



SJVN LIMITED
(A JOINT VENTURE OF GOVT. OF INDIA & GOVT. OF H.P.)

**LUHRI HYDRO ELECTRIC PROJECT
(588 MW)**

**REVISED
DETAILED PROJECT REPORT**

**VOLUME – 1
MAIN REPORT**

SHIMLA

FEBRUARY –2013

1 DPR Executive Summary and Salient Features

1.1 Introduction

This Detailed Project Report was prepared by Mott MacDonald and subsequently modified by SJVN Ltd. to present the development of the proposed Luhri hydro electric project on the Satluj River. The project lies downstream of the Rampur hydroelectric project and upstream of the Koldam project which are presently under construction.

The report is set out in five volumes:

- Volume 1: Main Report
- Volume 2: Drawings
- Volume 3: Rate Analysis and Cost Estimate
- Volume 4: Appendices and Civil Design
- Volume 5: Geological & Geotechnical Aspects

1.2 Project Development

This study draws on the Feasibility Study Report by Mott MacDonald dated September 2006 as well as previous pre-feasibility studies and a review of possible development options considered in March 2006.

This study has concluded that there is a feasible scheme and the economic analysis indicates that the project will be viable within the current market. However, the relatively high capital cost of the scheme will require a correspondingly high tariff.

There are three major issues that are of particular significance for the Luhri Project and these are:

- The high concentrations of quartzite sediments in the Satluj River.
- The relatively low slope and high flows of the Satluj River require relatively large tunnels.
- The region is seismically active and the tunnel route passes through thrust zones which are associated with sections of poor rock conditions.

The studies that are reported in this document have therefore concentrated on these issues and the preliminary designs that have been prepared attempt to find solutions to the resulting engineering problems.

It is anticipated that the proposed designs will provide a significant increase in the life and availability of the turbines compared to Nathpa-Jhakri. This will be achieved by a combination of :

- Significantly increased silt removal efficiency provided by the creation of a larger reservoir.
- The provision of low speed turbines with coated internal surfaces.
- A powerhouse that has been designed to allow easy repair of complete turbines without the need for generator dismantling.

The proposed reservoir within the river channel is expected to remove at least, twice as much sediment from the water entering the headrace tunnel than the desilting chambers used at Nathpa-Jhakri. Studies indicate that there will be a significant reduction in the duration of interruptions to generation to allow sediment flushing.

1.3 Scope of Project

The project configuration includes the following features:

- A concrete dam at Nirath around 86 m high above deepest foundation level with integral gated spillway.
- Use of the river channel to provide a desilting facility of much larger capacity than adopted on previous schemes.
- A headrace tunnel around 38 km long on the right bank of the river. The headrace shall be constructed using single tunnel of 10.5m internal diameter.
- An underground power station near Chaba with three turbine-generator units and an installed capacity of 588 MW.
- With design discharge 380 cumecs, 10.5m diameter single tunnel 38 km long and underground power station near Chaba with three generator units having installed capacity of 588 MW.

1.4 Need for Project

The need for the project arises from:

- The need to fulfil a steady increase in peak electricity demand.
- The growing energy deficit in the Northern Region.
- The ranking of the Luhri project by CEA as 4th out of 93 schemes identified in the Indus basin.

It is clear that as long as the scheme can be implemented at a reasonable cost there will be a demand for the energy generated by the scheme.

1.4.1 Topography and Engineering Geology

The project lies in terrain characterised by steep narrow valleys. Rock formations have been extensively folded.

Relatively massive augen gneiss will provide good foundation conditions for the dam at Nirath. Much of the headrace tunnel will lie in good to fair rock. However, a significant length will pass through a thrust zone of very weak, highly fractured and deformed carbonaceous shale/phyllites where tunnelling conditions are likely to be extremely difficult.

The proposed location for the powerhouse lies in interbedded dolomite, limestone and shale which are anticipated to provide good conditions for construction, although there is some risk that karstic formations could be encountered.

