Project

The Pinnapuram IREP has been conceived as an off stream project near Pinnapuram Village, in the state of Andhra Pradesh

12.3 Generation

In a year, the planned peak power generation will be 2806 hours considering the rate of 8.11 hours per day for 346 days operation the estimated maximum annual energy generation will be 3376MU. Only net volume turbine by PSP during the non -monsoon period is considered.

12.4 Annual Requirement Of Pumping Energy

The pumping will have to be carried out for 3021 hours (i.e., 346 days and 8.73 hours each day) per year. The energy required for pumping works out to 4480 MU per annum.

Load factor in turbine mode – 32.11 %

Load factor in Pump mode – 34.55 %

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.

12.5 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 based on the estimates will be obtained from the financial institutions.

The analysis has been carried out, considering the rate of interest equal to 10.20% on term loan. Repayment of loan is assumed to be over a period of 12 years in Quarterly equal installments for principal amount and interest charges on balance outstanding. Interest charges have been computed based on average of opening and closing amount of outstanding loan in each quarter. Loan amount would also account for payment of interest charges during construction period and other incidental charges associated with financing.

12.6 Cost Of Project

Estimated cost of the project is Rs.5468.02 Crores (including IDC) based on year 2017-2018 prices. The actual cost, till the completion of the project is higher due to interest charges during construction. Construction work is assumed to take 36 months and the power station is expected to be commissioned in 3.0 Years.

12.7 Interest During Construction

Interest charges during construction would depend on phasing of expenditure. IDC has been considered for scheduled completion period of 30months. The Interest during Construction period is expected to be Rs. 519.58 Crore.

12.8 Depreciation Provision

Depreciation is considered @5.28% p.a. for the initial period of 12 years and the remaining depreciation to cover 90% depreciable value shall 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.

12.9 Sales Revenue

The annual sales revenue is considered based on projected rate and following assumptions are made to arrive at the annual charges for calculation of Cost of Energy. The operating expenditure has been arrived based on the estimated cost.

Operation and maintenance O & M Expenses @2.0%, 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, one-month operation and maintenance cost, two months receivables.

Discount Factor is taken as Post tax weighted average cost of capital, which comes to 9.08%

