SHAHPUR STANDALONE PUMPED STORAGE PROJECT (1800 MW)

PRE-FEASIBILITY REPORT

GREENKO RJ01 IREP PRIVATE LIMITED
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CHAPTER – 1

EXECUTIVE SUMMARY

This PFR is for the Shahpur Standalone Pumped Storage Project (PSP) of 1800 MW / 10800 MWH storage capacity, located at Shahabad Tehsil, Baran District, Rajasthan. The Shahpur Standalone PSP will comprise of two reservoirs which are to be constructed newly. The upper reservoir is proposed to be located on flat / gradually sloping land which is suitable for creating the desired gross storage capacity of 1.21 TMC by doing excavation up to the desired level. Out of 1.21 TMC, the live storage capacity is 1.01 TMC and the dead storage capacity is 0.20 TMC by keeping FRL & MDDL at EL 507.00m & EL 490.00m respectively. For creating this storage, it is proposed to construct rockfill embankment for the average height of around 24.5 m (with maximum height of 30m) for the length of 5309m. Similarly, the lower reservoir is proposed to be located on the natural depression which is suitable for creating the desired gross storage capacity of 1.06 TMC by doing excavation up to the desired level. Out of 1.06 TMC, the live storage capacity is 1.01 TMC and dead storage capacity is 0.05 TMC by keeping FRL and MDDL at EL 349.00m & EL 328.00m respectively. For creating this storage, it is proposed to construct rockfill embankment for the average height of 26.5m (with maximum height of 30m) for the length of 2937m. This Project is standalone in nature and both the reservoirs are located across few tributaries / nalas of Kuno river and will have some small catchment area. One-time requirement of 1.26 TMC of water will be lifted from existing nearby Shahabad Kuno River to the proposed Shahpur Standalone PSP lower reservoir and used cyclically for energy storage and discharge. As per the communication from Water Resource Department (WRD) of Rajasthan Government, it has been proposed to construct a barrage (i.e., Hanotiya barrage) across Kuno river under Eastern Rajasthan Canal Project (ERCP) and the FRL and top of the barrage are EL 306.00m and EL 308.00m respectively. Considering the FRL of proposed Hanotiya barrage across Kuno river, the location of Shahpur Standalone PSP lower reservoir is kept accordingly. Losses due to evaporation will be recouped periodically from Shahabad Kuno River. This Project envisages non-consumptive re-utilization of 1.01 TMC of water for recirculation among two proposed reservoirs. The geographical coordinates of the proposed upper reservoir are at Latitude 25°11'25.21"North and Longitude is 77°10'55.78"East and that of lower reservoir are at 25°11'40.00"North and 77°11'50.00"East. Proposed rating of Pumped Storage Project is 1800 MW.

The cycle efficiency of the project is expected to be around 80%. It is proposed to use One 400KV Double Circuit Transmission Line of length 75 Km (appx) and will be connected to 400 / 765KV PGCIL substation at New Shivpuri of Madhya Pradesh State for evacuation of generated Power and for Supply of power during pumping mode The total land required for the construction of various components including land required for infra item like road, job facilities, muck disposal area etc. are tentatively estimated to about 624.91 Ha. It is proposed to construct the project within a period of 3.5 years including infrastructure development which is proposed to be completed within 6 months. The total cost of the project is estimated to **9721.76** Crores.

CHAPTER – 2

INTRODUCTION OF THE PROJECT/BACKGROUND INFORMATION

2.1 Introduction

India is leading the world's renewable energy revolution and is on track to achieve 500 GW of RE capacity by 2030. Today, Wind & Solar, are the lowest cost source of new energy, however their inherent infirm nature & non-schedulable 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.

In this scenario, Off-Stream Closed Loop type of Pumped Storage Projects present a unique and viable solution to the needs of the National Grid by being able to provide lowest cost proven energy storage, grid management, frequency regulation and renewable energy integration solutions. During **COP 26 summit** held in Glasgow (UK), Government of India (GoI) has reiterated its commitment to effectively harness the renewable energy capacity to 500GW by year 2030. This large scale long duration of energy storage is essential which can be achieved through Pumped Storage Projects.

Greenko Group is India's leading clean energy company, with **~7.5 GW** operational portfolio across 15 states in India. Greenko Group has an existing asset base of over **USD 8.5 Billion** with an equity investment of **USD 2.2 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 has conceptualized two worlds first and largest GW scale Integrated Renewable Energy storage projects located in Andhra Pradesh and Karnataka. **IREP Pinnapuram** is located in Andhra Pradesh which configurates **3000MW Solar, 500MW Wind and**

1200MW PSP with 9hrs of storage Similarly, other project is **IREP Saundatti** which configurates **2900MW Solar, 500MW Wind and 1260MW PSP** with 10.5hrs of storage. IREP Pinnapuram is already under advanced stage of construction whereas IREP Saundatti is in advanced stage of obtaining statutory clearances and groundbreaking at site is expected shortly.

Greenko Group has been in the process of evaluating suitable locations for such Standalone Hydro Storage project and has identified Shahpur, Shahabad Tehsil, Baran District, Rajasthan for the proposed Shahpur Standalone Pumped Storage Project. The Project requires 1.01 TMC of water for establishing the 1800 MW Pumped Storage component with 6 hours storage capacity.

The upper reservoir is proposed to be located on flat / gradually sloping land which is suitable for creating the desired gross storage capacity of 1.21 TMC by doing excavation up to the desired level. Out of 1.21 TMC, the live storage capacity is 1.01 TMC and the dead storage capacity is 0.20 TMC by keeping FRL & MDDL at EL 507.00m & EL 490.00m respectively. For creating this storage, it is proposed to construct rockfill embankment for the average height of around 24.5m (with maximum height of 30m) for the length of 5309m. Similarly, the lower reservoir is proposed to be located on the natural depression which is suitable for creating the desired gross storage capacity of 1.06 TMC by doing excavation up to desired level. Out of 1.06 TMC, the live storage capacity is 1.01 TMC and dead storage capacity is 0.05 TMC by keeping FRL and MDDL at EL 349.00m & EL 328.00m respectively. For creating this storage, it is proposed to construct rockfill embankment for the average height of 26.5m (with maximum height of 30 m) for the length of 2937m. This Project is standalone in nature and both the reservoirs are located across few tributaries / nalas of Kuno river and will have some small catchment area. One-time requirement of 1.26 TMC of water will be lifted from existing nearby Shahabad Kuno River to the proposed Shahpur Standalone PSP lower reservoir and used cyclically for energy storage and discharge. As per the communication from Water Resource Department (WRD) of Rajasthan Government, it has been proposed to construct a barrage (i.e., Hanotiya barrage) across Kuno river under Eastern Rajasthan Canal Project (ERCP) and the FRL and top of the barrage are EL 306.00m and EL 308.00m respectively. Considering the FRL of proposed Hanotiya barrage across Kuno river, the location of Shahpur Standalone PSP lower reservoir is kept accordingly. Losses due to evaporation will be recouped periodically from Shahabad Kuno River. This Project envisages non-consumptive re-utilization of 1.01 TMC of water for recirculation among two proposed reservoirs. The geographical co-ordinates of the proposed upper reservoir are at Latitude 25°11'25.21"North and Longitude is 77°10'55.78"East and that of lower reservoir are at 25°11'40.00" North and 77°11'50.00"East. Proposed rating of Pumped Storage Project is 1800 MW.

2.2 Scope of Report

The proposed Shahpur Standalone Pumped Storage Project is a self-identified project and this Pre-Feasibility Study Report has been prepared to study, evaluate and establish the technical feasibility and economic viability of the proposed Pumped Storage Project.

2.3 Scope of Works

The Standalone Pumped Storage Component of Shahpur PSP envisages construction of upper and lower reservoir near Shahpur village in Shahabad Tehsil, Baran District. The one-time filling of 1.26 TMC of water for the proposed Shahpur Standalone PSP lower reservoir will be taken up from nearby Shahabad Kuno River to the proposed Shahpur Standalone PSP lower reservoir.

Proposed Scheme will involve construction of Rock fill embankment of average height of around 24.5m with maximum of 30m height for short length in upper reservoir of Shahpur Standalone PSP. Similarly, the scheme involves construction of Rock fill embankment of average height of around 26.5m with maximum of 30m height for short length in lower reservoir of Shahpur Standalone PSP. Intake structure and trash rack for Six number of independent pressure shafts will be taking off from Power block of Shahpur Standalone PSP upper reservoir and large penstock is bifurcated into two unit pressure tunnels. Surface Powerhouse will be located at about 830 m from the intake structure and shall be equipped with five vertical-axis reversible Francis type units composed each of a generator/motor and a pump/turbine having generating/pumping capacity of 300MW / 330MW respectively and two vertical-axis reversible Francis type units composed each of a generator/motor and a pump/turbine having generating/pumping capacity of 150MW / 165MW respectively.

Indoor Gas insulated switchgear (GIS) will be provided inside powerhouse. Step up transformers will be placed adjacent to the GIS building, which will be connected by double bus bar arrangement with bus coupler & with bus sectionalizer to machine hall.

One 400 KV Double Circuit transmission line with Quad Moose Conductor of length 75 KMs (appx.) from PSP will be connected to 400KV / 765KV PGCIL Substation at New Shivpuri of Madhya Pradesh State for evacuation of stored power during generating mode and for supply of power during pumping mode.

The Shahpur Standalone Pumped Storage Project envisages construction of

- Rock fill embankments of average height of around 24.5m with maximum of 30m height in upper reservoir and average height of around 26.5m with maximum of 30m in lower reservoir for creation of Shahpur upper & lower reservoir with 1.01 TMC each live storage capacity respectively.
- 37.45 m high Power Intake Structure
- 6 nos. each of 830 long and 7.50m dia. surface circular steel lined Penstock / Pressure Shaft (i.e., consisting of 663m long surface penstock, 72m long vertical pressure shaft and 95m long Horizontal pressure shaft) out of which 5 nos. will feed 5 units of 300 MW and one no. of 830m long 7.50m dia. which will get bifurcated into 2 nos. near power house each of about 50m long and 5.30m dia. to feed 2 units of 150MW.
- A surface Powerhouse having an installation of five nos. reversible Francis turbine each of 300 MW capacity (all units of fixed speed turbines) and two reversible Francis turbine each of 150MW (Both are fixed speed turbines) operating under a rated head of 154.73 m & 154.41m respectively (i.e., 300 MW & 150 MW Turbine) in generating mode and 162.56m & 163.21 m respectively (i.e., 330 MW & 165 MW Pump) in pumping mode.
- 5 nos. of 8.5m diameter and 2 nos. of 6.2m diameter, Tail race tunnel of 179m long.
- 140 m wide and FSD of 6.2m Tail race channel of 717 m long joining with the proposed lower reservoir.

2.4 Hydrology

The Shahpur Standalone PSP is proposed between two reservoirs i.e. Shahpur Standalone PSP upper reservoir and Shahpur Standalone PSP lower reservoir (both are to be constructed newly) and one-time water of 1.26 TMC will be pumped from existing nearby Shahabad Kuno River to the proposed Shahpur Standalone PSP lower reservoir and used cyclically for energy storage and discharge. As per the communication from Water Resource Department (WRD) of Rajasthan Government, it has been proposed to construct a barrage (i.e., Hanotiya barrage) across Kuno river under Eastern Rajasthan Canal Project (ERCP) and the FRL and top of the barrage are EL 306.00m and EL 308.00m respectively. Considering the FRL of proposed Hanotiya barrage across Kuno river, the location of Shahpur Standalone PSP lower reservoir is kept accordingly.

Secondly, since these two reservoirs are located across few tributaries / nalas of Kuno river and will have some small catchment area which is being the part of total catchment area of proposed Hanotiya Barrage on Kuno river. The intercepted catchment area by the Shahpur

Standalone PSP components including upper and lower reservoirs are worked out to be about 648 Ha and the details are shown in catchment area drawing no. SHAHPUR – PSP – 004. On the outer side of catchment area boundary, it has been proposed to construct artificial drains at various locations which will be connected suitably to the nearby natural drains to ensure the water drains into the natural drains. The required hydrological studies for the intercepted catchment area by the project components including Upper and Lower reservoirs, discharge and design flood in the nalas will be studied in detail during DPR stage.

Annual losses due to evaporation from upper & lower reservoir are 4 MCum & 3.31 MCum respectively. Provision of floating balls/floating solar panels or any other feasible solution which reduces losses shall be considered during the DPR stage so that the same can be reduced and the remaining evaporation losses will be recouped periodically from Shahabad Kuno River by establishing a separate pumping system from existing Kuno river.

The above estimated value of total losses including evaporation losses from the project of 7.31 MCum is tentative only. The same should be verified based on actual evaporation data of project site to be received from IMD station and approved by statutory authorities like CEA / CWC during concurrence process of DPR. In case if there is any revision of the same is mandated by the statutory authorities, necessary changes in the proposal will be made.

