PURULIA PUMP STORAGE PROJECT & ITS ROLE IN RES INTEGRATION

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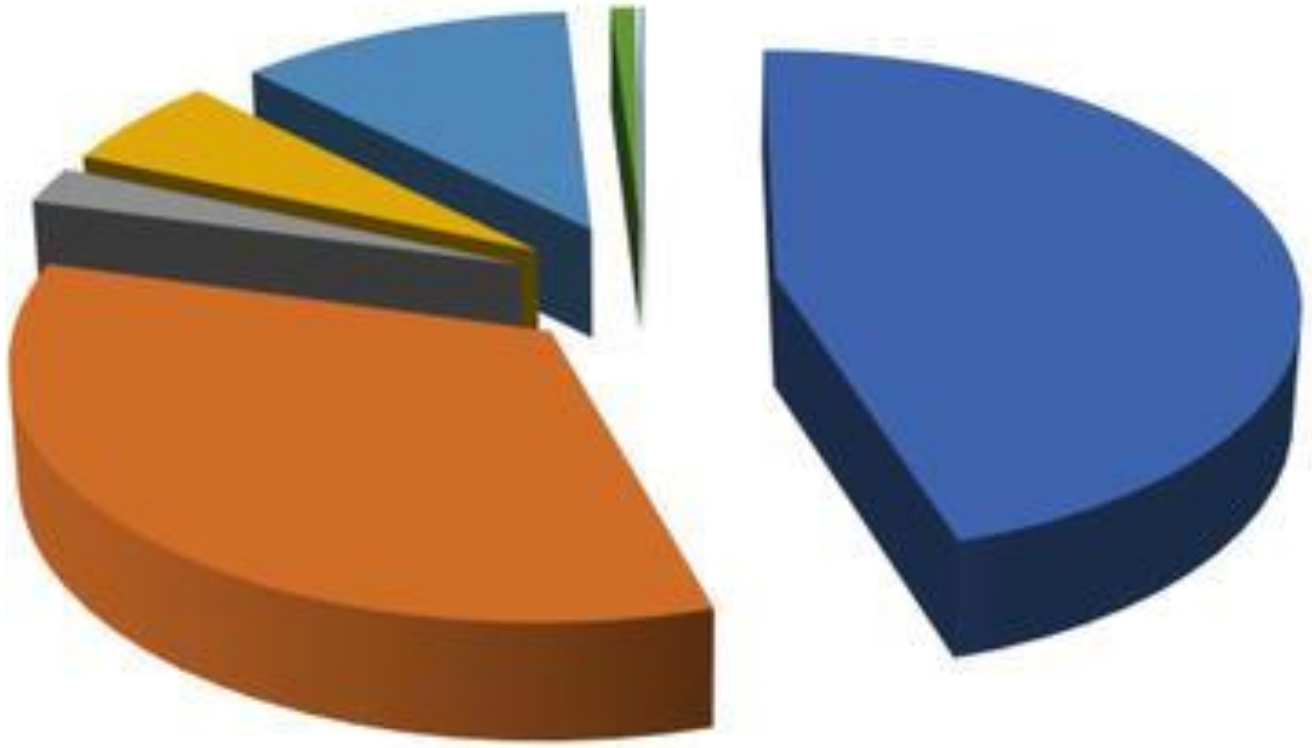
RE INTEGRATION…..NEED OF THE HOUR

- **Integrated Power grid of India is one of the largest in the World**
- **Large penetration of Intermittent source of Energy is expected by the year 2027**
- **Generation through Renewable has already touched 23.7% of the total generation .**
- **Variability of renewable resources like Wind & Solar energy needs immediate ramp up & back down of generation for grid balancing & stability of grid frequency**
- **So, Spinning Reserve, Flexible generation, DSM & Storage systems (both Pump Hydro & Battery storage) are the essential components in the present context of huge renewable integration to combat the consequent intermittency**

COMPONENTS OF RES



- Wind 45.3%
- PV- ground mounted 33.9%
- PV- roof top 2.3%
- Small Hydro 5.8%
- Biomass (Bagasse Cogeneration) 11.6%
- Biomass (Non-bagasse Cogeneration) 0.9%
- Waste to Power 0.2%

ADDITION OF RENEWABLES AT A FAST PACE ....

	2007	2018	2020	% INCREASE	
				2007-18	2018-20
TOTAL RES CAPACITY	11.12 GW	74.08 GW	87.02 GW	565 %	17.46 %
SOLAR CAPACITY	-----	25 . 21 GW	34.62 GW	------	37.80%
WIND ENERGY	7. 67 GW	35.14 GW	37.69 GW	358 %	7.25%

Based on AGENDA PAPER of IRADe on Soft Landing Of Indian Renewable Integration & CEA report

TECHNICAL CHALLENGE…..

RE integration will need gradual increase in share of the Solar & wind power & more intermittency in the system

- **Currently India has a total power generation of around 372 GW which includes 199.6 GW of Coal based Thermal Generation making it's share close to 54% of the total generation**
- **The total Thermal Generation from all the sources stands at 231 GW which is a whopping 62.2% of the total generation**
- **Fast ramp up of thermal generation is not possible**
- **Immediate backing down of a large chunk of generation is also difficult.**
- **Moreover there is a constraint of Technical Minimum (55%) below which a Thermal Plant is not allowed to operate**
- **Consequent frequency excursions & grid unbalancing.**

- **So increasing the flexibility of the predominant Thermal Generation is the biggest challenge …. MoP, GoI & NITI Aayog's report on RE Roadmap 2030 also stressed on the need of flexible generation.**

INTERMITTENCY OF SOLAR & WIND GENERATION

RES integration will need gradual increase in share of the Solar & wind power & more intermittency in the system.

