TAAS-0045: Adaptation to Climate Change in the Hydro-electricity Sector in Nepal

Field Study Report

Submitted by:

Nepal Development Research Institute (NDRI)-Nepal

in collaboration with:

Practical Action Consulting (PAC), Nepal

Global Adaptation Partnership (UK) Limited (GCAP)

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This project, TAAS-0045: Adaptation to Climate Change in the Hydroelectricity Sector in Nepal, is being undertaken at the request of the Government of Nepal, and is supported by Climate and Development Knowledge Network (CDKN).

The work is led by Nepal Development Research Institute (NDRI)-Nepal in collaboration with: Practical Action Consulting (PAC), Nepal and Global Adaptation Partnership (UK) Limited (GCAP).

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Acronyms:

CDKN:	Climate and Development Knowledge Network
GCAP:	Global Climate Adaptation Partnership
GoN:	Government of Nepal
GWhr:	Giga Watts hour
JICA:	Japan International Corporation Agency
NDRI:	Nepal Development Research Institute
NEA:	Nepal Electricity Authority

Acknowledgments

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We heartily thank our resource persons - Dr. Laxmi Prasad Devkota, Chairperson, Budhi Gandaki Hydropower Project Development Committee; Er. Ram Kumar Yadav, Station Chief, Marsyangdi Hydropower Station, Nepal Electricity Authority; Er. Karna Adhikari, Site Inspector, Upper Marsyangdi A, Sino Hydro Sagarmatha Power Company; Er. Pashupati Raj Gautam, Deputy Manager, Nepal Electricity Authority and Mr. Krishna Bahadur Rajbhat, Site Incharge, Kudhi Hydropower for providing necessary information and visiting arrangements on hydropower plants.

The report is prepared by NDRI - CDKN Team. Dr. Divas B Basnyat (Team Leader), NDRI, of the study team led the field study.

1 Introduction

Field study of hydropower plants in Western Nepal were carried out from 9th to 11th November 2016. The key objectives of the field visit are:

- To provide exposure and raise awareness about current level and extent of climate risks / hazards in hydropower sector
- To understand current mitigation / adaptation measures to current climate conditions adopted by existing hydropower projects
- To study current issues in operation of hydropower plants

Target groups of this exposure visit are officials from Government of Nepal, researchers from national universities and the study team.

Field visit was conducted to four operating hydropower stations in Marsyangdi river basin and to proposed site of one planned storage project in Budhi- Gandaki basin. Four hydropower plants in Marsyangdi River Basin are Marsyangdi hydropower station (69MW), Middle Marsyangdi hydropower station (70MW), Upper Marsyangdi 'A' hydropower station (50MW) and Khudi hydropower (4MW). The planned storage project is Budhi Gandaki hydropower project (1200 MW). Location map of above hydropower stations is shown in **Figure 1-1**.