2.5 Installed Capacity

The Shahpur Standalone Pumped Storage Project is proposed with rating of 1800 MW and with a storage capacity of 10800 MWH (1800 MW X 6hrs). This Project is comprising of 5 units of 300 MW each and 2 units of 150MW each. The prime mover for all seven generators shall be Reversible Vertical Francis Turbine suitable for bidirectional operation. During the Generator mode of operation, the power shall be generated at 18 kV for 300 MW units and 150 MW units. The generated power will be transmitted through Generator Step-Up Transformer (GSUT) located in transformer room. HT side of generator transformer shall be connected to 400kV Gas insulated switchgear (GIS) located above transformer hall. Auxiliary power required during start-up of plant will be derived from 400kV GIS through Station Transformer (ST) to the medium voltage system (11kV).

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 1800 MW by utilizing a design discharge of 1320.70 Cumec and rated head of 154.73m for larger units and 154.41m for smaller units. The Shahpur Standalone PSP will utilize 1980 MW to pump 1.01TMC of water to the upper reservoir in 6.86 hours.

The Key parameters of Shahpur Standalone PSP are as follows:

Sl. No.	Parameter	Unit	Value
1	Energy Storage Capacity	MWH	10800 (1800 MWx6hrs.)
2	Rating	MW	1800
3	No. of Units	Nos.	7
4	Rated Head in Turbine mode (Larger & Smaller Units)	M	154.73 & 154.41
5	Total Design Discharge	Cumec	1320.70
6	Design Discharge per unit of 300 MW	Cumec	220.04
7	Design Discharge per unit of 150 MW	Cumec	110.25
8	Water Requirement for One-time	TMC / MCum	1.26 / 35.68
9	Water Requirement for re-utilisation	TMC / MCum	1.01/28.60
10	Generation Duration	Hrs	6
11	Turbine Capacity – 5 Units	MW	300
12	Turbine Capacity – 2 Units	MW	150
13	Annual Energy Generation	MU	3744.9
14	Pump Capacity – 5 Units	MW	330
15	Pump Capacity – 2 Units	MW	165
16	Rated Head in Pump mode (Larger & Smaller units)	M	162.56 & 163.21
17	Pumping Duration	Hrs.	6.86
18	Expected Cycle Efficiency	%	80

The volume of water required for turbine mode of operation is equated to the pumped mode. Annual energy generation by Shahpur Standalone PSP in Turbine mode is 3744.9 MU with 95% machine availability.

2.6 Power Evacuation

The 1800 MW power generated at 18 kV will be stepped up to 400 kV. This power will be further evacuated from Pothead yard area through 1 no. of 400kV double circuit transmission line with quad moose conductor (with N-1 contingency). Further these transmission line will be connected to 400/765 kV PGCIL substation at New Shivpuri of Madya Pradesh State. Proposed transmission line will be used for both evacuation of generated power and input of power during pumping mode.

Power evacuation system consists of transmission line, control and relay protection system, metering equipment, Circuit breakers, CT's, PT's, LA's along with its supporting structures and Receiving end equipment including bay extension at the other end, with communication equipment like FOTE/DTPC, 48V DC battery system etc.,

Pumped storage plant will be operated based on quantum of power required as per the PPA commitment.

2.7 Environmental Aspects

Upper and lower reservoir for Shahpur Standalone PSP will be constructed newly and the one-time filling of 1.26 TMC of water for the proposed Shahpur Standalone PSP lower reservoir will be taken up from nearby Shahabad Kuno river. There will be an additional land requirement for creation of the proposed Shahpur Standalone PSP upper and lower reservoirs for the pumped storage project. Also, land will be required for the construction of powerhouse complex and its appurtenant works Viz., Intake structure, Penstocks / Pressure Shafts, powerhouse, Tail Race Pool, Tail Race Tunnel, Tail Race Channel etc. Total land required for the construction of various components are tentatively estimated to about 624.91 Ha including creation of Shahpur Standalone PSP upper and lower reservoir and also land required for other infra item like road, job facilities, muck disposal area etc. The same will be analysed once again after finalization of layout during DPR stage. Based on assessment of environmental impacts, management plans must be formulated for compensatory afforestation and other environmental issues. These issues would be addressed during the investigations for DPR.

2.8 Construction Planning & Schedule

It is proposed to construct the project within a period of 3.0 years for construction work and 6 months for preconstruction work. Hence the total construction period will be 3.5 years.

2.9 Employment generation due to the project

As project is planned to complete in 36 months, at the time of peak construction work in the project, around 3600 persons may be engaged. Out of 3600 nos. the majority of about 2400 nos. will be from the local population/surrounding Villages and balance persons of about 1200 nos. will be skilled /semiskilled from other area. All the local persons will come from their homes only. Only the migrated manpower will stay at site camp.

Then after commissioning of the project, about 300 persons will be required for operations, which might be from local areas or migrated from another area.

2.10 Project Cost Estimate

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 Basic Schedule of Rates of Baran district, Rajasthan (Year 2020) & local prevailing rates are adopted for the items not covered by the SOR wherever quantification has not been possible at the present stage of design, lump sum provisions have been made based on judgment / experience of other projects.

The quantities of Civil Works are estimated based on designs and drawings prepared for various components of the project.

The total project cost works out as given below:

S.NO.	Description of Item	Cost in Crores
1	Cost of Civil & HM Works (with escalation)	5482.25
2	Cost of Power Plant Electro - Mechanical Equipment including Transmission line	3096.20
3	Total Hard Cost	8578.45
4	Interest during Construction & Others	1143.31
5	Total cost of the Project	**9721.76 cr**

2.11 Economic Financial Analysis

The economical evaluation of Shahpur Standalone PSP will be arrived at as per the prevailing guidelines of PSP.

2.12 Conclusions

The Shahpur Standalone PSP is envisaged to be completed in a period of 3.5 years. The project would generate designed energy of 3744.9 MU at 95% plant availability. 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 – 3
PROJECT DESCRIPTION

3.1 SALIENT FEATURES OF THE PROJECT

1		**NAME OF THE PROJECT**	**Shahpur Standalone Pumped Storage Project**
2		**Location**	
	a	Country	India
	b	State	Rajasthan
	c	District	Baran
	d	Tehsil	Shahabad
	e	Village near Power House	Shahpur
3		**Geographical Co-Ordinates**	
	a	**Shahpur Standalone PSP Upper Reservoir- (Now Proposed)**	
		Latitude	25°11'25.21"N
		Longitude	77°10'55.78"E
	b	**Shahpur Standalone PSP Lower Reservoir - (Now Proposed)**	
		Latitude	25°11'40.00"N
		Longitude	77°11'50.00"E
4		**Access To Project Site**	
	a	Airport	Gwalior Airport – 200 kms from project site
	b	Rail head	Baran Railway Station, 77 kms from project site
	c	Road	NH 76
	d	Port	Kandla Port- 980 kms from project site
5		**Project**	
	a	Type	Standalone Pumped Storage Project
	b	Storage Capacity	10800 MWH
	c	Rating	1800 MW

	d	Peak Operation duration	6 Hours
6		**Shahpur Standalone PSP - Upper Reservoir**	
	a	Live Storage	1.01 TMC (28.60 MCM)
	b	Dead Storage	0.20 TMC (5.66 MCM)
	c	Gross Storage	1.21 TMC (34.28 MCM)
7		**Upper Reservoir**	
	a	Full Reservoir level (FRL)	EL + 507.00 m
	b	Min. Draw Down Level (MDDL)	EL + 490.00m
	c	Top Bund Level (TBL)	EL + 510.00 m
	d	Type of Embankment	Asphalt faced Rockfill Embankment
	e	Max. Height of Rockfill Embankment	30 m
	f	Length at the top of Rockfill Embankment	5309 m
	g	Top width of the Rockfill Embankment	10.0 m
	h	Type of Power Block	Gates with Concrete Breast walls
	i	Height of Power Block	37.5 m
	j	Length at the top of Power Block	162.0 m
	k	Top width of the Power Block	10.0 m
8		**Shahpur Standalone PSP - Lower Reservoir**	
	a	Live Storage	1.01 TMC (28.60 MCM)
	b	Dead Storage	0.05 TMC (1.42 MCM)
	c	Gross Storage	1.06 TMC (30.02 MCM)
9		**Lower Reservoir**	
	a	Full Reservoir level (FRL)	EL + 349.00 m
	b	Min. Draw Down Level (MDDL)	EL + 328.00m

	c	Top Bund Level (TBL)	EL + 352.00 m
	d	Type of Dam	Asphalt Faced Rockfill Embankment
	e	Max Height of Embankment	30 m
	f	Length of Embankment	2937 m
10		**Intake Structure**	
	a	Type	Diffuser Type
	b	No. of Vents	3 nos.
	c	Size of Each Intake	24 m (W) x 11.2 m (H) including piers
	d	Length of each Intake	38.98 m (covered with RCC slab at top up to Intake Gate)
	e	Elevation of Intake centre line	EL + 476.30 m
	f	Elevation of Intake bottom	EL + 472.55 m
	g	Design Discharge of each Intake (Turbine mode)	220.04 cumecs for 300MW Unit Intake and 220.50 cumecs for 150MW Unit Intake
	h	Trash rack type	Vertical with inclination of 15°
	i	Size of Trash Rack	3 nos. of 7.50 m (W) x 11.60 m (H) for each unit
	j	Numbers & Size of Intake Service Gate	6 nos. of 6.20 m (W) x 7.50 m (H)
	k	Numbers & Size of Intake Emergency Gate	1 set. – 6.20 m (W) x 7.50 m (H) with Moving Gantry Crane
11		**Head Race Pipe/Pressure Shafts**	
	a	Type	Finished steel lined - circular
	b	Number of Pressure Shaft	Total 6 No. of Independent Head Race Pipe/Pressure Shaft with one pressure shaft bifurcating into two unit pressure shaft
	c	Diameter of Pressure Shaft	7.5 m
	d	Diameter of unit Pressure shaft	5.30 m
	e	Length of Penstock/Pressure Shaft	830 m

			Length of Head Race Pipe from Intake to Vertical Pressure Shaft – 663 m Length of Vertical Pressure Shaft – 72 m Length of Horizontal Pressure Tunnel – 95 m
	f	Length of unit Pressure Shaft -	About 50 m each
	g	Design Discharge of each Penstock / Pressure Shaft	220.04 cumec for 300MW unit and 220.50 cumecs for 150MW units
	h	Design Discharge of each branch unit of Pressure Shaft	110.25 cumec
	i	Velocity in the Head Race Pipe/Pressure Shaft	4.99 m/sec
	j	Maximum velocity in the Unit Pressure Shaft	4.99 m/sec
12		**Powerhouse**	
	a	Type	Surface pit type Powerhouse
	b	Centre line of Unit	EL + 298.00 m
	c	Dimensions (Excluding Service bay)	L 196.166m x B 28.50m x H 61.50 m
	d	Size of Service Bay	40.00 m (L) x 28.50 m (W)
	e	Service bay Level	EL +313.72 m
	f	Size of Unloading Bay	25.00 m (L) X 28.50 m (W)
	g	Unloading Bay Level	EL + 336.70 m
13		**Tail Race Tunnel**	
	a	Type & Shape	Concrete Lined – Circular
	b	Number of Tunnels	7 Nos.
	c	Dia. of Tunnel for 300MW unit	8.50 m
	d	Dia. of Tunnel for 150MW unit	6.20 m
	e	Length of the Tunnel	179 m for 8.5 dia as well as for 6.2 m dia
	f	Design Discharge for 300MW unit in Turbine mode	220.04 Cumec
	g	Design Discharge for 150 MW unit in	110.25 cumec