Variability in solar & wind power generation affects load-generation balance

Wind generators are usually induction type & absorbs large amount of reactive power during start up

Due to inherent intermittency of wind pressure & velocity, these start ups takes place several times a day and a substantial quantum of reactive power is absorbed from the grid resulting in voltage excursions

Solar power is also intermittent due variation of Solar Insolation, Cloud cover, diurnal variation etc. Moreover ,due to te dependency of the irradiation level, PV output ramps up & down at high rate & that may cause voltage fluctuations in the grid.

So, unless there is an effective grid balancing component on the generation side , a mere progressive addition of RES will only be a threat to the grid security.

WHY PUMP STORAGE ?

Pump Storage Technology is the only long term technically proven, cost effective, highly efficient & operationally flexible way of energy storage on a large scale & available at short notice

Pump storage Hydro is the World's largest energy storage system with the following advantages to make it most effective as far as the RE integration is concerned

- **Peak shaving**
- **Load balancing (Peak/off-peak balancing support)**
- **Spinning reserve at almost no cost to the system**
- **Black start capability**
- **Fast ramp up & ramp down of generation**
- **Large energy Storage capacity**
- **Long life**

National Electricity Policy, 2005 mandates 5% of the total generation as spinning reserve requirement at national level.

WHY PUMP STORAGE……..

PSPs absorb the off peak energy in the system

Provides peaking power to the system

Helps in system stability

Increases capacity utilization of thermal plants

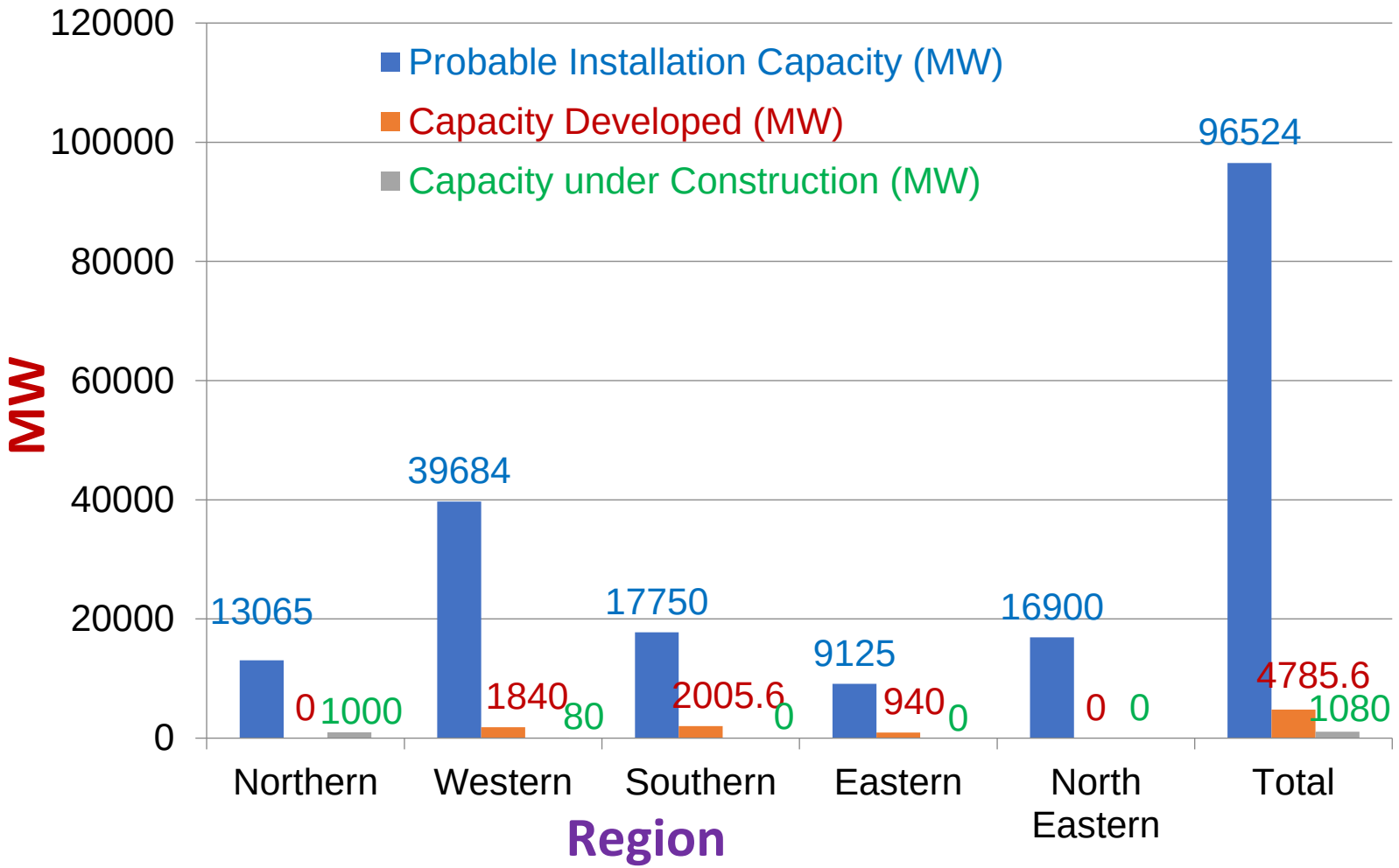
Regulates frequency during sudden load changes

Voltage & Power Factor correction

Last but not the least, only PSP can meet most of the grid scale energy storage needs and no other storage system can and therefore almost 95% of the storage projects are Pump hydro (127000MW globally)

▪Potential of Pumped Storage Hydro Capacity in India

❑Region wise Pumped Storage Hydro:



WEST BENGAL….A PREDOMINANTLY THERMAL POWER BASED STATE

- **The state of West Bengal and the Eastern region is having predominantly thermal power generation with an insignificant capacity of hydroelectric power generation**

THERMAL GENERATION : 7727 MW

CONVENTIONAL HYDRO : 175 MW

For catering Base Load/ Fluctuating/ Peak/ Off Peak power, this region had to depend mainly on the thermal power generating units with insignificant capacity of hydro power

If the Thermal Power Stations are to share both base and peak load then the power system become unstable with frequency excursions