1.5 Seismo-tectonics

An assessment has been made of the regional geology in terms of the seismotectonic behaviour of the project area. It has been concluded that the works should take account of the following design criteria:

- Maximum Credible Earthquake: peak ground acceleration of 0.31 g.
- Design Base Earthquake: peak ground acceleration of 0.16 g.

1.6 Reservoir Stability

Studies included in the preparation of this DPR have shown that there are areas around the proposed reservoir site which will require further stabilisation.

1.7 Hydrology

Relevant records of discharges in the Satluj River are available from 1972 to 2008. These provide a high quality basis for assessment of the energy available for hydropower generation. High flows are experienced during the June to September monsoon period. PMF analysis has concluded that a flood discharge of 13462m³/s will be adopted for the design of the permanent works and that the diversion works will be designed for a non-monsoon flood of 1000 m³/s.

1.8 Sedimentation

A detailed numerical analysis has been undertaken to model the deposition and flushing of the proposed Nirath reservoir. The model has been run for three different cases:

- A reservoir without diversion tunnels.
- The same reservoir with diversion tunnels.
- Desilting chambers similar to those at Nathpa-Jhakri.

The results indicate that the reservoir will be around twice as effective as the sedimentation chambers. It is also anticipated that this will also increase the life of the turbines by a similar factor. In addition, there are indications that improvements in sediment deposition performance may be possible in practice. The hydraulic model studies for reservoir sedimentation are being carried out at CWPRS, Pune. Initial results are favourable for using the reservoir as desilting basin.

1.9 Power and Energy Studies

A detailed spreadsheet based model has been prepared for the power and energy studies by based on FRL at 862.9m, MDDL at 855m, Normal TWL at 647.0m and Minimum TWL at 642.2m. For the proposed case of single 10.5 m diameter headrace tunnel, 2244 GWh design energy will be generated in a 90% dependable hydrological year for 95% plant availability during high flow season.

1.10 Optimisation Studies

The optimisation analysis has been carried out for single and twin tunnels option considering environmental releases recommended by EAC in this modified DPR

Key conclusions are:

- Installed capacity confirmed at 588 MW with three machines with single tunnel option is found to be more techno-economically viable.
- There is no financial advantage by having “spare” machines unless the outage period required for runner maintenance is greater than 31 days.

1.11 Conceptual Layout and Planning: Civil Works

1.11.1 Headworks

For the base scheme, the headworks consist of four main components:

- A concrete gravity diversion dam to form a reservoir with a full reservoir level equal to the tailwater level of the upstream Rampur project. The diversion dam will include gates to allow

the passage of flood flows and for silt flushing.

- A pair of diversion tunnels to allow construction of the diversion dam and to allow flows in excess of generation flows to bypass the downstream section of the reservoir and thereby improve its desilting performance.
- An intake structure for the headrace tunnel.
- Toe power house to utilise Environmental releases.

1.11.2 Headrace Tunnel

It is proposed that the headrace tunnel will be located on the right bank of the river. The study has examined alternative schemes with either a single 10.5 m diameter tunnel or twin 9.0 m diameter tunnels. The proposed designs incorporate short steel lined sections to allow the tunnel to pass below low cover. It is anticipated that the tunnels will be constructed using the drill and blast technique and it is currently proposed that there will be a total of 8 construction adits.

The use of tunnel boring machines was examined but it is considered that these are not preferred as they will be close to the largest ever made and their additional cost cannot be offset by a route length reduction. Further there is a potential with the single tunnel option for squeezing ground conditions and rock bursts due to high rock cover.

1.11.3 Powerhouse

The powerhouse has been designed around several key issues. One important issue is the high silt load in the Satluj River. Experience at the upstream hydropower station of Nathpa-Jhakri indicated that runner damage is likely due to these high silt loads, even when measures are incorporated into the design to reduce the silt passing through the power station. As such, the Luhri powerhouse has been designed to facilitate easy runner removal for maintenance and replacement as well as to provide significant storage space on the machine floor for machine components during these maintenance periods.