		Turbine mode	
14		**Tailrace Outlet**	
	a	Type	Diffuser Type
	b	No. of Outlet	7 Nos.
	c	Size of each outlet	For 300 MW Unit - 24.00 m (W) x 12.50 m (H) including piers For 150 MW Unit - 18.00 m (W) x 9.0 m (H) including piers
	d	Length of each Outlet	31.40 m (covered with RCC slab at top up to Intake Gate)
	e	Elevation of outlet centre line	For 300 MW Unit - EL + 315.30 m For 150 MW Unit - EL + 314.15 m
	f	Elevation of Outlet bottom	EL + 311.05 m for 300 MW as well as for 150 MW unit
	g	Trash rack Type	Vertical with inclination of 15°
	h	Size of Trash rack	For 300 MW Unit - 3 sets of 7.0 (W) x 12.94 m (Inclined Height) for each unit For 150 MW Unit - 3 sets of 5.0 (W) x 9.32 m (Inclined Height) for each unit
	i	Tailrace outlet Service Gate	5 nos. of 6.00 m (W) x 8.50 m (H) 2 nos. of 4.20 m (W) x 6.20 (H)
	j	Tail Race outlet Emergency Gate	5 nos. of 6.00 m (W) x 8.50 m (H) and 2 nos. of 4.20 m (W) x 6.20 m (H)
15		**Tail Race Channel**	
	a	Type & Shape	Trapezoidal shape with concrete lined
	b	Length of channel	717m
	c	Bed width	140m
	d	Full supply depth	6.8m
	e	Bed slope	1 in 6400
16		**Electro Mechanical Equipment**	
	a	Pump Turbine	Francis type, vertical shaft reversible pump-turbine
	b	Total No of units	5 nos. (5 X 300MW) + 2 nos. (2 X 150MW)

	c	Total Design Discharge (Turbine Mode)	1320.70 cumec (5 x 220.04 cumec + 2 x 110.25 cumec)
	d	Rated Head in Turbine mode	154.73 m for 300 MW unit and 154.41 m for 150 MW unit
	I	**300MW Turbines**	
	a	Total No. of units	5 Units (All Fixed speed)
	b	Turbine Design Discharge	220.04 cumec
	c	Pump Capacity	330 MW
	d	Rated Pumping Head	162.56 m
	e	Rated Pump Discharge	190.96 Cumec
	f	Synchronous speed	187.50 RPM
	II	**150 MW Turbines**	
	a	Total No. of units	2 Units (All Fixed Speed)
	b	Turbine Design Discharge	110.25 cumec
	c	Pump Capacity	165 MW
	d	Rated Pumping Head	163.21 m
	e	Rated Pump Discharge	95.10 cumec
	f	Synchronous Speed	250 rpm
	III	**Generator-Motor**	
	a	Type	Three (3) phase, alternating current synchronous generator motor semi umbrella type with vertical shaft
	b	Number of units	5 Units (5 x 300 MW) and 2 Units (2x150 MW)
	c	Rated Capacity	Generator – 300 MW & 150 MW Pump Input – 330 MW & 165 MW
	d	Rated Voltage	18.0 KV
	IV	**Main Power Transformer**	

	a	Type	Indoor Single-Phase Power transformers with ON Load tap changer (OLTC)
	b	Number of units	3 nos. X 1 Ph transformers per unit for 300 MW Units + 1 Spare limb = 16 nos. 6 nos. X 1 Ph transformers per unit for 150 MW Units + 1 Spare limb = 7 nos. Total : 23 Nos.
	c	Rated Capacity of each unit	Single Phase, 18 kV/400kV, 123 MVA – 16 Nos. (15 Nos. working + 1 No. spare) for 300 MW Units and Single Phase, 18 kV/400kV, 62 MVA – 7 Nos. (6 Nos. working + 1 N. Spare) for 150 MW Units.
	d	Rated Voltage	Primary – 18.0 kV; Secondary - 400 kV adjustable range of the secondary voltage: -10% to +10% in steps of 1.25%
17		**400 KV Gas Insulated Switchgear**	
	a	Type of GIS	Indoor Type
	b	No. of GIS units	1 No.
	c	Location	Inside GIS building above ground
	d	Scheme	Double Busbar Arrangement with bus Coupler and Sectionalizer.
18		**POWER EVACUATION**	
	a	Voltage Level (KV)	400 KV
	b	No. of Transmission Lines	One no. 400 kV double circuit transmission line
		Conductor	Quad Moose
	c	Total Length	One 400 kV Double Circuit Transmission Line of length **75 km (approx.)** from PSP will be connected to 400/765 kV PGCIL substation at New Shivpuri of Madya Pradesh State for evacuation of stored power during generating mode and for supply of power during pumping mode.

3.2 HYDROLOGY & POWER POTENTIAL STUDIES

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 Standalone PSP is proposed between two reservoirs i.e., Shahpur Standalone PSP upper and lower reservoirs (both are to be constructed newly) and one-time requirement of 1.26 TMC of water will be pumped from existing nearby Shahabad Kuno River to the proposed Shahpur Standalone PSP lower reservoir and used cyclically for energy storage and discharge. As per the communication from Water Resource Department (WRD) of Rajasthan Government, it has been proposed to construct a barrage (i.e., Hanotiya barrage) across Kuno river under Eastern Rajasthan Canal Project (ERCP) and the FRL and top of the barrage are EL 306.00m and EL 308.00m respectively. Considering the FRL of proposed Hanotiya barrage across Kuno river, the location of Shahpur Standalone PSP lower reservoir is kept accordingly.

Since these two reservoirs are located across few tributaries / nalas of Kuno river and will have some small catchment area which is being the part of total catchment area of proposed Hanotiya Barrage on Kuno river. The intercepted catchment area by the Shahpur Standalone PSP components including upper and lower reservoirs are worked out to be about 648 Ha and the details are shown in catchment area drawing no. SHAHPUR – PSP – 004. On the outer side of catchment area boundary, it has been proposed to construct artificial drains at various locations which will be connected suitably to the nearby natural drains to ensure the water drains into the natural drains. The required hydrological studies for the intercepted catchment area by the project components including Upper and Lower reservoirs, discharge and design flood in the nalas will be studied in detail during DPR stage.

Annual losses due to evaporation from upper & lower reservoir are 4 MCum & 3.31 MCum respectively. Provision of floating balls/floating solar panels or any other feasible solution which reduces losses shall be considered during the DPR stage so that the same can be reduced and the remaining evaporation losses will be recouped periodically from Shahabad Kuno River by establishing a separate pumping system from existing Kuno river.

The above estimated value of total losses including evaporation losses from the project of 7.31 MCum is tentative only. The same should be verified based on actual evaporation data of project site to be received from IMD station and approved by statutory authorities like

CEA / CWC during concurrence process of DPR. In case if there is any revision of the same is mandated by the statutory authorities, necessary changes in the proposal will be made.

The Shahpur Standalone PSP is proposed to utilize the water available in the existing Shahabad Kuno River located near Shahpur Village in Baran district. The two upper and lower reservoirs are formed to have a live storage capacity of 1.01 TMC each. The upper and lower reservoir comprises of max. of 30m and 30m high rockfill embankment respectively with Asphalt Faced for short reach and the average height of embankment for both upper and lower reservoirs are 24.5 m & 26.5m respectively. An RCC Concrete Structure is proposed in upper reservoir with power block of 162m long comprising of Six power intake structure and Six independent steel lined pressure shafts 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 pool and Tail Race Channel.

Since the proposed scheme is a pumped storage scheme and envisages to utilize 1.01 TMC of water and no modification in the operating levels are needed. Moreover, only recycling of water between these two reservoirs are proposed for Shahpur Standalone PSP operation.

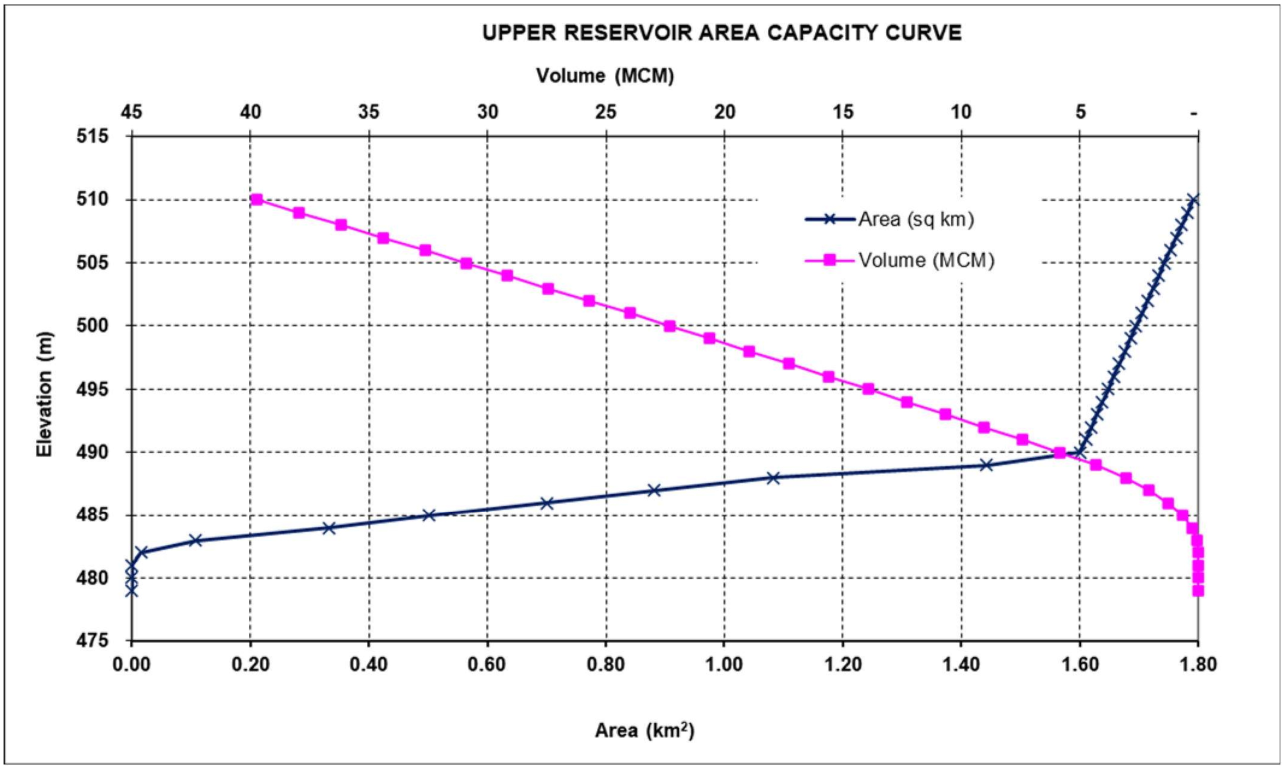
The Key parameters of proposed Shahpur Standalone PSP Upper Reservoir are as follows:

Sl. No.	Parameter	Unit	Value
1	Full Reservoir Level (FRL)	M	EL + 507.00
2	Minimum Draw Down Level (MDDL)	M	EL + 490.00
3	Live Storage	TMC	1.01
4	Dead Storage	TMC	0.20
5	Gross Storage	TMC	1.21
6	Maximum Height of Rockfill Embankment	M	30
7	Average Height of Rock Fill Embankment	M	24.5

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

UPPER RESERVOIR CAPACITY CALCULATION						
EL (m)	**Area (sq.m)**	**Area (Ha.)**	**Area (sq km)**	**Volume bet. EL (cum)**	**Cumulative volume (cum)**	**Volume (MCM)**
479.00		-	-	-	-	-
480.00		-	-	-	-	-
481.00	112.29	0.01	0.00	37.43	37.43	0.00
482.00	14872.85	1.49	0.01	5425.81	5463.24	0.01
483.00	107730.10	10.77	0.11	54210.37	59673.61	0.06
484.00	332984.95	33.30	0.33	210038.48	269712.09	0.27
485.00	500812.45	50.08	0.50	414054.56	683766.64	0.68
486.00	699684.74	69.97	0.70	597484.10	1281250.74	1.28
487.00	880470.61	88.05	0.88	788348.36	2069599.09	2.07
488.00	1081460.91	108.15	1.08	979245.37	3048844.46	3.05
489.00	1442855.49	144.29	1.44	1257824.28	4306668.74	4.31
490.00	1600402.43	160.04	1.60	1520948.83	5827617.58	5.83
491.00	1609749.15	160.97	1.61	1605073.52	7432691.10	7.43
492.00	1619116.22	161.91	1.62	1614430.42	9047121.52	9.05
493.00	1628503.66	162.85	1.63	1623807.68	10670929.20	10.67
494.00	1637911.44	163.79	1.64	1633205.29	12304134.49	12.30
495.00	1647339.59	164.73	1.65	1642623.26	13946757.75	13.95
496.00	1656788.09	165.68	1.66	1652061.59	15598819.34	15.60
497.00	1666256.96	166.63	1.67	1661520.28	17260339.62	17.26
498.00	1675746.17	167.57	1.68	1670999.32	18931338.94	18.93
499.00	1685255.75	168.53	1.69	1680498.72	20611837.66	20.61
500.00	1694785.69	169.48	1.69	1690018.48	22301856.14	22.30
501.00	1704335.98	170.43	1.70	1699558.59	24001414.73	24.00
502.00	1713906.63	171.39	1.71	1709119.07	25710533.80	25.71
503.00	1723497.63	172.35	1.72	1718699.90	27429233.70	27.43
504.00	1733109.00	173.31	1.73	1728301.09	29157534.78	29.16
505.00	1742740.72	174.27	1.74	1737922.63	30895457.42	30.90
506.00	1752392.80	175.24	1.75	1747564.54	32643021.95	32.64
507.00	1762065.23	176.21	1.76	1757226.80	34400248.75	34.40
508.00	1771758.03	177.18	1.77	1766909.41	36167158.16	36.17
509.00	1781471.18	178.15	1.78	1776612.39	37943770.55	37.94
510.00	1791204.69	179.12	1.79	1786335.72	39730106.28	39.73

The area capacity curve for the proposed upper reservoir is given below



The Key parameters of the proposed Shahpur Standalone PSP lower reservoir are as follows:

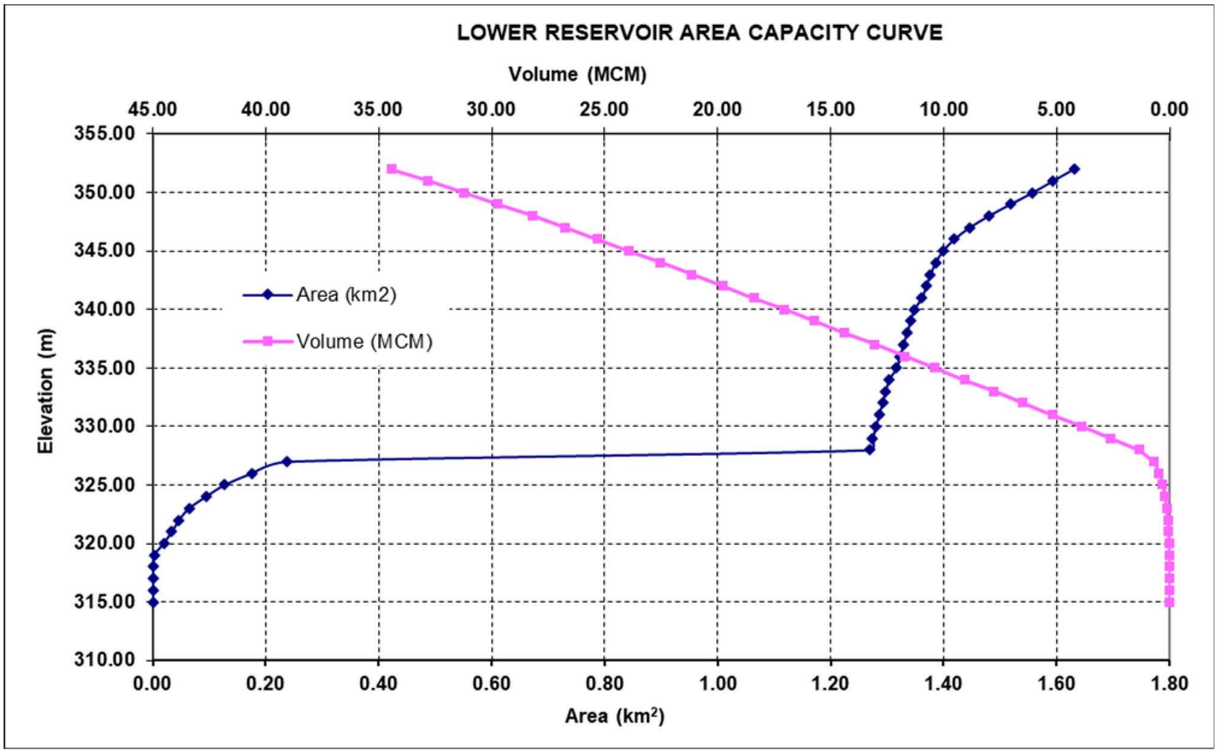
Sl. No.	Parameter	Unit	Value
1	Full Reservoir Level (FRL)	M	EL + 349.00
2	Minimum Draw Down Level (MDDL)	M	EL + 328.00
3	Live Storage	TMC	1.01
4	Dead Storage	TMC	0.05
5	Gross Storage	TMC	1.06
6	Maximum Height of Rockfill Embankment	M	30
7	Average Height of Rock Fill Embankment	M	26.5

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

LOWER RESERVOIR CAPACITY CALCULATION						
EL (m)	**Area (sq.m)**	**Area (Ha.)**	**Area (km2)**	**Volume bet. EL (cum)**	**Cumulative volume (cum)**	**Volume (MCM)**
315.00	0.00	0.00	0.00	0.00	0.00	0.00
316.00	0.00	0.00	0.00	0.00	0.00	0.00
317.00	0.00	0.00	0.00	0.00	0.00	0.00
318.00	525.28	0.05	0.00	175.09	175.09	0.00
319.00	2274.63	0.23	0.00	1297.66	1472.76	0.00
320.00	19131.38	1.91	0.02	9334.25	10807.00	0.01
321.00	33880.06	3.39	0.03	26156.89	36963.89	0.04
322.00	46490.00	4.65	0.05	40019.13	76983.02	0.08
323.00	63940.88	6.39	0.06	54984.18	131967.20	0.13
324.00	93608.66	9.36	0.09	78305.01	210272.21	0.21
325.00	126726.00	12.67	0.13	109750.15	320022.37	0.32
326.00	175288.11	17.53	0.18	150352.09	470374.45	0.47
327.00	238170.23	23.82	0.24	205927.54	676301.99	0.68
328.00	1269707.77	126.97	1.27	685931.03	1362233.01	1.36
329.00	1274321.39	127.43	1.27	1272013.88	2634246.90	2.63
330.00	1279968.61	128.00	1.28	1277143.96	3911390.86	3.91
331.00	1285705.49	128.57	1.29	1282835.98	5194226.84	5.19
332.00	1291544.07	129.15	1.29	1288623.68	6482850.52	6.48
333.00	1297438.34	129.74	1.30	1294490.09	7777340.60	7.78
334.00	1303361.69	130.34	1.30	1300398.89	9077739.49	9.08
335.00	1316671.94	131.67	1.32	1310011.18	10387750.67	10.39
336.00	1322665.63	132.27	1.32	1319667.65	11707418.32	11.71
337.00	1328728.46	132.87	1.33	1325695.89	13033114.21	13.03
338.00	1334939.72	133.49	1.33	1331832.88	14364947.10	14.36
339.00	1341336.17	134.13	1.34	1338136.67	15703083.77	15.70
340.00	1347746.14	134.77	1.35	1344539.88	17047623.65	17.05
341.00	1361619.93	136.16	1.36	1354677.11	18402300.76	18.40
342.00	1368793.69	136.88	1.37	1365205.24	19767506.00	19.77
343.00	1376595.83	137.66	1.38	1372692.91	21140198.92	21.14
344.00	1385524.53	138.55	1.39	1381057.77	22521256.69	22.52
345.00	1398692.17	139.87	1.40	1392103.16	23913359.85	23.91
346.00	1418653.61	141.87	1.42	1408661.10	25322020.95	25.32
347.00	1445811.67	144.58	1.45	1432211.18	26754232.14	26.75
348.00	1480289.71	148.03	1.48	1463016.83	28217248.97	28.22
349.00	1518787.60	151.88	1.52	1499497.47	29716746.44	29.72
350.00	1557889.27	155.79	1.56	1538297.02	31255043.46	31.26
351.00	1594045.28	159.40	1.59	1575932.71	32830976.18	32.83

352.00	1630965.32	163.10	1.63	1612470.08	34443446.25	34.44

The area capacity curve for the proposed lower reservoir is given below



3.2.1 Discharge Series

Based on the storage capacity of the proposed upper and lower reservoir, power potential study was carried out to assess the installed capacity. The Shahpur Standalone PSP is envisaged to utilize 1.01 TMC of water for power generation which will be pumped from the nearby existing Shahabad Kuno River to the proposed Shahpur Standalone PSP lower reservoir. The project is a pumped storage scheme and hence, no consumptive utilization of water is required for its operation.

3.2.2 Operation of Shahpur Standalone Pumped Storage Project

The Shahpur Standalone PSP is proposed with a Storage Capacity of 10800 MWH with Rating of 1800 MW. This project is comprising of 5 units of 300 MW each and 2 units of 150MW each. The Project will generate 1800 MW by utilizing a design discharge of 1320.70 Cumec and rated head of 154.73m for larger units & 154.41m for smaller units. The Shahpur Standalone PSP will utilize 1980 MW to pump 1.01 TMC of water to the upper reservoir in 6.86 hours.

The Key parameters of Pumped Storage Operation are as follows:

Sl. No.	Parameter	Unit	Value
1	Energy Storage Capacity	MWH	10800 (1800 MW x 6hrs.)
2	Rating	MW	1800
3	No. of Units	Nos.	7
4	Rated Head in Turbine mode (Larger & Smaller Units)	m	154.73 & 154.41
5	Total Design Discharge	Cumec	1320.70
6	Design Discharge per unit of 300 MW	Cumec	220.04
7	Design Discharge per unit of 150 MW	Cumec	110.25
8	Water Requirement for One-time	TMC / MCum	1.26 / 35.68
9	Water Requirement for re-utilisation	TMC / MCum	1.01/ 28.60
10	Generation Duration	Hrs	6
11	Turbine Capacity – 5 Units	MW	300
12	Turbine Capacity – 2 Units	MW	150
13	Annual Energy Generation	MU	3744.9
14	Pump Capacity – 5 Units	MW	330
15	Pump Capacity – 2 Units	MW	165
16	Rated Head in Pump mode (Larger & Smaller Units)	m	162.56 & 163.21
17	Pumping Duration	Hrs.	6.86
18	Expected Cycle Efficiency	%	80

The volume of water required for turbine mode of operation is equated to the pumped mode. Annual energy generation by Shahpur Standalone PSP in Turbine mode is 3744.9 MU with 95% machine availability.

3.2.3 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 Shahpur Standalone PSP upper reservoir is at EL+507.00 and MDDL is at EL+490.00m. Full reservoir level of Shahpur standalone PSP lower reservoir is at EL+349.00m and MDDL is at EL+328.00m. The total head loss in the system is arrived as 4.6m for larger units & 4.92m for smaller units. Thus, the rated head of 154.73 m for larger units & 154.41m for smaller units are considered for the proposed project. The normal tail water level is the level at the tail race outlet corresponds to design discharge flow of 1320.70 Cumec passing through the turbine considering all machines running at full plant load. Normal tail water level corresponding to above design discharge is EL +328.00 m . The bed level of the tail race Channel is kept at EL +322.20 m.

3.3 DESIGN FEATURES OF MAJOR COMPONENTS

3.3.1 Introduction

The Shahpur Standalone Pumped Storage Project envisages construction of upper and lower reservoirs near village Shahpur in Baran District.

The scheme will involve construction of rock fill embankment of average height of around 24.5 m with the maximum height of 30m for short reach for creation of Shahpur Standalone PSP upper reservoir of 1.21 TMC gross capacity. Similarly, this project envisages construction of rock fill embankment of average height of around 26.5m with the maximum height of 30m for short reach for creation of lower reservoir of 1.06 TMC gross capacity. The Shahpur Standalone PSP is proposed in between two reservoirs i.e., Shahpur Standalone PSP Upper reservoir (to be constructed newly) & Shahpur Standalone PSP Lower reservoir (to be constructed newly) and one-time water of 1.26 TMC will be pumped from the existing nearby Shahabad Kuno River to the proposed Shahpur Standalone PSP lower reservoir.

Water will be let out from the Shahpur Standalone PSP upper reservoir through Power Intake and Penstock/Pressure shaft of 830 m long to feed the Shahpur Standalone PSP, having a Storage Capacity of 10800 MWH with Rating of 1800 MW. This project is comprising 5 units of 300 MW each and 2 units of 150MW. The water after power generation will be conveyed through a 717 m long Tail Race Channel to discharge water into Lower reservoir. The total design discharge for the proposed scheme is 1320.7 Cumec with the rated head of 154.73m for larger units and 154.41m for smaller units. General Layout of the proposed scheme is enclosed in the drawing no. SHAHPUR-PSP-002.

3.3.2 Alternate Studies

The following parameters were kept in mind during the optimization study.

- Topography & Geology
- Accessibility
- Availability of water & its distance for initial filling of lower reservoir

- To meet the minimum storage requirement for 6.0 hours of generation.
- Installed Capacity
- Length & Height of Upper and Lower Reservoir Embankment
- Length of Water Conductor System
- Natural Head between two reservoirs
- L/H Ratio for Water Conductor system
- Type of Powerhouse (surface/ Underground)
- Type of Land (Forest/Non- Forest)

Considering the above points, desk study/reconnaissance survey is carried out based on the SOI toposheets and contours generated from SRTM data. Total three project layout alternatives have been studied and their details are given in the subsequent sections. All the three project layouts are marked on contours generated from SRTM data and toposheets (54G/3 & 54G/4) and are shown in Figure 1 & Figure 2 respectively.