Moreover the Thermal Plants in such conditions have to run at very low load for prolonged period needing fuel oil support,

and thus cost of generation become too high

With wide range of Frequency variation, the industrial unit consumers as well as Thermal Power units run their plants with risk and hazards of damage,

Their efficiency and life expectancy reduce drastically

As such the total power system become unstable with risk of grid collapse

HENCE THE NEED TO DEVELOP PSP

PURULIA PUMPED STORAGE PROJECT

Location : Ayodhya hills, in Purulia district, West Bengal , India

Capacity : 4 X 225MW

Executing Authority :

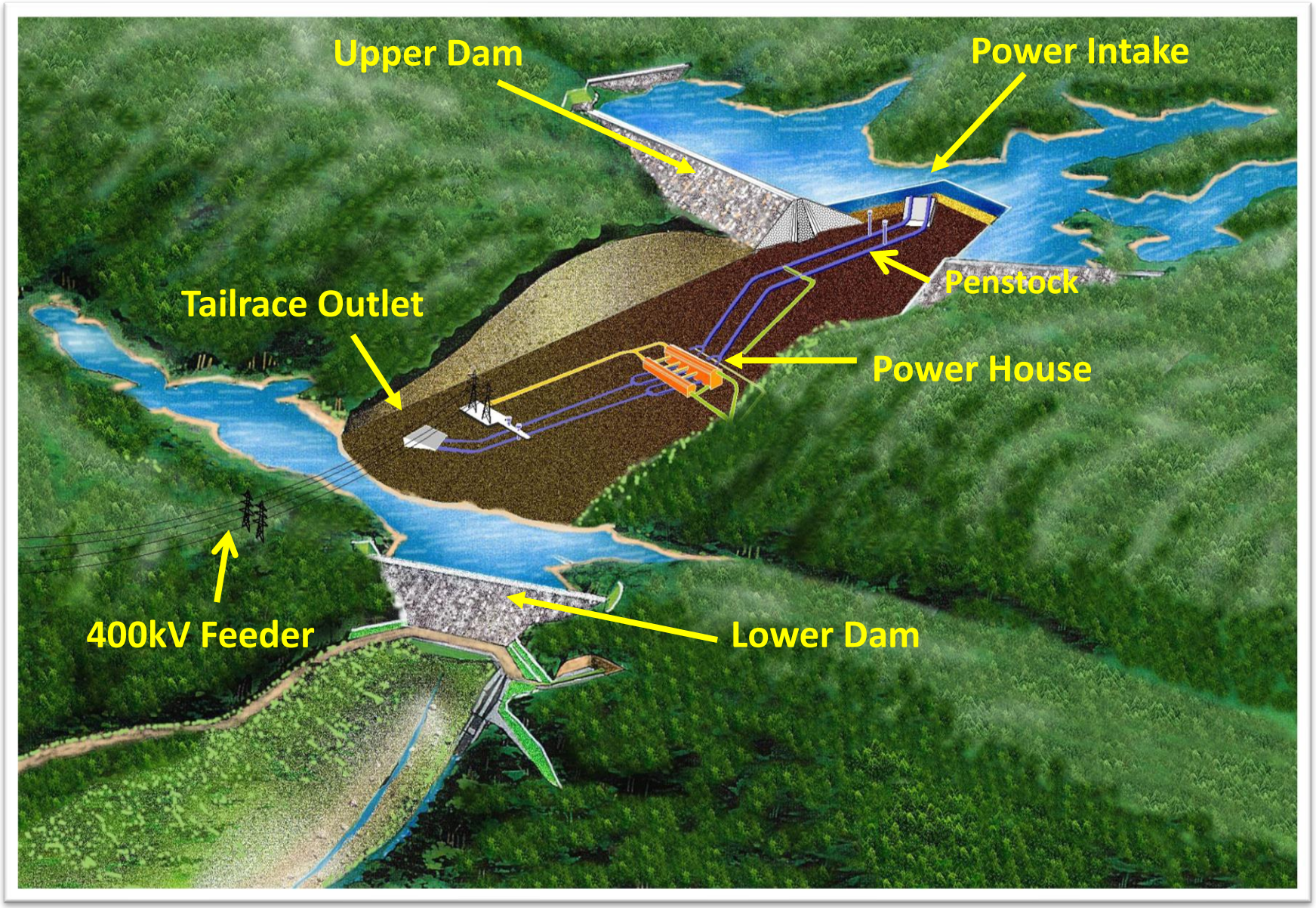
West Bengal State Electricity Distribution Company Ltd(WBSEDCL), A Govt. of West Bengal Enterprise (erstwhile WBSEB)

Consultant : EPDC(J-Power), Japan & WAPCOS,

Project Cost : 2476 Crore

Project Completion date : December 2007

General view of the project:



PPSP - A Closed-loop Pumped Storage Utility

- **A relatively new approach for developing pumped storage projects is to locate the reservoirs in areas that are physically separated from existing river systems**

- **These projects are termed ‘closed-loop’ pumped storage, because they present minimal to no impact to existing river systems**

- **After the initial filling of the reservoirs, the only additional water requirement is minimal operational make-up water required to offset evaporation or seepage losses**

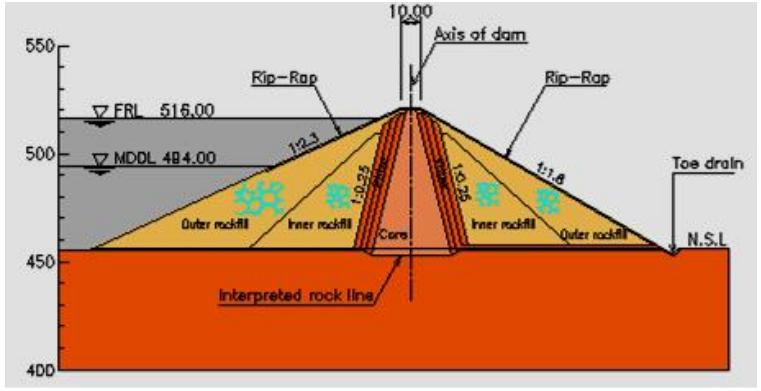
- **By avoiding existing complex aquatic systems entirely, these types of projects have the potential to greatly reduce the most significant aquatic impacts associated with project development**