The design was also optimised to simplify the powerhouse construction in order to minimise the costs. Such considerations included:

- Preferences for long and narrow caverns as these are generally cheaper to construct than shorter wider caverns.
- Careful consideration of optimal construction tunnel locations in order to ensure sufficient space is allowed for.
- All tunnels and caverns have been sized to ensure adequate space for equipment transport and assembly.
- In order to reduce the width of the power house cavity, a separate cavern on the upstream side of the powerhouse has been considered for housing three number spherical type MIV with provision of EOT crane.

1.12 Conceptual Layout and Planning: Electrical and Mechanical Works

The suitable machines for the scheme will be vertical Francis turbines and generators. Three machines have been selected as this number provides adequate operational flexibility and these are not too bulky for the available transport facilities. To minimise the effects of the high silt content, the turbine speed and setting has been selected to reduce relative water velocity and cavitation.

Spherical type turbine inlet valves are proposed as the gross head is more than 200 meters.

The generator transformers are proposed to be installed in a separate underground cavern which shall also be utilised to house individual Draft Tube Gates for all the three units with provision of suitable capacity separate EOT crane.

The drainage and dewatering system has been designed to provide adequate redundancy and to cope with the failure of the largest pipe connected to either the upstream or downstream waterways. In addition to this, Flood protection system has also been envisaged being an underground power house as per the recommendations of CEA.

1.13 Hydraulic Transients

Studies of the behaviour of the hydraulic system during operation of the power plant have been undertaken to identify behaviour during stopping and starting of the project. It is concluded that surge dissipation facilities are required both upstream and downstream of the power plant, consisting of:

- Surge shaft at the downstream end of the headrace tunnel.
- Surge tunnels at the upstream end of the tailrace tunnel.

1.14 Instrumentation

Geotechnical instrumentation is proposed to be carried out in the vicinity of the dam and underground structures to monitor their behaviour during construction and subsequent operation stage to verify design assumptions and to confirm continuing ground stability.

1.15 Power Evacuation

Due to adequate open space available outside the power house and to optimise the cost of the project, surface air-insulated switchyard is proposed with breaker and half scheme. The connection from generator transformer to this switchyard will be through XLPE insulated cables that will be laid in a separate tunnel from transformer hall. Air insulated terminal equipment will also be provided in the switchyard for evacuation of power to the 400 kV network of Power grid.

1.16 Environmental and Social Issues

The environment impact assessment and environmental management plan have been carried out by CISHME. The proposed designs have been attempted to minimise potential negative impacts. The main effects of the proposed scheme will be due to two factors:

- The inundation due to the creation of the reservoir.
- The reduction of the flow in the Satluj River downstream of the diversion dam.

With regard to inundation the area where most of the people are currently living and will be displaced is in the reach between the proposed discharge from the Rampur scheme and the entrance to the

proposed diversion tunnel. The reach between the diversion tunnel entrance and the diversion dam is steeply sided and the ground submerged will be small. We consider that it would be difficult to develop a scheme design that did not require the submergence of the upstream area.

The EIA has addressed impacts associated with hydropower projects for all phases of the development including:

- Habitat disturbance, fragmentation and destruction
- Habitat loss as a result of inundation
- Road construction
- Solid waste management
- Anthropogenic pressures (e.g. as a result of additional population pressures)
- Impact on wildlife/species population losses
- Impact on aquatic ecosystems (habitat degradation, fragmentation and destruction)
- Impact on water quality and aquatic ecosystems
- Impact on human ecosystem
- Impact from pollution such as air, noise
- Geophysical impacts

The mitigation and management of environmental impacts has been addressed under the following plans supported by an Environmental Management Programme. Provision has also been made for providing financial support for the implementation of these plans.

- Biodiversity Management Plan
- Catchment Area Treatment
- Fisheries Enhancement Plan
- Public Health Delivery System
- Air, Water & solid waste management
- Provision for Fuel wood/LPG Depots and Energy Conservation Measures
- Disposal & Rehabilitation of Muck
- Landscaping and Restoration of Construction Areas
- Development of Green Belt
- Resettlement and Rehabilitation Plan
- Dam Break Modelling
- The Expert Appraisal Committee of MoEF for environment clearance has reviewed the environmental aspect of the project in their meeting on 31.03.2012 and 23.11.2012, and has now recommended the environment clearance subject to Environmental Release of 25% during lean season, 30% during monsoon season and 25-30% during non monsoon non lean period with respect to respective discharges of those seasons.