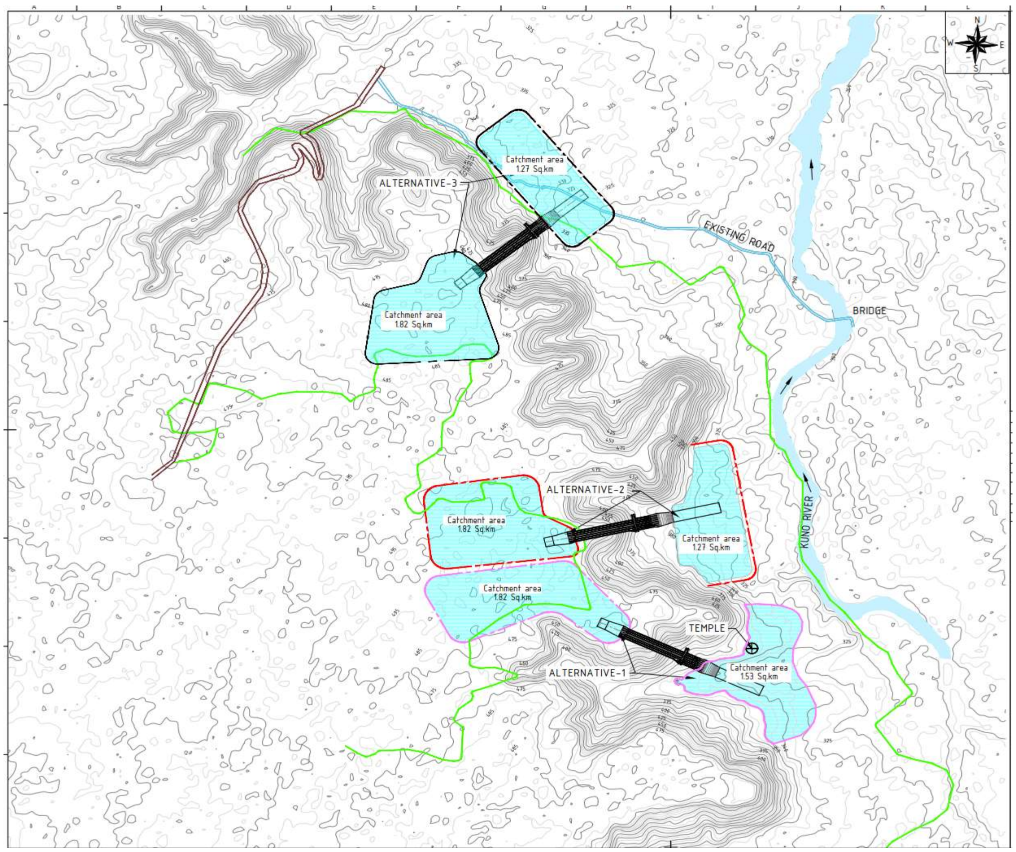


Figure 1: Project Layout Alternatives on the contour plan generated from SRTM data.

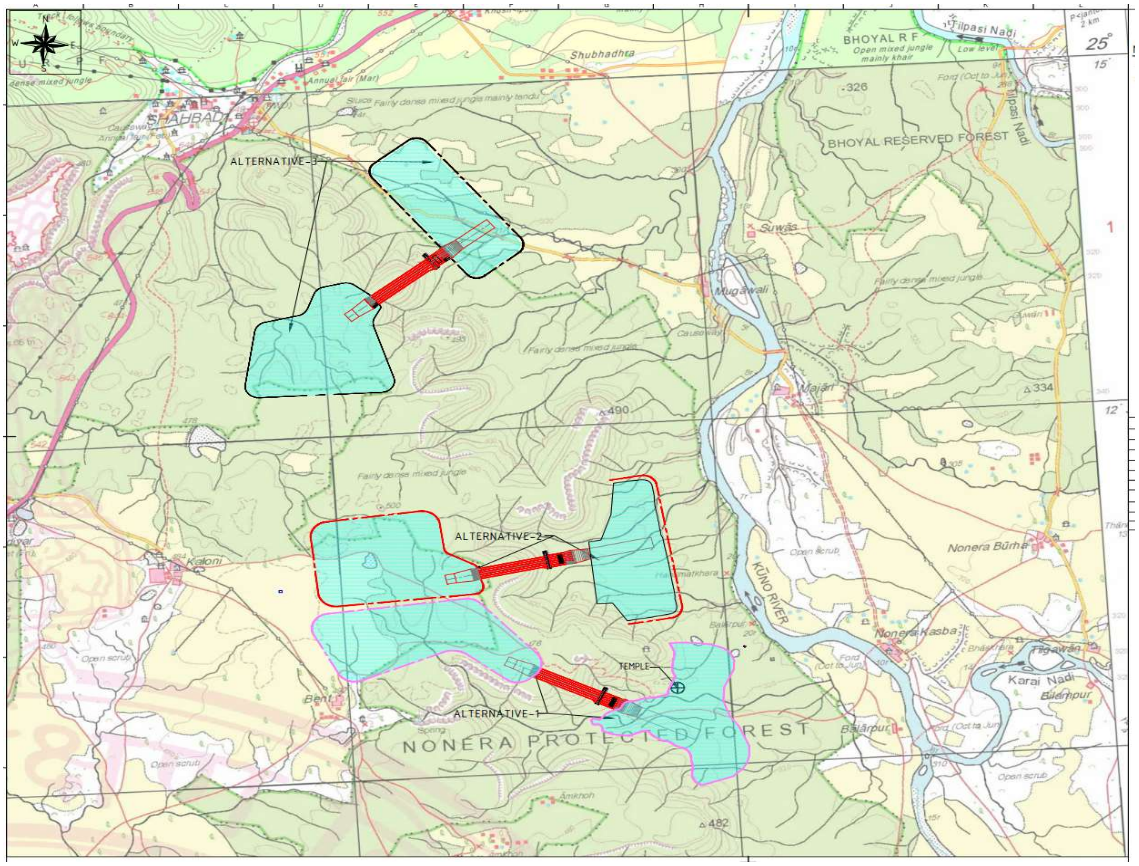


Figure 2: Project Layout Alternatives on Toposheets (54G/3 & 54G/4).

Geology of Alternative Reservoir Locations

All the Alternate reservoir layouts have similar geological setup. The geology is represented by >40m thick bed of sandstone underlain by shale with intermediate thin beds of sandstone/ siltstone. The Upper Reservoirs rests over the sandstone and the Lower Reservoirs over the shale.

Topographically, the area in general, from Upper Reservoir to Lower Reservoir represents the vertical cut face of sandstone for about 20-25m height followed by slumped rock blocks dominating slopes having dislodged rock blocks of mostly sandstone having slope angles of >45°. Immediately after the moderate to steep slopes of the slumped rock blocks, moderate overburden slopes consisting of rock blocks of sandstone and shale in sandy and silty matrix having slope angle of about 30° is evident which finally merges to the flat horizontal slopes comprising rounded to sub-rounded boulders mixed with angular rock blocks. The slopes towards the Kuno River represent vertical cut sections of thick shale with thin intermediate sandstone/ siltstone bands. The plateau area where the Upper Reservoir is proposed is having an elevation of about El >480m and that of the Lower Reservoir the general elevations are about El >320m in most of the reaches.

Alternative 1

The reservoirs of Alternative-1 are in the southernmost part of the explored region at around 5 kms from NH

76. The upper reservoir is envisaged on top of the plateau and the lower reservoir is identified in the bottom within the alluvial plains.

The average elevation of the plateau where the Upper reservoir is proposed is about 485.0m and gradually declines towards the SE boundaries and reaches to elevation El 480.0m. Thus, the average embankment height in the southern part becomes relatively higher and reaches to about 31m. The length of the Upper reservoir embankment in this alternative is 6384m. The proposed area occupies partially forest and mainly private lands.

The proposed Lower reservoir for this alternative in the alluvial plains having elevation variance from El 350.0m to El 325.0m. With the catchment area of 1.53 Km2 the maximum height of the embankment reaches upto 26.5m. The proposed reservoir is completely located in forest area. A major Nallah flows in this alignment which will require diversion. Also, a local temple will be submerged if the lower reservoir is constructed at this location and will invite local issues.

The structures envisaged according to these proposed reservoirs are Upper embankment and upper intake, surface steel head race pipe, vertical pressure shaft, horizontal pressure tunnel, surface pit type powerhouse, tail race tunnel and lower embankment and lower intake (Figure 3).

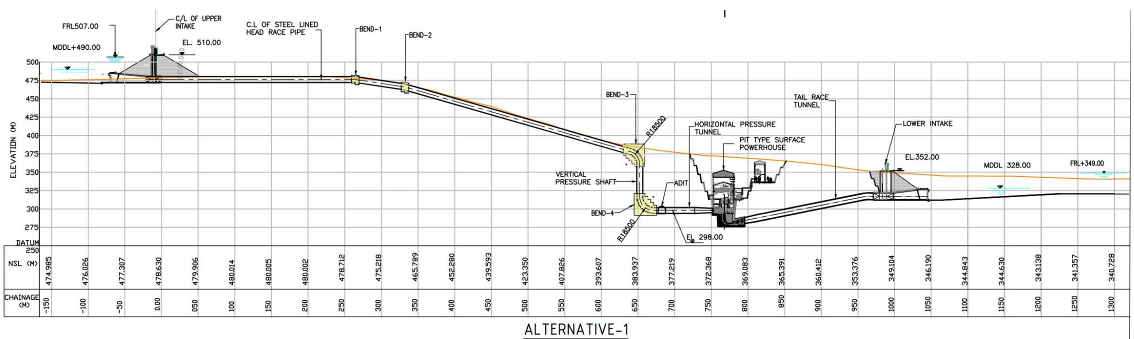


Figure 3: L-section along water conductor system for proposed Alternative-1.

Alternative 2

This alternative is envisaged just north of Alternative-1 with Upper reservoir located at around 3.5 kms from NH 76. The Upper reservoir of this proposal shares the southern boundary with the Upper reservoir of Alternative- 1. The upper reservoir is envisaged on top of the plateau and the lower reservoir is identified in the bottom within the alluvial plains.

The elevation of the plateau where the Upper reservoir is proposed varies from El 485.0m to El 495.0m with the higher elevations on the northern and western parts of the embankment. However, the change in elevations is very gradual and uniform all along the proposed reservoir boundary. Thus, the average embankment height reaches upto 24.5m. The length of the Upper reservoir embankment in this alternative is 5450m. The proposed area occupies partially forest and mainly private lands.

The proposed Lower reservoir for this alternative in the alluvial plains having elevation variance from El

350.0m to El 320.0m. With the catchment area of 1.27 km2 the maximum height of the embankment reaches upto 26.5m. No major perennial drainage exists in the proposed reservoir area. The proposed reservoir is completely located in forest area.

The structures envisaged according to these proposed reservoirs are Upper embankment and upper intake, surface steel head race pipe, vertical pressure shaft, horizontal pressure tunnel, surface pit type powerhouse, tail race tunnel and lower embankment and lower intake (Figure 4).

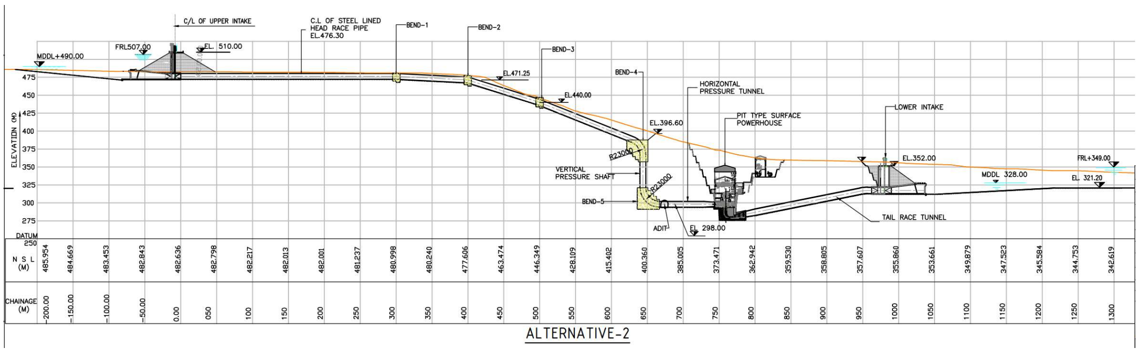


Figure 4: L-section along water conductor system for proposed Alternative-2.

Alternative 3

This alternative is envisaged about 1.7 km north of Alternative-2 near to the NH76 which is about 700m to 900m from Upper reservoir and Lower reservoir, respectively. Similar to the other alternatives, the upper reservoir is envisaged on top of the plateau and the lower reservoir is identified in the bottom within the alluvial plains.

The elevation of the plateau where the Upper reservoir is proposed varies from elevation El 480m to El 485m in most of its area. The average embankment height reaches to about 30m. The length of the Upper reservoir embankment in this alternative is 5453m. The proposed area is mostly in the forest land and very few in private lands.

The envisaged Lower reservoir for this alternative in the alluvial plains having elevation variance from El 350.0m to El 325.0m. With the catchment area of 1.27 Km2 the maximum height of the embankment reaches upto 28m. The area for lower reservoir is mostly in the private land. The State Road of about 2km connecting the NH76 comes under submergence alongwith few village habitations along the roads. The rehabilitation of the nearby villages and the realignment of the State Road are mandatory to construct this reservoir.

The structures envisaged according to these proposed reservoirs are Upper embankment and upper intake, surface steel head race pipe, vertical pressure shaft, horizontal pressure tunnel, surface pit type powerhouse, tail race tunnel and lower embankment and lower intake (Figure 5).