PPSP have the above advantages

❖ Upper Reservoir

High water level	EL.516.00 m
Low water level	EL.494.00 m
Available draw down 22.0 m	
Full water capacity	16,404,924 m3
Available capacity	13,371,025 m3

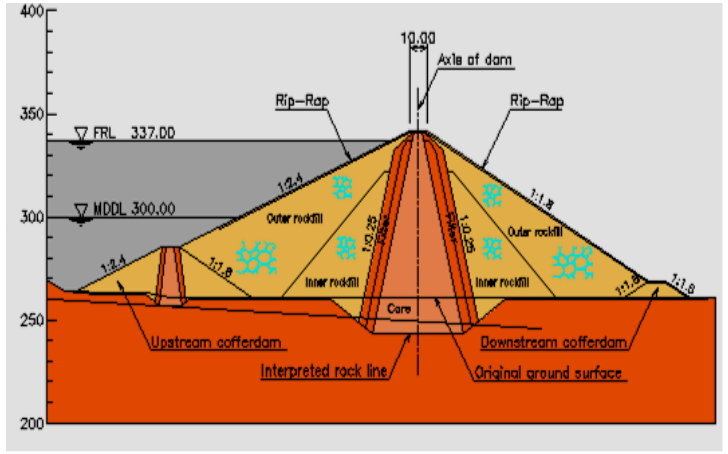
(used about 6 hour by 600m3/s)



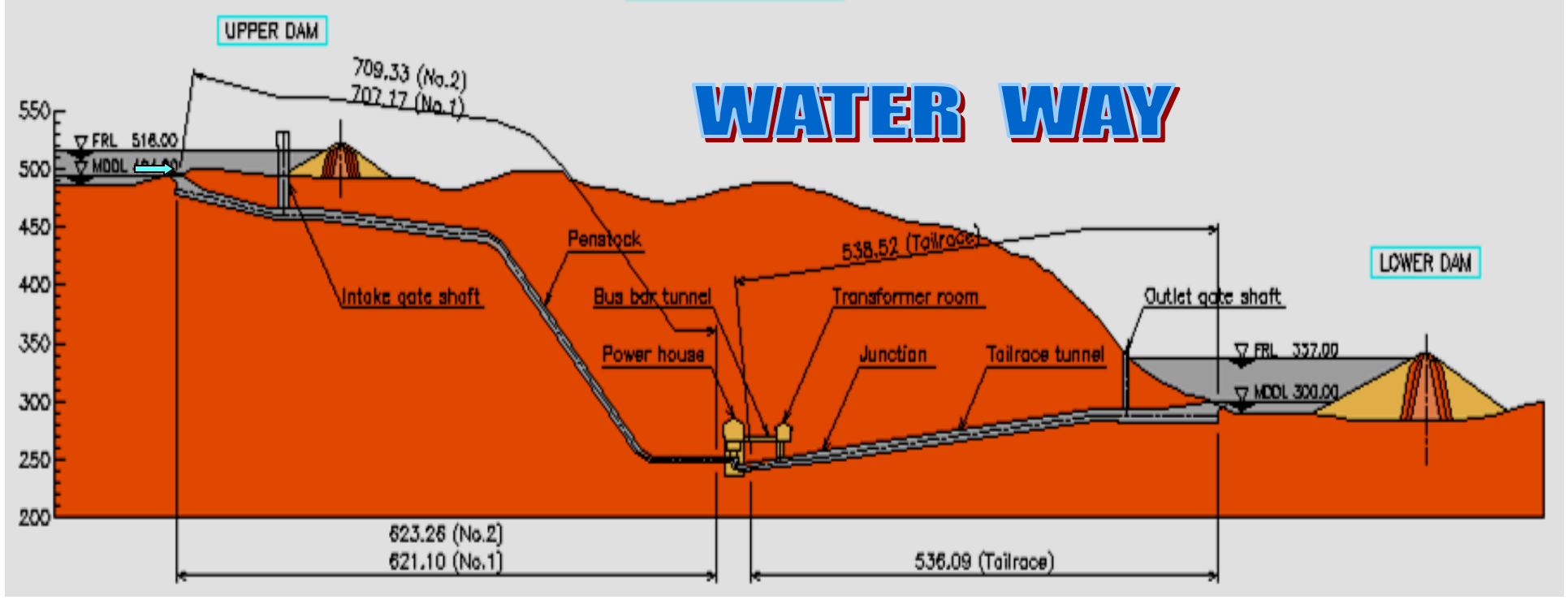
❖ Lower Reservoir

High water level	EL.337.00 m
Low water level	EL.300.00 m
Available draw down	37.0 m
Full water capacity	17,253,036 m3
Available capacity	14,475,571 m3

(used about 6 hour by 600m3/s)



Headrace Intake Tunnel	**7.70 m dia. x 2 nos.**
Penstock	**7.70 ~ 7.30 m dia. x 2 nos.**
	4.30 m dia. x 4 nos
Tailrace	**8.70 m dia. x 2 nos**
	5.60 m dia. x 4 nos
Sedimentation rate	**9.50 Cum/SqKm./Year**



PUMPING MODE

- **The unit takes starting power (Max 11.5 MW) through Static Frequency Controller (SFC) or Back to Back (BTB) operation & the unit rotates in clockwise direction when viewed from the top of G/M**

- **After synchronization with grid the Turbine operates as Pump & Generator as Motor. Motor takes active & reactive power from 400 KV grid .**

- **Water of the Lower Reservoir is pumped up & stored in the Upper Reservoir as Potential Energy for using it at peak demand of 400 KV grid by converting it into Electrical Energy.**