1.17 Infrastructure

A number of major hydro electric schemes have already been developed on the Satluj River and the majority of the regional infrastructure is already in place. The most significant work that will be required to allow the project to be constructed will be associated with improvements to the road system local to the scheme. The State Highway/ MDR (Major District Road) near the project will need to be upgraded to allow the passage of construction plant and equipment. Furthermore 10 numbers of bridges will need to be built across the Satluj River to allow access to the right bank headrace tunnel construction adits. About 35 kms of new approach roads of 7/9 m wide shall also be required to be constructed to approach the various components of the project and project colony etc. Water supply systems will need to be developed and upgraded to provide facilities for construction and for the residential and non-residential establishments. Further, for construction power, it is proposed that 220 kV system of State Electricity Board will be tapped near to project site from where suitable capacity lines will be extended to the various components of the project with suitable transformers along with D.G. set backup.

Temporary construction facilities will be required including quarries and batching plants.

1.18 Construction Schedule and Planning

The time required for construction schedule has been calculated for the proposed scheme. The time required for construction of this option is 96 months excluding infrastructure works. In order to achieve this construction period, it will be necessary to make physical and contractual arrangements to enable driving of the headrace tunnel to commence as rapidly as possible after any decision to proceed with the implementation of the project. The construction time to complete the project will be determined by the time required to drive the headrace tunnel between adits AT-3 and AT-4 and adits AT-4 and AT-5.

Before construction can start it will be necessary to obtain all statutory approvals, prepare tender specifications, completion of infra works and award the contracts.

1.19 Cost Estimate

The cost estimate has been prepared for this scheme based on January 2013 price level.

The cost estimate has been developed assuming use of Indian materials and equipment where possible and hence Indian rates have generally been used. In some cases, either where the required equipment was not expected to be available in India or where accurate cost estimates were not available from India, international prices have been used in US dollars and converted to Rupees. Civil quantities for dams, tunnels and caverns have been taken from the drawings shown in Volume 2. The electrical and mechanical costs are based on the costs of plant and equipment procured for similar projects in India, updated with appropriate cost indices.

1.20 Economic Evaluation

Tariff calculation has been done for the proposed scheme and the levelised tariff for the scheme will be Rs 6.95/ unit (R.o.I-12.25%) as per the guidelines of CERC applicable for the period 2009-14.

1.21 Salient Features

The salient features of Luhri Hydroelectric Project in tabular form for quick reference are as given

Below :

Luhri Hydroelectric Project

Salient Features

LOCATION

1. State	Himachal Pradesh
2. Districts	Mandi-Shimla-Kullu
3. River	Satluj
4. Vicinity	Dam near Village Nirath on NH-22 and Powerhouse near village Marola on Sainj – Sunni Road

HYDROLOGY

1. Catchment Area at Dam site	51600 Sq.km
2. Design Flood(PMF)	13462 cumec
3. Percent availability corresponding to design discharge of 380 cumec	20%

RIVER DIVERSION WORKS

1. Diversion Tunnel	
Dia	10.0m
Length	2680 m (Average)
No. of tunnels	2
2. Cofferdams	
Type	Rock fill with cut-off wall
Upstream	12.0m high
Downstream	9.0m high
3. Cut-off for Cofferdams	Soil – Cement – Bentonite core walls

RESERVOIR

1. Full Reservoir Level (FRL)	EL 862.90 m
2. Minimum Drawdown Level (MDDL)	EL 855.0 m
3. Gross Storage	35 Million m ³
4. Live Storage	9 Million m ³
5. Length of Reservoir	7 km
6 Area of Reservoir	153.05ha

DIVERSION DAM

1. Type	Concrete Gravity
2. Top of dam	EL 866.00m
3. Height from deepest foundation level	86 m
4. Total length at top	231.5 m

5. No. of blocks	17
6. Minimum river bed level at dam axis	El 811.20m
7. Deepest foundation level	El 780.00m

MAIN SPILLWAY (SLUICES)