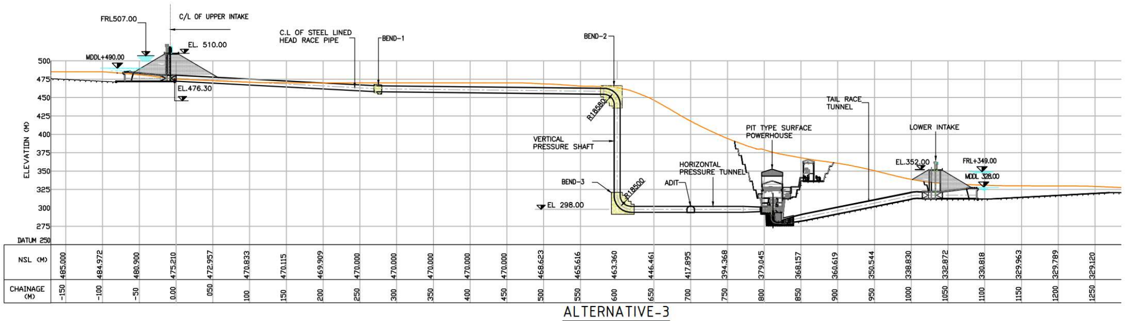


Figure 5: L-section along water conductor system for proposed Alternative-3.

The comparison of parameters for all the three alternative reservoir locations are given below in Table 1.

Table 1: Comparison of parameters of Reservoir Alternatives

#	Parameter	Unit	Alternative 1	Alternative 2	Alternative 3
1	Storage Capacity	MWh	10,800	10,800	10,800
2	Installed Capacity	MW	1800	1800	1800
3	FRL of Upper Reservoir	m	507	507	507
4	MDDL of Upper Reservoir	m	490	490	490
5	FRL of Lower Reservoir	m	349	349	349
6	MDDL of Lower Reservoir	m	328	328	328
7	Plan Area of Upper Reservoir at FRL	Sq km	1.762	1.762	1.762
8	Plan Area of Upper Reservoir at MDDL	Sq km	1.602	1.602	1.602
9	Plan Area of Lower Reservoir at FRL	Sq km	1.519	1.519	1.519
10	Plan Area of Lower Reservoir at MDDL	Sq km	1.269	1.269	1.269
11	Available Live Storage in Upper Reservoir	TMC	1.01	1.01	1.01
12	Available Live Storage in Upper Reservoir	TMC	1.00	1.00	1.00
13	Length of Upper Reservoir Embankment	m	6384	5450	5453
14	Length of Lower Reservoir Embankment	m	2901	2937	5177
15	Average Height of Upper Reservoir Embankment	m	31.0	24.5	30.0
16	Maximum Height of Lower Reservoir Embankment	m	26.5	26.5	28.0
17	Length of Water Conductor System	m	1083.4	1083.4	1194.3
18	L/H Ratio of Water Conductor System	m	7.0	7.0	7.7

19	Type of Land in Upper Reservoir		Partially Forest	Partially Forest	Mostly Forest
20	Natural Head between Reservoirs	m	154.73	154.73	154.73
21	Type of powerhouse (Surface/ Underground)		Surface	Surface	Surface
22	Type of Land in Lower Reservoir		Entirely Forest Land	Entirely Forest Land	Mostly Private Land
23	Social Issues		Requires Relocation of Hindu Temple	-	Requires diversion of the State road and rehabilitation of village.
24	Diversion of Nallah		Requires Diversion of Nallah	Presence of minor Nallah. Diversion not required.	No Nalla along the Alignment
25	Length of Water Conductor for Initial Filling	m	450	500	2382

Conclusions

Based on the above studies carried out for various locations of reservoirs, the following has been concluded.

- The approach for all the studied reservoirs would be through the available road network (National Highway & State Road) with additional construction road to the reservoir locations for reasonable lengths.
- Topographically, the availability of the desired elevation with desired lengths are also not constraints for the selected reservoir locations. The Kuno river is also available for the initial filling at an reasonable distance, except that for the Alternative-3 with a required water conductor length of about 2.3km.
- Geological conditions will remain same for all the three alternatives with Upper reservoir resting on Sandstone and the Lower reservoir on Shale with intermittent bands of siltstone/ sandstone.
- For the development of Lower reservoirs complete forest land is available for Alternative-1 and Alternative-2, whereas, for Alternative-3, private land with village habitation and state road are coming in submergence which would lead to diversion of state road and village rehabilitation. Similarly, for the Upper reservoir, partial forest land is involved in Alternative-1 and Alternative-2, whereas mostly forest land is involved in Alternative-3. Social issue of relocation of existing Temple is involved in Lower reservoir of Alternative-2.
- Regarding the length of embankments, the Upper Reservoir embankment of all the 3 alternatives is reasonably same, whereas, for the Lower Reservoirs, the length of the embankment for Alternative-3 is almost double than the other alternatives.

- The envisaged civil components are mostly same consisting of Upper embankment and upper intake, surface steel head race pipe, vertical pressure shaft, horizontal pressure tunnel, surface pit type powerhouse, tail race tunnel and lower embankment and lower intake. The lengths of water conductor are varied with pit type surface powerhouse.

Based on above, the Alternative-2 has been selected.

3.3.3 Key Parameters of Upper and Lower Reservoirs

The Key parameters of the proposed Shahpur Standalone PSP Upper Reservoir are as follows:

Sl. No.	Parameter	Unit	Value
1	Top of Bund	M	EL +510.00
2	Full Reservoir Level (FRL)	M	EL +507.00
3	Minimum Draw Down Level (MDDL)	M	EL +490.00
4	Live Storage	TMC	1.01
5	Dead Storage	TMC	0.20
6	Gross Storage	TMC	1.21
7	Deepest Foundation Level (m)	M	EL +480.00
8	Maximum Height of Rockfill Embankment	M	30

The Key parameters of the Proposed Shahpur Standalone PSP Lower Reservoir are as follows:

Sl. No.	Parameter	Unit	Value
1	Top of Bund	M	EL +352.00
2	Full Reservoir Level (FRL)	M	EL +349.00
3	Minimum Draw Down Level (MDDL)	M	EL +328.00
4	Live Storage	TMC	1.01
5	Dead Storage	TMC	0.05
6	Gross Storage	TMC	1.06
7	Lowest Foundation Level (m)	M	EL +318.00
8	Maximum Height of Rockfill Embankment	M	30

3.3.4 RCC Intake Structure

The intake structure of Shahpur Standalone PSP is proposed with Diffuser type and will be constructed in the Upper reservoir. Generally, for normal hydroelectric projects, the bell mouth entrance is ideal for generation (turbine) mode when water enters. In this case there is a minimal loss as water accelerates through the bell-mouth and into the penstock. But in pumped storage project, this design may not be suitable for pumped storage operation as when in pumping mode water flows in the opposite direction through the bell-mouth transition. Water discharging from the penstock will not follow the bell-mouth and will continue as a column of water with minimum divergence.

Therefore, it is proposed to have long and gradual diffuser section at a shallow angle so that the discharging pump mode flow can be maintained with an even velocity distribution and decelerate with minimal losses prior to reaching the Intake.

Six separate intakes are provided to feed the steel lined Penstock/ pressure shaft independently. It is proposed to have independent trash rack in front of each intake structure which will be installed in slanting position with the slope of 15° with vertical. The hydraulic design of trash rack opening is done considering the velocity of flow through the trash rack which will be limited to 1.0 m/sec without clogging.

Submergence of Intake shall be checked for a discharge corresponding to design discharge to prevent vortex formation and entry of air into the system as per IS: 9761 and accordingly the MDDL and center line of intake is kept at EL+490.00m and EL +476.30 m respectively.

3.3.5 Penstock / Pressure Shaft

Water under pressure is conveyed to the turbines through steel lined penstock/Pressure shaft. The steel liner is proposed in view of the high strength and flexibility required under different operational modes of the machine.

A 7.50 m diameter circular Penstock / Pressure shaft takes off from Power Intake to feed the units of Powerhouse. Six nos. of Penstock / Pressure shaft each of 7.50 m diameter will lead water from intake for a length of 830 m up to the powerhouse location. Out of 6 nos. of Penstock / Pressure Shaft, 5 nos. of Penstock / Pressure Shaft each of 7.50 m diameter will feed 5 units of 300 MW and 1 no. of Penstock / Pressure Shaft will get bifurcated in to2 units each of 5.30m dia. to feed 2 units of 150 MW each. 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 length of 5 nos. of Penstock / Pressure shaft of 7.50m dia. is 830m each consists of Steel Lined-Circular 663m long surface type Penstock and 72m long Vertical Pressure Shaft followed by 95m long Horizontal Pressure shaft to feed 5 units of 300 MW. Similarly, the length of 1 no. of Penstock / Pressure Shaft of 7.50m dia. is 830m consists of Steel Lined-Circular 663m long surface type penstock and 72m long Vertical Pressure Shaft followed by 95m long Horizontal Pressure shaft up to bifurcation point which will get bifurcated in to 2nos. near power house each of 50m long and 5.30m dia. to feed 2 units of 150 MW. The steel lined pressure shaft will be backfilled with concrete. Flow from each of these pressure shafts to turbines shall be controlled by a butterfly valve (MIV) in the powerhouse. Economical dia. of the pressure shaft has been worked out by cost optimization studies for various diameters.

Accordingly, a diameter of 7.50m has been adopted to carry the design discharge of 220.04Cumec for each unit of 300MW capacity and a diameter of 5.30m has been adopted to carry the design discharge of 110.25 Cumec for branch units of 150 MW capacity.

3.3.6 Powerhouse

It has been proposed to have powerhouse and all associated components on the surface. As the proposed powerhouse 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 154.73m for larger units and 154.41m for smaller units. The Pumped storage plant comprises of 7 units.

The Key parameters of Storage Operation are as follows:

Sl. No.	Parameter	Unit	Value
1	Energy Storage Capacity	MWH	10800 (1800 MW x 6hrs.)
2	Rating	MW	1800
3	No. of Units	Nos.	7
4	Rated Head in Turbine mode (Larger & Smaller Units)	m	154.73 & 154.41
5	Total Design Discharge	Cumec	1320.70
6	Design Discharge per unit of 300 MW	Cumec	220.04
7	Design Discharge per unit of 150 MW	Cumec	110.25
8	Water Requirement for One-time	TMC / MCum	1.26 / 35.68
9	Water Requirement for re-utilisation	TMC / MCum	1.01/ 28.60
10	Generation Duration	Hrs	6
11	Turbine Capacity – 5 Units	MW	300
12	Turbine Capacity – 2 Units	MW	150
13	Annual Energy Generation	MU	3744.9
14	Pump Capacity – 5 Units	MW	330
15	Pump Capacity – 2 Units	MW	165
16	Rated Head in Pump mode (Larger & Smaller Units)	m	162.56 & 163.21
17	Pumping Duration	Hrs.	6.86
18	Expected Cycle Efficiency	%	80

Pumping operation is proposed at 6.86 hours/day. Each day turbine volume is equal to the Pumped volume. Turbine operation is proposed at 6 hours/day during morning peaking and evening peaking hours.

3.3.7 Machine Hall

The internal dimensions of powerhouse have been proposed with length 196.166m m and width 28.50m including control room. The units have been kept at about 27.00m spacing forlarger units and 21.00m spacing for smaller units while the erection bay have been proposedas 40m long. For housing control room and various auxiliaries/offices, 4 nos. floor have beenproposed on the D/s side of Powerhouse over the draft tube. The main inlet valve is proposed to be housed in powerhouse just u/s of turbine. 2 Nos. of EOT crane of suitable capacity shall be installed 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.

3.3.8 Tail Race Outlet

The outlet structure of Shahpur Standalone PSP is proposed with Diffuser type and will be constructed at the end of Tail Race Tunnel. Generally, the bell mouth entrance is ideal for pumping mode when water enters. In this case there is a relatively even velocity distribution over the trash rack and minimal losses as water accelerates through the bell- mouth and in to the TRT. But when operating in generation (turbine) mode water will be discharged to the lower reservoir through this structure.

Water discharging from the TRT will not follow the bell-mouth and will continue as a column of water with minimaldivergence. This column of discharging water will continue to the trash rack and result in very high localized water velocities through the trash rack center, resulting in excessive localized load and flow induced vibration and in the longer term resulting in trash rack failure. The localized water velocity through the central portion of the trash rack could be multiple times the average velocity estimated for the trash rack.

In case of pumped storage project, this bell-mouth arrangement shall be replaced by a long and gradual diffuser section at a shallow angle so that the discharging turbine mode flow can be maintained with an even velocity distribution and decelerate prior to reaching the trash rack and therefore, finally the flow will discharge through a flat trash rack at the end of the diffuser with a uniform low velocity.

Seven separate outlets are provided to discharge the water from the TRT. It is proposed to have independent trash rack in front of each outlet structure which will be installed in slanting position with the slope of 15° with vertical. The hydraulic design of trash rack opening is done considering the velocity of flow through the trash rack which will be limited to 1.0 m/sec without clogging.