- **The Guide vane of the P/T is controlled to the optimum opening position of the Guide Vane by Governor System for the entire water head of the Upper reservoir (EL 516m - 494 m) & the Lower Reservoir (EL 337m – 300m)**

GENERATION MODE

- **The unit is reversible one ….the same machine can be run as Generator as well as Motor**

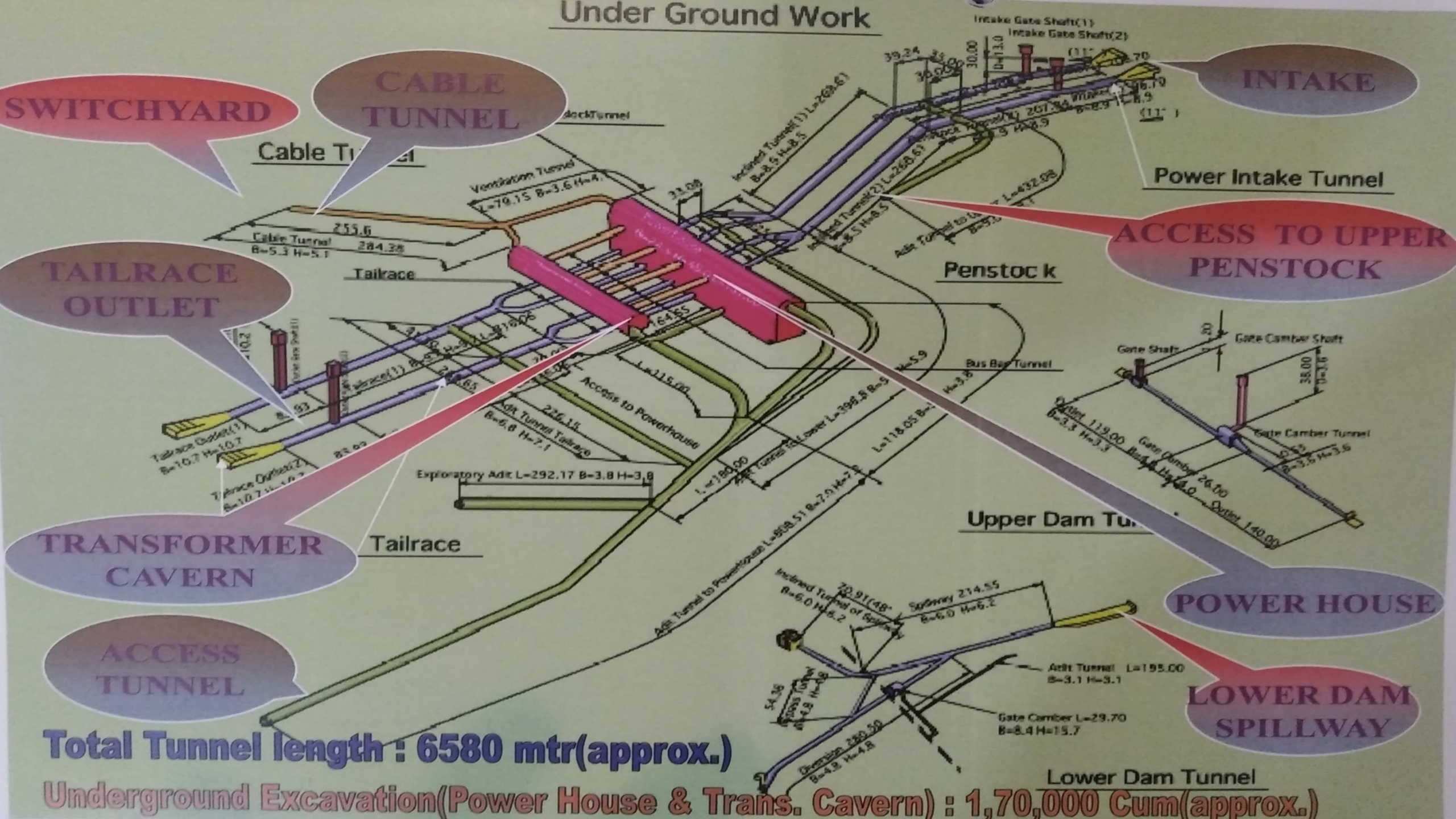
- **Execution Command is given from Central Control Room through Operator Station (OPS) the unit starts as generator by opening the Main Inlet Valve (MIV) & Guide Vane (GV) which allows the water to flow from the Upper to Lower Reservoir through Runner & the Runner rotates through water pressure & the reaction forces.**

- **Runner is connected to the Generator Rotor. So the Rotor rotates & the electrical energy is produced in the Stator.**