1. Location	Block nos. 5 to 11 of Dam
2. No. of bays	7
3. Size of each sluice	7.5m (W) x 12m (H)
4. Sluice crest elevation	El. 822.00 m
5. Thickness of intermediate piers	4m
6. Type of gates	Radial Gates (top sealing type)
7. Ski-jump bucket lip elevation	El. 816.00 m

REGULATING SPILLWAY

1. Location	Block no. 4 of Dam
2. No of bays	1
3. Width of bay	11m
4. Crest elevation	El. 860.50m
5. Size of opening	11.0m (W) x 5.5 m (H)
6. Maximum discharge capacity	73 cumec
7. Ski-jump bucket lip elevation	El. 816.00m

INTAKE

1. No. of intake bays	2
2. Inclination of Trash rack with Horizontal	63°
3. Crest level	El. 836.00 m
4. Minimum Drawdown Level (MDDL)	El. 855.00 m
5. Discharge Capacity of each intake Bay	210 cumec (10% additional capacity)
6. Number of intake gates	2
7. Size of opening	8.0m (W) x 8.0m (H)
8. Size of intake tunnels	8.0m Circular

SEDIMENTATION ARRANGEMENTS

1. Particle size to be excluded	+ 0.1 mm
2. Type of arrangement	Reservoir sedimentation with bye pass tunnels (diversion cum desilting tunnels)
3. Flushing discharge	500 cumces - 1500 cumecs

HEADRACE TUNNEL

- | | |
|---|---------------------|
| 1. Size & Type | 10.50m dia circular |
| 2. Length | 38 km |
| 3. Velocity through tunnel | 4.39 m/s |
| 4. Invert of tunnel at inlet end | El. 836 m |
| 5. Invert of tunnel at junction with surge shaft/tunnel | El. 700 m |
| 6. Design discharge | 380 cumecs |
| 7. Slope | 1V:281H |

8. Adits	Chainage from intake axis (m)	Length(m)
Intermediate adit 1	3571	623
Intermediate adit 2	7780	529
Intermediate adit 3	12368	710
Intermediate adit 4	17059	494
Intermediate adit 5	22649	637
Intermediate adit 6	27080	592
Intermediate adit 7	30928	196
Intermediate adit 8	35863	380

HRT SURGE SHAFT

- | | |
|---------------------------------|--------------------------------|
| 1. Type | Vertical surge shaft with dome |
| 2. Diameter of surge shaft | 31.0 m |
| 3. Height of surge shaft | 110 m |
| 4. Height of connecting shaft | 100 m |
| 5. Diameter of connecting shaft | 9 m |

PRESSURE SHAFTS

- | | |
|----------------------------|------------------|
| 1. No. and type | 3 nos. ,Vertical |
| 2. Diameter | 5.0 m |
| 3. Length of each penstock | 250 m |
| 4. Type of lining | Steel lined |

PENSTOCK VALVE CHAMBER

- | | |
|---------------------------|---------------------------|
| 1. Location | Downstream of Surge shaft |
| 2. Type of valves | Butterfly valves |
| 3. Diameter of each valve | 5000mm |
| 4. E.O.T. Crane | 150 T |

POWER STATION COMPLEX

POWER HOUSE / TRANSFORMER CAVITY

- | | |
|-----------------------|-------------------|
| 1. Type | Underground |
| 2. Installed capacity | 588 MW (3x196 MW) |

3. Size of machine hall	140 m (L) x 21 m (W) x 47 m (H)
4. Size of transformer hall	98 m (L) x 18 m (W) x 21 m (H)
5. Main Access Tunnel	8m D-shaped 530m long

ELECTRO-MECHANICAL EQUIPMENT

TURBINES

1. No. and type	3 (Three) nos., Francis turbines
2. Unit Rated Capacity	196 MW/217.78 MVA
3. Unit maximum capacity	239.56 MVA
4 Gross Head	220.7 m
5. Gross Operating Head	213.3 m
6. Rated net head	170.42 m
7. Discharge at rated capacity	380 cumecs
8. Speed	166.7 rpm
9. Runner Discharge Dia	4380 mm