Submergence of Outlet has been checked for a discharge corresponding to design discharge and to prevent vortex formation and entry of air into the system as per IS: 9761 and accordingly the MDDL and center line of outlet for larger units is kept at EL 328.00m and EL 315.30m respectively. Similarly, the MDDL and centerline of outlet for smaller units is kept at EL 328.00m and EL 314.15m respectively.

3.3.9 Tail Pool and Tail Race Channel

The tail water from the machines, is lead back to the lower reservoir through a tail race channel. Water from the draft tube of each of the machines will enter into a tail pool constructed with RCC walls on three sides. The tail pool is connected to a tail race channel that conveys the water into the Lower Reservoir.

3.4 ELECTRO - MECHANICAL EQUIPMENTS

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

1. Main inlet valve.
2. Reversible Turbine and its auxiliaries like HP/LP air compressor system, water depression system, lubricating oil system, Governor and its oil pressure unit and cooling water system etc.
3. Synchronous Generator/Motor and its auxiliaries, Excitation system, Cooling system, Brakes, PLC and Automation arrangement etc.,
4. Control, Protection, metering, measurement and annunciation panels for complete powerhouse and for 400KV feeder panels.
5. Isolated Phase Bus duct shall be provided for connecting generator/Motor, PRDS to the Generator Step-up transformer, UAT, LAVT, NGT etc., for trouble free reliable operation.
6. Phase reversal disconnecting device etc. with all accessories.
7. Generator Step-up Transformers with **On Load** tap changer along with control and protective gear and breakers etc.
8. 400KV Gas Insulated switchgear (GIS) units is proposed for connecting grid through Double bus scheme with bus coupler and with bus sectionalizer.
9. 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, HT & LT switchgear.
10. Control supply system consisting of AC supply, station battery, charger, and its distribution system.

11. The station auxiliaries like **3 Nos. of EOT cranes** (2 nos. at service bay and 1 no at unloading bay), Air Compressor system, Dewatering and Drainage system, firefighting equipment, Air conditioning, Ventilation system and illumination system, Cooling water system, High pressure oil injection system, jacking oil system, public addressing system etc.
12. 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, PLCC, 48V DC battery system.
13. SCADA system with necessary panels and workstations for GIS and for power plantoperation from Local and Remote.
14. **Starting Bus system suitable for Back-to-back starting** and also **Starting the units with SFC systems**. It consists of Current limiting reactor, starting Bus circuit breaker and Isolators system at Each unit tap off and the output connected to a common SP Bus duct toconnect to other units and also to SFC equipment.

3.4.1 MECHANICAL EQUIPMENT:

The Mechanical equipment consists of Turbine, Main Inlet Valve, Governor, instrumentation & control system, HP/LP Air Compressor system, oil pumping system, cooling water system, Drainage, Dewatering system, EOT cranes etc.

3.4.1.1 Spherical Valve:

Each Turbine is provided with a Spherical Valve to act as a main inlet valve 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 Spherical valve shall be normally opened and closed by hydraulic system and also have backup closing system with counterweight for closing during emergency. Hydraulic operated Bypass valve is provided across the Butterfly valve for smooth operation with pressure balance condition.

3.4.1.2 Turbine/Pump:

The type of turbine will be reversible vertical shaft Francis type directly coupled to the vertical synchronous generator. The turbine will have adjustable guide vanes forcontrol of the flow. In hours of low demand electricity gets consumed and watergets pumped into the higher reservoir. When the peak hours arrive, and the demand is high, water gets turbine and generates therefore Electricity. The final design ofthe Turbine components would be carried out by means of Model Test results of Turbine.

3.4.1.3 GOVERNING SYSTEM:

The turbine will be controlled by an electronic governor. The Governor in general shall be designed in accordance to IEC 61362.The guide vanes will be actuated by guide vane servomotor through the governor. The system will be so designed that the main functions of speed control, power control are handled as a separate program part and shall be programmed to suit Francis turbine having adjustable guide vanes. Governor shall also support RGMO/FGMO mode of operation, Electrical Inertia as per the Indian Electricity Grid Code.

3.4.1.4 AUXILIARY SYSTEMS:

i) *Air Conditioning System* :

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

ii) *Ventilation System* :

Adequate ventilation tunnels have been proposed in this project, consists of Transformer cavern, Powerhouse, and other areas. Air Handling units are to be placed in transformer cavern. Detailed design of same shall be done at DPR stage.

iii) *Crane and Hoists* :

Three nos. EOT cranes of suitable capacity each will be installed in the powerhouse building (2 Nos. in Service bay and 1 No. in Unloading bay) 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 in service bay shall be provided.

iv) *Dewatering and Drainage System* :

For Dewatering of turbine casing water up to the Tail race gate, required number of submersible pumps with suitable capacity will be provided. The Dewatering sumpwill 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. Sizing of pumps will be done during preparation of DPR.

To remove drain water collected in the drainage sump located in the BF/Spherical valve pit / Station floor, required number of pumps of suitable capacity 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. Sizing of pumps will be done during preparation of DPR.

v) Flood water system

Provision of Flood water evacuation system has also been made in case of inadvertent flooding of the powerhouse. The system shall comprise of suitable number of submersible pumps with main and standby installed along with valves, piping, control annunciation to discharge water outside the powerhouse building and shall have provision to extend DG set power supply. The Control Panel along with DG set system for the Submersible pumps shall be located well above the maximum tail water level to enable the pumps operation in case of flooding. The outlet from flood pump will be laid above the ground to release water into tailrace channel.

vi) Fire Protection System:

The proposed fire protection system shall be designed to provide adequate safety measures in the area susceptible to fire in the power station. TAC classifies hydel power generating stations as "Light hazard Occupancy" and hence the system shall be designed accordingly. This system is designed as per applicable requirements of NFPA 851.

vii) Air Compressor System

Suitable Tank mounted HP and LP air compressor system to meet the station requirements such as for brakes, cleaning, Blowdown system etc. are considered.

3.4.2 ELECTRICAL EQUIPMENT:

The Electrical scheme showing the major system, such as the Generator and its connections to 400 KV Switch Yard for Power evacuation, 11KV Switchgear and 415V Auxiliary Power distribution.

3.4.2.1 Synchronous Gener ator Motor:

The Synchronous Generator Motor will be 3 phase with 0.9 PF (lag), 50 Hz with Static type excitation system suitable for parallel operation with the grid. 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 Fixed Speed machine) for better stability on faults.

3.4.2.2 Static Excitation System :

For fixed speed machines the excitation system will be of static type system. 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 200% of the normal field voltage and response ratio will be about 2.0.

3.4.2.3 Starting Method :

Starting of the units in motoring mode:

Static frequency convertor type of starting is proposed to be adopted for starting of the units in motoring mode. **One set of S.F.C. equipment** is provided. To enable staring of all units in a short time provision is also proposed to be incorporated for back-to-back starting of the units. A common starting bus with Current limiting reactor, starting Bus Vacuum circuit breaker and Isolators system at Each unit tap off and the output connected to a common SP Bus duct to connect to other units and also to SFC equipment is envisaged. The schematic layout enclosed illustrates the arrangement.

Starting of the Pump – turbine units as pump will be done in two methods:

1. Back-to-Back starting
2. SFC Starting

Back-to-Back starting

In back to Back starting it is proposed to start the units as pumps with any one unit as generator to limit the complexity in automation.

The Runner of the Unit being started as pump will be Dewatered and this unit will be interconnected through Starting Bus at 18 KV. The selected unit as Generator will be connected to starting Bus by closing its Circuit Breaker. After switching the excitation to the Rotor of both the units connected to Starting Bus and the guide vanes of the Starting Generator will be opened to get the rated speed and Voltage. On synchronization of the unit selected as pump the Generator will be isolated by opening of Circuit breaker. After release of air from runner the Pump will be loaded by opening of its guide vanes to the required. This enables smooth starting of Pumps.

SFC starting

Mainly to the extent possible the units will be started in back-to-Back starting mode. The last unit has to be started individually through SFC equipment. Static Frequency Converter (SFC) based starting will be used for Conventional fixed speed system. The SFC used will be of High-Voltage large capacity thyristor converters designed for large capacity motor starters. The thyristor starter comprises of a source side converter, a machine side converter, AC reactors, DC reactors & a control & protection system.

3.4.2.4 Step-up Transformers:

Power generated will be stepped up to 400 KV by means of Three Single Phase, 18 KV/400KV, **123 MVA** oil filled power transformers/Unit i.e., total 16 Numbers (15 Nos + 1 No. spare) of Single Phase 18 KV/400 KV Power transformers for 5 Units of 300 MW and Three Single Phase, 18 KV/400KV, **62 MVA** oil filled power transformers/Unit i.e., total 7 Numbers (6 Nos + 1 No. spare) of Single Phase 18 KV/400 KV Power transformers for 2 Units of 150 MW are envisaged.

3.4.2.5 Generator – Motor/Transformer connection:

The connection between of generator, generator transformer and unit transformers will be achieved by isolated phase type bus-duct. Bus duct will be provided with required tap offs for LAVT, Excitation transformer, SFC circuit etc.

3.4.2.6 Phase Reversing Switch disconnectors:

Phase reversing disconnectors is used whenever the system is operated in pumping mode for the motor operation. The equipment consists of five finger disconnectors wherein two fingers will be used to interchange the phase sequence in Pump mode compared with generator mode.

The main differences between the generating and pumping operating modes are changes in direction of the machine rotation and change of direction (i.e., sign) of the active power flow. This rotation direction change is achieved by so-called phase reversal disconnect switches.

3.4.2.7 400 KV GIS:

Indoor metal-enclosed phase segregated type SF6 gas insulated switchgear system rated for 400 kV, 3 phases, 50 Hz SF6 gas insulated metal enclosed bus bars complete with Generator transformer, Line, Bus coupler, Bus sectionalizer and SAT bays.

I) Local control cubicle

The Local control cubicle shall contain all the equipment required for controlling and monitoring the bay.

II) 400 KV Pothead Yard:

The 400 KV pothead yard will consist of two Outgoing line bays (One Double circuit line) with isolator, CT, CVT, WT & LA and take off tower. The isolators will be of Horizontal double break type with motor operated mechanism.

3.4.3 CONTROL, INSTRUMENTATION & PROTECTION SYSTEMS:

There shall be one control panel each for the Turbine governing, unit & its auxiliaries, station and its auxiliaries, GIS & its auxiliaries. It should be able to synchronize the units either manually through these control boards or through SCADA system located in control room. Protection panel for turbine, units, generator transformer, GIS, auxiliary transformers, line protections etc. The protection system adopted should be state of art type with latest practices in compliance with CEA requirements.

3.4.4 COMMUNICATION SYSTEM:

To communicate inside powerhouse and pothead yard internally, to HO and LDC following communication systems are considered.

a) Internal Telephone System

b) External Communication.

c) Power Line Carrier Communication/OPGW.

3.4.5 POWER EVACUATION

It is proposed to have One Double Circuit Transmission Line to connect the project to existing substation for evacuation of stored power during Generating mode and for supply of power during Pumping mode. Details of existing substation is given below:

1. One 400 KV double circuit transmission Lines of length 75 km (approx.) from PSP from PSP will be connected to 400/765 kV PGCIL substation at New Shivpuri of Madya Pradesh State for evacuation of stored power during generating mode and for supply ofpower during pumping mode.

3.4.6 SALIENT FEATURES OF E & M EQUIPMENT

1		**Electro Mechanical Equipment**	
	a	Pump Turbine	Francis type, vertical shaft reversible pump-turbine
	b	Total No of units	5 nos. (5 X 300MW) + 2 nos. (2 X 150MW)
	c	Total Design Discharge (Turbine Mode)	1320.70 cumec (5 x 220.04 cumec + 2 x 110.25 cumec)
	d	Rated Head in Turbine mode	154.73 m for 300 MW unit and 154.41 m for 150 MW unit
	I	**300MW Turbines**	
	a	Total No. of units	5 Units (All Fixed speed)
	b	Turbine Design Discharge	220.04 cumec
	c	Pump Capacity	330 MW
	d	Rated Pumping Head	162.56 m
	e	Rated Pump Discharge	190.96 Cumec
	f	Synchronous speed	187.50 RPM
	II	**150 MW Turbines**	
	a	Total No. of units	2 Units (All Fixed Speed)
	b	Turbine Design Discharge	110.25 cumec
	c	Pump Capacity	165 MW
	d	Rated Pumping Head	163.21 m
	e	Rated Pump Discharge	95.10 cumec
	f	Synchronous Speed	250 rpm
	III	**Generator-Motor**	
	a	Type	Three (3) phase, alternating current synchronous generator motor semi umbrella type with vertical shaft

	b	Number of units	5 Units (5 x 300 MW) and 2 Units (2x150 MW)
	c	Rated Capacity	Generator – 300 MW & 150 MW Pump Input – 330 MW & 165 MW
	d	Rated Voltage	18.0 KV
	IV	**Main Power Transformer**	
	a	Type	Indoor Single-Phase Power transformers with ON Load tap changer (OLTC)
	b	Number of units	3 nos. X 1 Ph transformers per unit for 300 MW Units + 1 Spare limb = 16 nos. 3 nos. X 1 Ph transformers per unit for 150 MW Units + 1 Spare limb = 7 nos. Total : 23 Nos.
	c	Rated Capacity of each unit	Single Phase, 18 kV/400kV, 123 MVA – 16 Nos. (15 Nos. working + 1 No. spare) for 300 MW Units and Single Phase, 18 kV/400kV, 62 MVA – 7 Nos. (6 Nos. working + 1 N. Spare) for 150 MW Units.
	d	Rated Voltage	Primary – 18.0 kV; Secondary - 400 kV adjustable range of the secondary voltage: -10% to +10% in steps of 1.25%
2		**400 KV Gas Insulated Switchgear**	
	a	Type of GIS	Indoor Type
	b	No. of GIS units	1 No.
	c	Location	Inside GIS building above ground
	d	Scheme	Double Busbar Arrangement with bus Coupler and Sectionalizer.
3		**POWER EVACUATION**	
	a	Voltage Level (KV)	400 KV
	b	No. of Transmission Lines	One no. 400 kV double circuit transmission line
		Conductor	Quad Moose

	c	Total Length	One 400 kV Double Circuit Transmission Line of length **75 km (approx.)** from PSP will be connected to 400/765 kV PGCIL substation at New Shivpuri of Madya Pradesh State for evacuation of stored power during generating mode and for supply of power during pumping mode.