EMBANKMENT TO BE CONSTRUCTED

EMBANKMENT TO BE CONSTRUCTED

EMBANKMENT TO BE CONSTRUCTED

EMBANKMENT TO BE CONSTRUCTED

TAIL RACE CHANNEL LENGTH 1300m

LOWER RESERVOIR

POWER HOUSE

PENSTOCK LENGTH 760m

INTAKE STRUCTURE

HEAD RACE CHANNEL LENGTH 1245m

EMBANKMENT TO BE CONSTRUCTED

UPPER RESERVOIR

N

For Pre-Feasibility Report only

Client

GREENKO ENERGIES PVT. LTD

Project

STANDALONE PUMPED STORAGE COMPONENT OF PINNAPURAM IREP

Title

GENERAL LAYOUT ON CONTOUR DATA

Consultants

aarvee associates
architects engineers & consultants pvt ltd.
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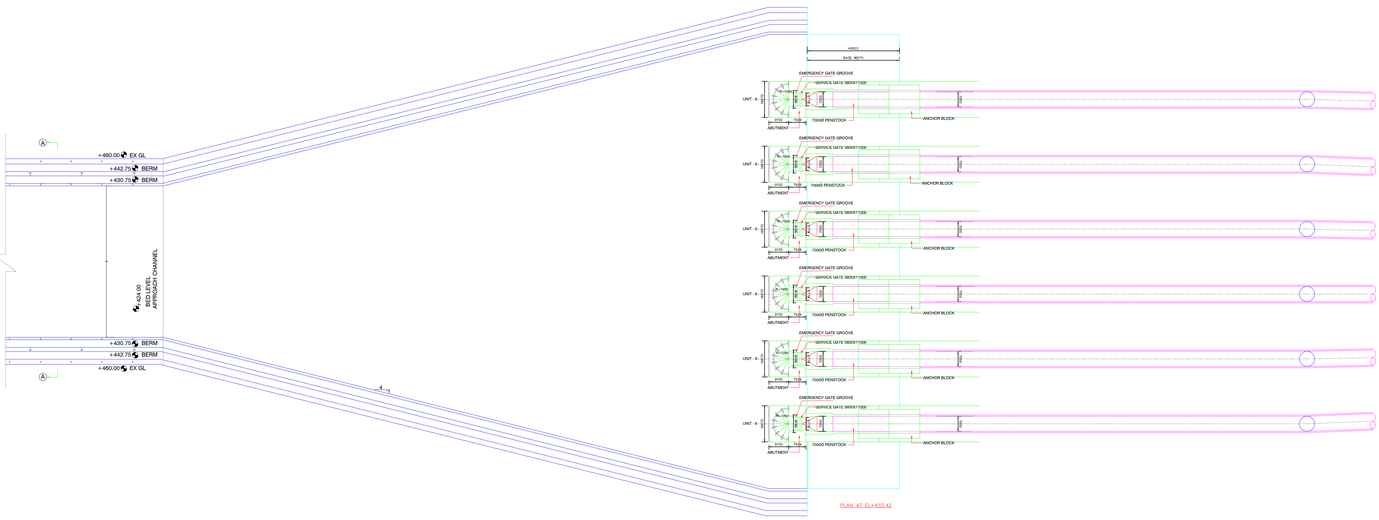
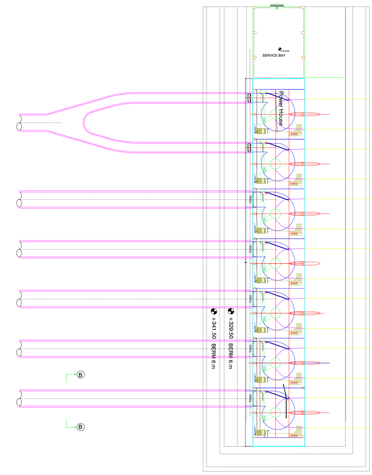
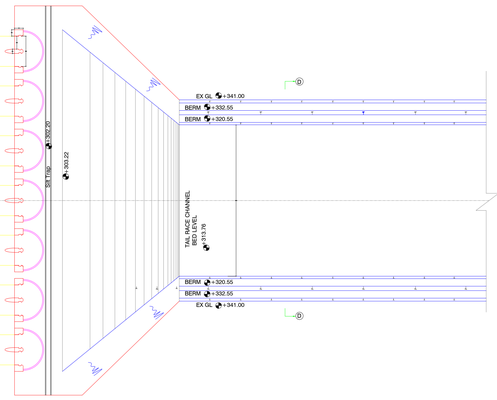
DATE: 13.07.2018 | Drg.No. AA/PSP/POWER/2154/01







PLAN

For Pre-Feasibility Report only

Client	GREENKO ENERGIES PVT. LTD
Project	STANDALONE PUMPED STORAGE COMPONENT OF PINNAPURAM IREP
Title	PLAN
Consultants	aarvee associates
DATE: 13.07.2018	Drg.No.: AA/PSP/PHEP/2154.7/2