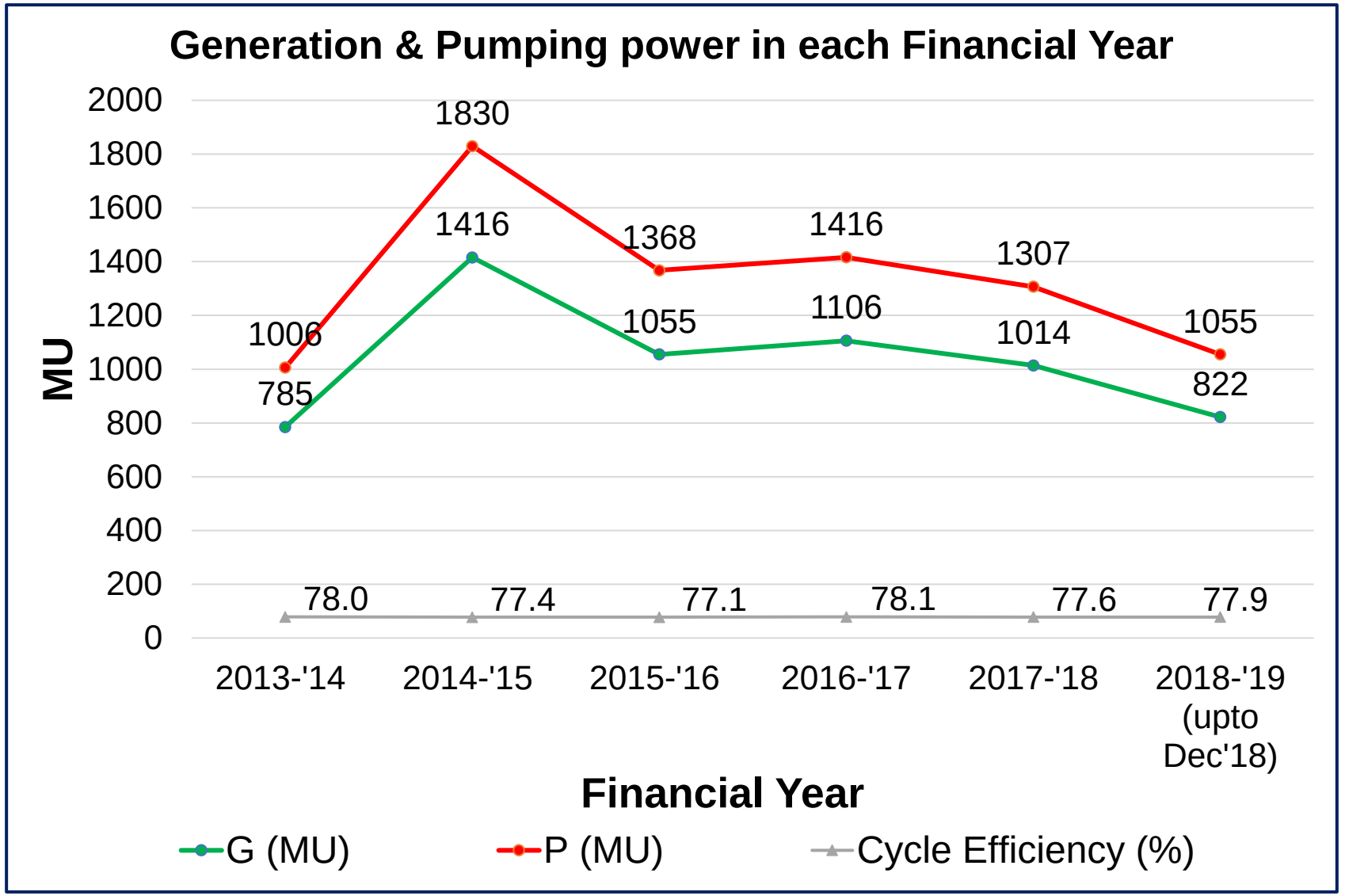
- **The electrical energy so produced is fed to 400 KV feeder through Main Transformer & Gas Insulated Switchgear (GIS)**

SYNCHRONOUS CONDENSER MODE

- **Unit can be run both in SCOG & SCOP modes**
- **In SCOG, the unit starts like Generating mode until synchronized with grid. Once synchronized, water flow stops by closing the guide vane & MIV and water in Turbine section is depressed by pressurized air. The unit draws minimum power from the grid (4 MW) to rotate freely.**
- **In SCOP, the unit starts like Pumping mode by using Static Frequency Converter(SFC) until synchronized with grid. After synchronization, the unit draws minimum power (4 MW) in water depressed condition.**
- **In both the cases the reactive power can be controlled fully and when required SCOG can be converted to Generation mode & SCOP may be converted to Pumping mode very quickly**


Under Ground Work
SWITCHYARD
CABLE TUNNEL
INTAKE
Power Intake Tunnel
ACCESS TO UPPER PENSTOCK
Penstock
TAILRACE OUTLET
Tailrace
Cable Tunnel
Ventilation Tunnel
Access to Powerhouse
Bus Bar Tunnel
Gate Shaft
Gate Camber Shaft
Gate Camber Tunnel
TRANSFORMER CAVERN
Tailrace
Upper Dam
POWER HOUSE
ACCESS TUNNEL
Spillway
Adit Tunnel
Gate Camber
Lower Dam Tunnel
LOWER DAM SPILLWAY
Total Tunnel length : 6580 mtr(approx.)
Underground Excavation(Power House & Trans. Cavern) : 1,70,000 Cum(approx.)

Generation & Pumping Data of PPSP for last 5 years



UPDATED GENERATION & PUMPING DATA OF PPSP

Power Generated		Pumping Power Received		Auxiliary Power (MU)	Efficiency
Financial Year	MU	Financial Year	MU		
Total Gen from Commissioning to COD	112.95	Total Pumping Power from Commissioning to COD	144.87		
Total Generation in 2007-'08	271.64	Total Pumping Power in 2007-'08	352.11		
Total Generation in 2008-'09	669.83	Total Pumping Power in 2008-'09	859.62	2.059	77.92%
Total Generation in 2009-'10	868.35	Total Pumping Power in 2009-'10	1113.77	5.669	77.97%
Total Generation in 2010-'11	878.88	Total Pumping Power in 2010-'11	1131.44	6.946	77.68%
Total Generation in 2011-'12	766.41	Total Pumping Power in 2011-'12	979.32	6.925	78.26%
Total Generation in 2012-'13	797.50	Total Pumping Power in 2012-'13	1026.27	5.905	77.71%
Total Generation in 2013-'14	784.70	Total Pumping Power in 2013-'14	1005.80	6.560	78.02%
Total Generation in 2014-'15	1415.89	Total Pumping Power in 2014-'15	1829.60	7.918	77.39%
Total Generation in 2015-'16	1054.99	Total Pumping Power in 2015-'16	1367.86	7.227	77.13%
Total Generation in 2016-'17	1105.45	Total Pumping Power in 2016-'17	1416.92	7.267	78.02%
Total Generation in 2017-'18 (Jan)	855.94	Total Pumping Power in 2017-'18 (Jan)	1099.83	5.792	77.82%
Total Generation Since COD	7508.19	Total Pumping Power Since COD	9665.77	62.267	77.68%
Total Gen Since Commission	7621.15	Total Pumping Power Since Commission	9810.64		77.68%