CHAPTER – 4 PLANNING BRIEF

4.1 General

The Shahpur Standalone Pumped Storage Project envisages construction of upper and lower reservoir near village Shahpur village in Shahabad Tehsil, Baran district.

The scheme will involve construction of rock fill embankment of maximum height of 30m for creation of Shahpur Standalone PSP upper reservoir of 1.21 TMC gross capacity. Similarly, the scheme will involve construction of rock fill embankment of maximum height of 30m for creation of Shahpur Standalone PSP lower reservoir of 1.06 TMC gross capacity. The Shahpur Standalone PSP is proposed in between two reservoirs i.e., Shahpur Standalone PSP Upper & Lower (to be constructed newly) and one-time requirement of 1.26 TMC of water will be pumped from existing nearby Shahabad Kuno River to fill up the proposed Lower reservoir. Water will be let out from the Shahpur Standalone PSP upper reservoir through Power Intake and Penstock/Pressure shaft of 830m long to feed the Shahpur Standalone PSP, having a Storage Capacity of 10800 MWH with Rating of 1800 MW. This project is comprising 5 units of 300 MW each and 2 units of 150MW each. The water after power generation will be conveyed through a 179m long Tail Race tunnel to discharge water into Lower reservoir. The total design discharge for the proposed scheme is 1320.70Cumec with the rated head of 154.73m for larger units and 154.41m for smaller units.

4.2 Planning Concept

The proper selection of construction methodology, projects scheduling followed by strict monitoring during construction are the major tools available in the hand of developers for ensuring completion of projects within scheduled time and cost. The project implementation schedule of the scheme is divided in to five stages as follows:

1. Preparation of DPR
2. Clearances & Permits
3. Pre-Construction Activities
4. Construction Activities
5. Testing & Commissioning

The preparation of Detailed Project Report including Topographic Survey & Geotechnical Investigation will be completed within 6-month time. The Clearances & Permits includes Forest land clearance, Environmental clearances, DPR approval and other permits and licenses and all these activities will be completed within 1.0 to 1.5 years.

Pre-Construction activity involves construction infrastructure works like access road to project site and construction of building for accommodating men and materials, Award of tender for design works, Preparation of tender for Civil, H&M and E&M works, floating of tenders, Bid Evaluation, award of work and Mobilization to Site. This activity is proposed to be completed in 6 months.

The main Construction activities will be taken up once Pre-Construction activities are completed. The Construction work for Civil, H&M and E&M will be carried out either by EPC contract or based on item rate contract. Quality control of civil, H&M & E&M works will be taken care through internal / external agency. Based on the specific work of the project, equipment planning will be taken up and state of art equipment will be deployed at site during execution. It is proposed to get the Civil, Hydro-Mechanical and Electro-Mechanical works done through reputed contractors who have been doing similar kind of works.

The Testing & Commissioning including water filling in the system will be taken up once the construction works are completed. The total construction of the project including testing & commissioning are proposed to be completed within 3.0 years.

CHAPTER – 5
PROPOSED INFRASTRUCTURE

5.1 General

Shahpur Standalone PSP is located in Baran district of Rajasthan. It envisages creation of both upper and lower reservoir near Shahpur village in Baran district. The project is about 77 km from Baran Railway station. Nearest airport is Gwalior Airport. The Installed capacity of the Project is proposed as 1800 MW.

5.2 Access

5.2.1 Roads to Project

The upper reservoir of the project is accessible from NH-76 road (New No. NH-27) nearer to Mahuri Khera from where Shahpur village road takes off and the distance to the upper reservoir site from the takeoff point is approximately 3Km. Similarly, the lower reservoir of the project is accessible from Existing BT Road near Mungawali village and the distance to the lower reservoir site from the takeoff point is approximately 2Km.

5.2.2 Existing Road and Bridge Improvements

The conditions of Existing roads need to be improved.

5.2.3 Roads in the Project Area

The access road to the upper reservoir of project site takes off from NH-76 (New No. NH 27) nearer to Mahuri Khera from where Shahpur village road takes off. Similarly, the access road to the lower reservoir of project site takes off from the existing BT road near Mungawali village. The specification of access road has been kept equivalent category.

The permanent colony, office and other temporary facilities are planned along the access road discussed above.

5.3 Construction Power Requirement

The requirement of construction power will be met from the existing transmission network in the area. In addition to use of power from local grid, it is planned to install stand by Diesel Generating sets for ensuring un-interrupted power supply during project construction.

5.4 Telecommunication

Adequate provision required for telecommunications including:

- Development of the existing telephone system to provide sufficient capacity for both voice and data transmission.

- Provision of radio and microwave facilities.
- Provision of VSAT connection at site for communication with head office.

5.5 Project Colonies / Buildings

- The contractors for Civil, Electro-Mechanical and Hydro-Mechanical works are planned to be hired for execution of this project. The skilled, semi-skilled and unskilled labor will be arranged by these contractors. Contractors shall themselves arrange for housing facilities for its work force in nearby villages.
- In addition, the developer will have his own staff or supervision of the works. Some of the existing houses in the nearby areas / villages will be hired on rent during construction period. It is proposed to construct residential as well as non-residential buildings for the project. Office buildings, guesthouse, security post, dispensary, etc. will also be constructed. These facilities shall be permanent in nature and shall also be used by O & M staff, once the construction is over.

5.6 Job Facilities

Workshop is proposed near all the components to facilitate the various preparatory works batching plants, crushing plants, steel liner plates bending etc. The major fabrication and assembling of hydro- mechanical equipment can be done in this workshop and later can be transported to the desired sites. Labor colony, staff colonies will be provided nearer to the components.

5.7 Water Supply

The provision of adequate water supplies for both the construction purposes and the use of personnel shall be done. In order to avoid any deterioration in water quality and subsequent changes in the aquatic biota, a proper sewage disposal system in and around various labour colonies shall be planned to check the discharge of waste.

5.8 Explosive Magazine

One explosive magazine store has been proposed in the project area. Portable magazines shall be kept at the sites of work for day-to-day requirements.

5.9 Medical Facilities

Medical facilities are provided at Baran by State District Hospital and is equipped with almost all medical facilities.

CHAPTER – 6

REHABILITATION AND RESETTLEMENT

6.1 INTRODUCTION

The construction of Standalone Pumped storage component will result in land requirement. Among other land some private land will also come under the total land requirement for the standalone component.

6.2 LAND REQUIREMENT

The total land requirement for proposed project is about 624.92Ha; out of which 413.91Ha is forest land and remaining 211.01Ha is non-forest land. The details are given in **Table - 6.1**

Table - 6.1: Details of Land Requirement

S. No	Components	Total Area (Ha)	Forest Land (Ha)	Non-Forest Land (Ha)
1	Upper Reservoir	269.82	110.21	159.61
2	Lower Reservoir (Including TRC)	230.51	230.51	0.00
3	Approach Road to Project Components			
a	Proposed Road from Upper reservoir to NH-76	8.94	6.08	2.86
b	Proposed road from Lower reservoir to BT road	6.56	3.82	2.74
c	Proposed road from muck disposal area to BT road	0.70	0.00	0.70
d	Proposed road from UR to LR	3.78	3.78	0.00
4	Water Conducting System & Powerhouse	57.23	57.23	0.00
5	Job facilities	15.00	0.00	15.00
6	Muck Disposal area	30.00	0.00	30.00
7	Magazine	0.10	0.00	0.10
8	Pumping Alignment	2.28	2.28	0.00
	TOTAL	**624.92**	**413.91**	**211.01**

Out of the total land required for the project, the forest land will be diverted as per the guidelines issued under the Forest (Conservation) Act, 1980 and government land, if any will be transferred to the project from the competent authority as per the laid-out process.

The private land identified for the project will be purchased directly from respective landowners through private negotiations on land price and completed on a mutual agreement.

6.3 PURCHASE OF PRIVATE LAND

The private land required for the project is proposed to be purchased through a voluntary sale with a willing buyer and seller process. The process is undertaken through direct negotiations between landowners and Project Proponent with no obligation on the seller. The land owners are informed in advance, and each land owner negotiated on the price of land as part of land take.

The some of the steps in the land procurement process included the following:

- Identification of land required for the project and due diligence of land through verification of Revenue Records.
- Undertake consultation and negotiations with the landowners about the project and private land requirement.
- After negotiations on all aspects of purchase the voluntary sale of land is completed through a registered sale agreement.

6.4 REHABILITATION AND RESETTLEMENT

As mentioned above, only partial land holding is being acquired, none of the landowners are losing any house or any other assets such as borewell, Cattle shed, trees etc. Hence, none of the landowner family are being displaced due to the proposed project.

As part of land acquisition, private land acquisition shall be carried out as per the State Policy in vogue. If the land acquisition exceeds the specified limits as notified by the State Government Policy, National RFCTLARR, 2013 shall apply for the proposed Project. Detailed Rehabilitation and Resettlement Studies will be carried out as part of EIA / EMP Studies.

CHAPTER – 7

PROJECT SCHEDULE AND COST ESTIMATES

7.1 General

Construction of Shahpur Standalone PSP including erection of 7 generating units are planned to be completed in a period of 42 months including Pre-constructions works period of 6 months for creation of infrastructure facilities viz. additional investigations, improvement of road network, colonies etc.

Two shift working is considered economical for surface works. Opting 25 working days in a month, shift wise scheduled working hours annually are proposed to be adopted.

7.2 Target Schedule

The Total Construction period is scheduled as follows.

Preconstruction Period incl. Statutory Clearances	:	6 months
Construction Period (Main Works)	:	3.0 Years
Total Construction Period	:	3.5 Years

7.3 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 Rajasthan & 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.

7.4 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.

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 Basic Schedule of Rates of Baran district, Rajasthan (Year 2020) & local prevailing rates are adopted for the items not covered by the SOR wherever quantification has not been possible at the present stage of design, lump sum provisions have been made based on judgment / experience of other projects.

The quantities of Civil Works are estimated based on designs and drawings prepared for various components of the project.

The total project cost works out as given below:

S.NO.	Description of Item	Cost in Crores
1	Cost of Civil & HM Works (with escalation)	5482.25
2	Cost of Power Plant Electro - Mechanical Equipment including Transmission line	3096.20
3	Total Hard Cost	8578.45
4	Interest during Construction & Others	1143.31
5	Total cost of the Project	**9721.76 cr**

CHAPTER – 8

ANALYSIS OF PROPOSAL

This project will form part of Integrated Renewable Energy Project along with solar and Wind. Therefore, financial analysis for the same will be carried out once Solar and Wind project proposals are finalized.

ANNEXURES

Shahpur Standlone Pumped Storage Project 1800 MW - Tentative Construction Schedule for Pumped Storage Project | **Annexure 8.1**

Project Details	Year 1												Year 2												Year 3												Year 4					
	Q 1			Q 2			Q 3			Q 4			Q 1			Q 2			Q 3			Q 4			Q 1			Q 2			Q 3			Q 4			Q 1			Q 2		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Project Timeline	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Pre-Construction Activities	■	■	■	■	■	■																																				
Main Construction Activities																																										
Rockfill Dam							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
Intake Structure & Tunnel												■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■										
Pressure Shaft												■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
Power House							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■												
Tail Race Tunnel/ Tail Race Channel																				■	■	■	■	■	■	■	■	■	■	■	■	■	■									
Transmission Line																									■	■	■	■	■	■	■	■	■	■	■	■						
Filling of Upper/Lower Reservoir																														■	■	■	■	■	■	■	■					
Filling in Water Conductor System																																						■	■	■		
Testing and Commissioning of Units																																								■	■	■