SPHERICAL INLET VALVES HOUSE

1. Size of Cavern	80m(L)X10m(W)X21m(H)
2. Type of MIV	Spherical
3. Number	3 Nos.
4. Diameter	4200 mm

GOVERNORS

1. No. & Type 3	Digital PID Electro-Hydraulic
-----------------	-------------------------------

GENERATORS

1. No. & Type	3 nos. vertical, salient pole, synchronous generators
2. Rated output	239.56 MVA
3. Rated voltage	15.75 kV
4. Rated frequency	50 Hz
5. Power factor	0.9 lagging
6. Speed	166.67 rpm
7. Insulation class	F, Temperature rise as per Class B.
8. Cooling	Closed circuit air cooling
9. Fire protection	Water sprinkler/CO ₂

EXCITATION SYSTEM

1. Type of excitation	Static Excitation System
2. Type of voltage regulator	Duplicate Static AVR
3. Type of excitation transformer	Dry type or epoxy resin insulated

BUS DUCTS

1. Type Isolated	phase bus duct
------------------	----------------

2. Rated Voltage 15.75 kV

3. Cooling Natural

GENERATOR TRANSFORMERS

1. Number 10 (Ten), including one spare

2. Rating 3 banks of three single phase transformers,
79.85 MVA, 15.75/420/ $\sqrt{3}$ kV, ODWF cooled

UNIT AUXILIARY TRANSFORMERS

1. Capacity 1000 kVA

2. Type Dry Type or resin encapsulated

3. Voltage ratio 15.75 / 0.433 kV

AIR INSULATED SWITCHGEAR

1. Type A.I.S.

2. Rating 400 kV

3. No. of Feeders 6 comprising of 3 generator-transformer
Feeders, 2 Line feeders and 1 spare feeder.

4 Switching scheme Breaker and Half

5 Layout configuration I-Type

400 kV CABLES

1. No. of Single phase Cable 10 No, connecting Transformer to
A.I.S including 1 spare cable.

CONTROL AND PROTECTION

1. Type of control Supervisory Control and Data
Acquisition (SCADA)

2. Protection Numerical relays Conforming
IEC-61850.

CRANES

POWER HOUSE

1. No. & type 2 nos., E.O.T.

2. Capacity Main Hoist: 350 T
Auxiliary Hoist 50 T

PENSTOCK VALVE CHAMBER

1. No. and Type 1 no. E.O.T

2. Capacity 150 T

TRANSFORMER CAVERN

1. No. and Type 1 no. E.O.T.

2. Capacity 100 T

DRAFT TUBE GATE

1. Type	Fixed wheel vertical lift
2. No of Gate	3 nos
3. Gate Operation	Independent Rope Drum Hoist

SPHERICAL VALVE CAVERN

1. No. and Type	1 no. E.O.T.
2. Capacity	150 T

D/S SURGE TUNNEL

1. Type	Circular
2. Dia	9.0 m
3. Length	350 m
4. Maximum surge level	El. 658 m
5. Minimum surge level	El. 635 m

TAIL RACE TUNNEL

1. Size & Type	10.50m dia Circular shape
2. Length	454m (Average)
3. Invert level of tailrace tunnel at outfall	632.0m
4. Maximum tail water level	647.0m

POWER GENERATION

90% Dependable year with 95 % machine availability (Design Energy)	2244 MU
--	---------

COST OF PROJECT

Cost of Civil works	Rs 4939.47 crores
Cost of Electro Mechanical works	Rs 1047.84 crores
IDC and FC	Rs 1144.71Cr & Rs 5.00 Cr
Total Cost with IDC	Rs 7137.02 Cr
Cost per MW	Rs 12.14 Cr

TARIFF

First year tariff(Rs /unit)	7.99
Levellized tariff(Rs/unit)	6.95
Cost per MU(Rs crore/MU)	3.18

LAND REQUIREMENT

PRIVATE LAND	109.49 ha
FOREST LAND (Including Notional Land)	271.16 ha

FAMILY AFFECTED

No of persons affected	2337
No of displaced families	37