For Pre-Feasibility Report only

Client	GREENKO ENERGIES PVT. LTD
Project	STANDALONE PUMPED STORAGE COMPONENT OF PINNAPURAM IREP
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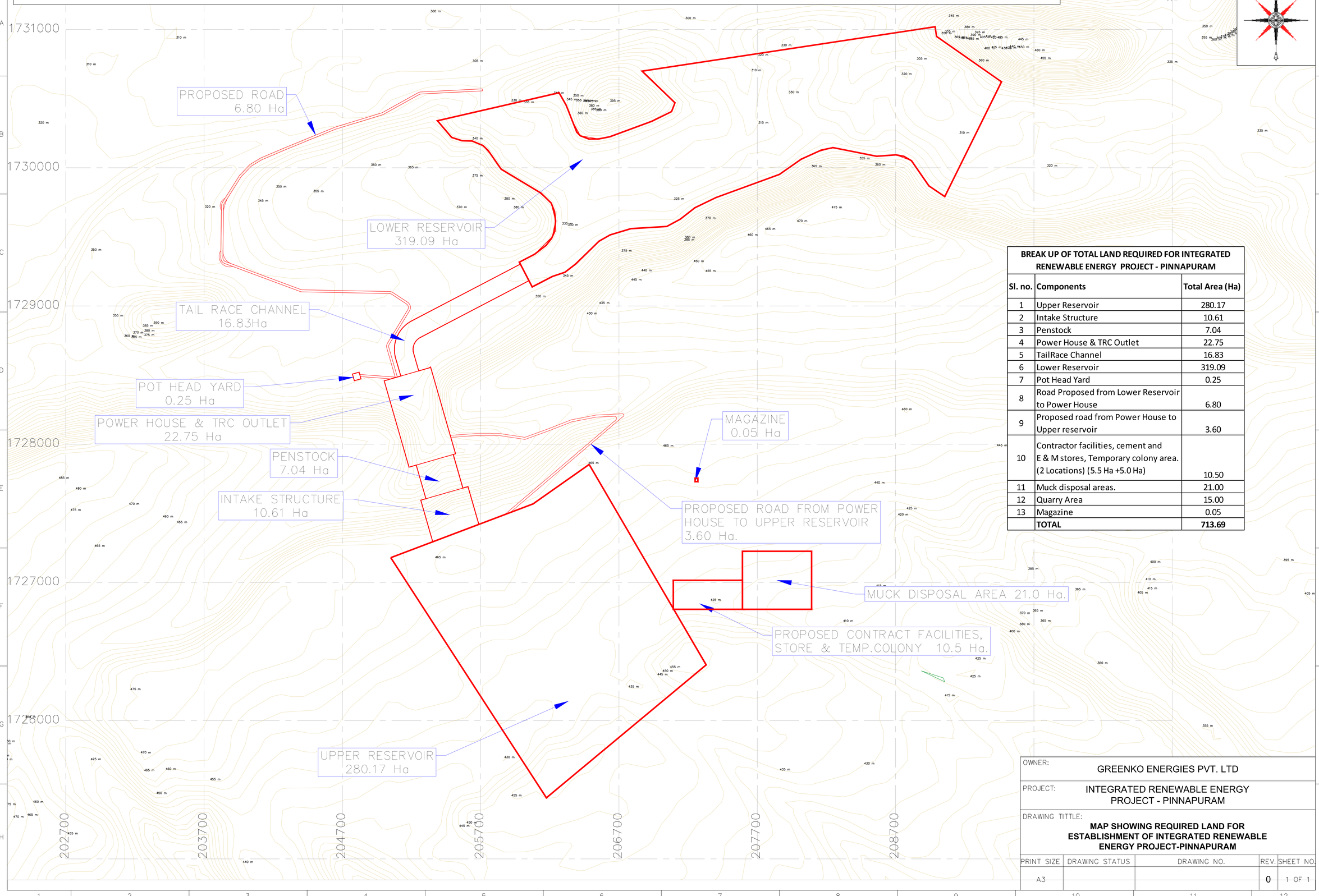
Consultants	aarvee associates architects engineers & consultants pvt ltd. Ravula Residency, Srinagar Colony, Hyderabad-82, India Tel: +91-40-23737633, fax: +91-40-23736277 Email: aarvee@aarvee.net; Web: www.aarvee.net
DATE: 13.07.2018	Drg.No. AA/PSP/POWER/2154/03

MAP SHOWING REQUIRED LAND FOR ESTABLISHMENT OF INTEGRATED RENEWABLE ENERGY PROJECT-PINNAPURAM



BREAK UP OF TOTAL LAND REQUIRED FOR INTEGRATED RENEWABLE ENERGY PROJECT - PINNAPURAM

Sl. no.	Components	Total Area (Ha)
1	Upper Reservoir	280.17
2	Intake Structure	10.61
3	Penstock	7.04
4	Power House & TRC Outlet	22.75
5	TailRace Channel	16.83
6	Lower Reservoir	319.09
7	Pot Head Yard	0.25
8	Road Proposed from Lower Reservoir to Power House	6.80
9	Proposed road from Power House to Upper reservoir	3.60
10	Contractor facilities, cement and E & M stores, Temporary colony area. (2 Locations) (5.5 Ha +5.0 Ha)	10.50
11	Muck disposal areas.	21.00
12	Quarry Area	15.00
13	Magazine	0.05
	TOTAL	**713.69**

OWNER:	GREENKO ENERGIES PVT. LTD
PROJECT:	INTEGRATED RENEWABLE ENERGY PROJECT - PINNAPURAM
DRAWING TITTLE:	**MAP SHOWING REQUIRED LAND FOR ESTABLISHMENT OF INTEGRATED RENEWABLE ENERGY PROJECT-PINNAPURAM**

PRINT SIZE	DRAWING STATUS	DRAWING NO.	REV.	SHEET NO.
A3			0	1 OF 1