GENERATOR CAPACITY	4 X 225 = 900 MW
MOTOR CAPACITY	4 X 255 = 1020 MW
FULL LOAD OPERATION IN GENERATING MODE	6 HOURS PER DAY
CYCLE EFFICIENCY	75.5%
AUXILIARY CONSUMPTION	0.5%
TRANSFORMATION LOSS	0.5%
PLANNED OUTAGE	10 DAYS
MAXIMUM ANNUAL ENERGY GENERATIO	$[(365-10) \times 6] \times 900 \times 1000 \times 10^{-6}$ = 1917 MU
ANNUAL AUXILIARY CONSUMPTION @ 0.5% 1917 MU	9.58 MU
ANNUAL ENERGY AVAILABLE AFTER AUXILIARY CONSUMPTION	1907.42 MU
ANNUAL TRANFORMATION LOSS @ 0.5% ON 1907.42 MU	9.53 MU
MAXIMUM ANNUAL ENERGY AVAILABLE AFTER CONSIDERING ALL LOSSES	1897.89 MU
ANNUAL ENERGY REQUIREMENT FOR PUMPING	1917/ 0.755= 2539.07 MU
ANNUAL AUXILIARY CONSUMPTION @ 0.5% ON 2539.07 MU	12.69 MU
ANNUAL ENERGY REQUIREMENT AFTER AUXILIARY CONSUMPTION	2551.76 MU
ANNUAL TRANSFORMATION LOSS @ 0.5%ON 2551 .76 MU	12.75 MU
ANNUAL PUMPING INPUT	2564.51 MU

OVERALL PLANT EFFICIENCY : 74%

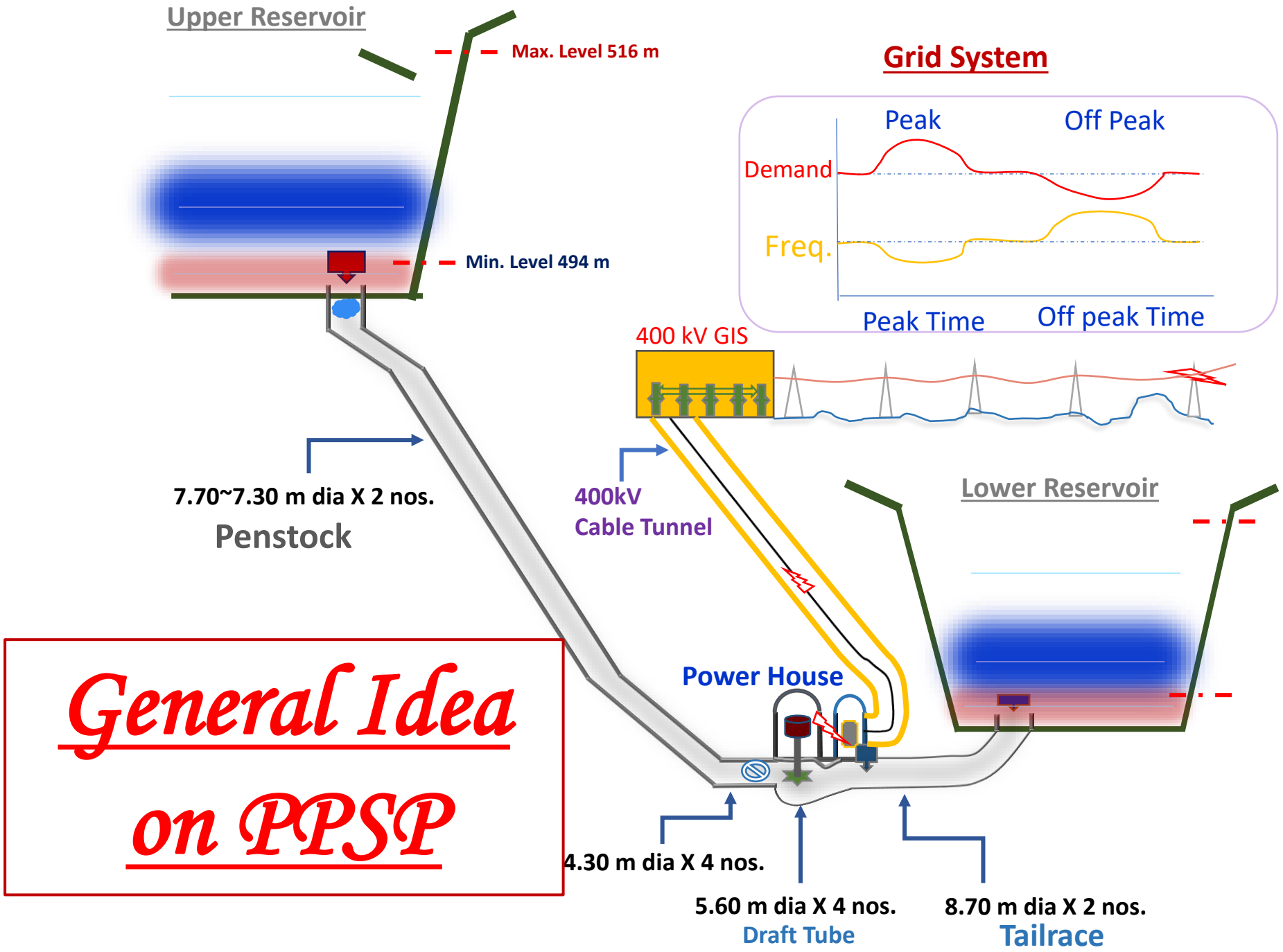
HOW FAST IS PPSP ?

Generation Mode:

- ❑Start: The Unit takes only 5 minutes to run from standstill to full load.
- ❑Stop: The Unit takes total 11 minutes to stop (including Auxiliary equipment stop like Oil Lifter)

❖Pumping Mode:

- ❑Start: The Unit takes only 11 minutes to run from standstill to full load.
- ❑Stop: The Unit takes total 11 minutes to stop (including Auxiliary equipment stop like Oil Lifter)



General Idea on PPSP

INITATIVES ON SOLAR ENERGY

Canal-Bank-Ground-Mounted	20	MW
Ground-Mounted-Grid-Connected	50	MW
Solar Rooftop (under IPDS) :	2.265	MW
Solar Rooftop (Project of WB Govt)	0.7	MW

PRESENT INSTALLED CAPACITY: 73 MW

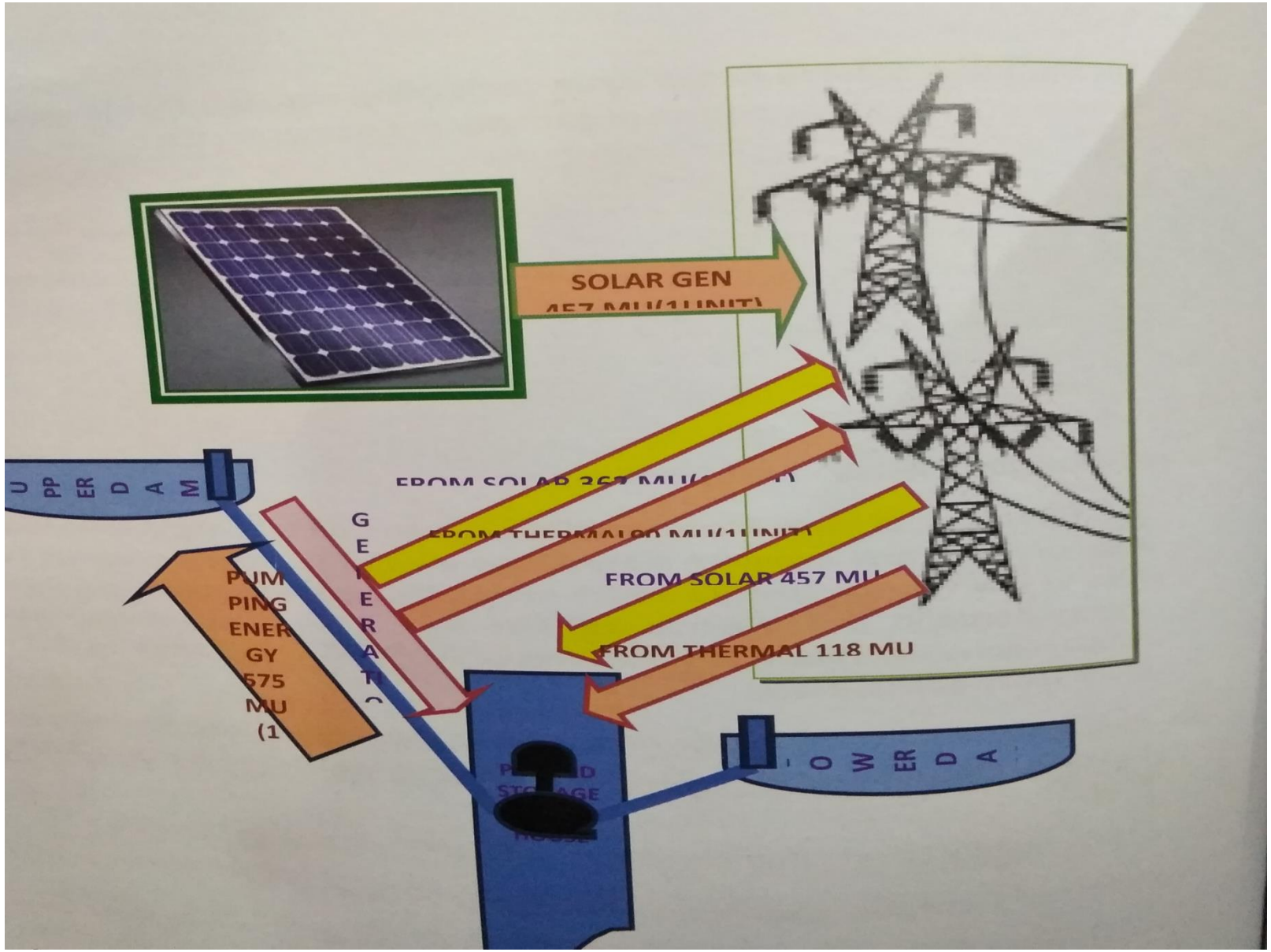
Another 12.82 MW Solar Rooftop are expected to be commissioned shortly

Moreover 1200 MW Mega Solar Power Plant to be installed in Purulia for pumping power for PSP Generation

&

200 MW Solar Park at Mandermoni, , Midnapore District of WB are two ambitious solar Power Projects by WBSEDCL

Integration of Thermal , Solar & PSP



INTEGRATION OF PSP WITH SOLAR POWER

WB has proposed a 1200 MW Capacity Mega Solar Power Project by tying up with the old & new closed loop PSPs

Solar power is intermittent and not available on demand & storage system is the only solution but not available in large scale

So with anticipation of huge infirm power in the grid by way of Solar & Wind in near future, importance of PSP assumes great importance for GRID BALANCING

This integration of Mega Solar Power with PSP will convert intermittent Solar Power to Firm Power

Reduce the use of conventional pumping power & in turn reduce emission of GHG

Last but not the least the proposed Variable Speed machines in upcoming TURGA PSP will help stabilize the grid in case of natural fluctuation of Solar Generation

RES INTEGRATION IN WB

The State of West Bengal proposes to implement the program in two phases

Phase I

One unit of Purulia PSP of 225 MW capacity to be combined with 300 MW Solar PV project through grid

Phase II

Turga Pump Storage Project to be combined with the balance 900 MW (3X300 MW each) of Solar PV project

Last but not the least the proposed Variable Speed machines in upcoming TURGA PSP will help stabilize the grid in case of natural fluctuation of Solar Generation


Thank you