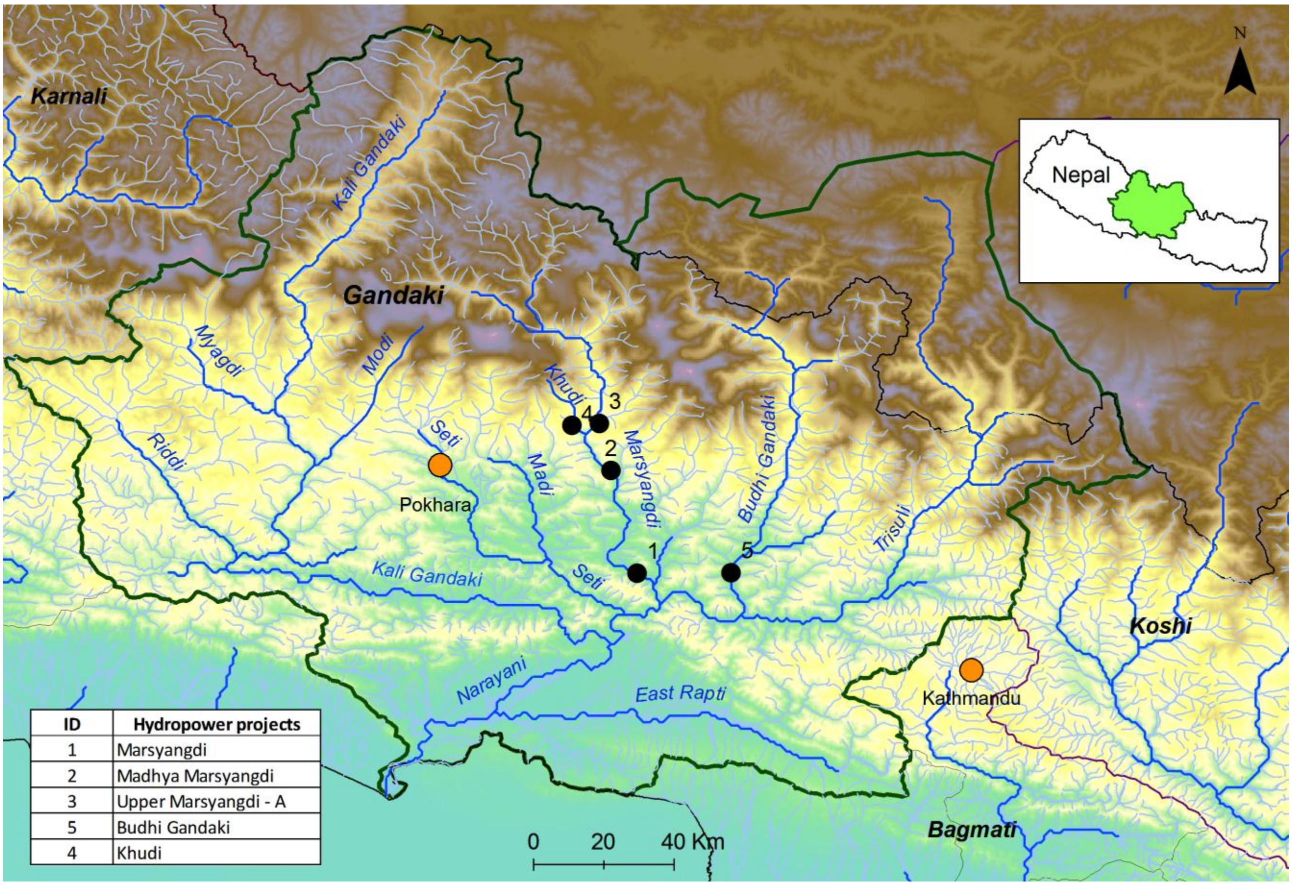

Figure 1-1: Location map of visited hydropower projects

2 Field observation and findings

Site selection for field visit

Marsyangdi River Basin has two of the largest operating hydropower plants owned by NEA and one of largest hydropower operated by private sector. These projects have their own unique features in terms of design, for instance sediment handling in the heavily sediment loaded Marsyangdi River. Likewise, we can compare medium and small scale hydropower project. Therefore, these hydropower projects offered diversity in addressing current climate variation which will be beneficial for our study.

2.1 Marsyangdi Hydropower Project, Abukhaireni ,Tanahu

General Introduction

Marsyandi Hydro Power Station is currently the second largest hydropower project after Kali Gandaki A with the annual energy generation of 462.5 GWhr. The power station is located at Aanboo Khaireni VDC Ward No.8 of Tanahu District at 84.5˚ E longitude and 27.55˚ latitude in Central Development Region. It is RoR facility with rated capacity of 69MW and daily peaking capacity of 4hrs when the river discharge is minimum. The gross head of the plant is 95m. The project was commissioned in 1989 AD. Detailed investigations, design, preparation of tender documents were carried out under the financial grant assistance of the Government of Federal Republic of Germany. Construction of the project was started in 1985/86 with co-financing of IDA, KFW, SFD, KFAED and ADB. The total project cost is equivalent to US$ 221.57 million in 1989.

Findings:

- Design of settling basin of Marsyangdi Hydropower Project: It is designed to handle the particle size of 60 micron (0.06 mm) instead of the general standard of 200 micron (0.20mm). Therefore, the length of settling basin is 400m.

Figure 2-1: De-silting basin

- Less wearing of turbine: Less wear and tear of turbines are reported in Marsyangdi hydropower even though the sediment load is high. Major repair of turbine is once in 3 years. This is due to large length of settling basin. There are no spare guide vanes.

Figure 2-2: Turbine Erosion (Source: NEA, 2016 a)

- Frequency of flushing:

Year	Frequency of Flushing	Flushing time
2070	12 times	48 hours
2071	13 times	43 hours
2072	13 times	64 hours
2073	16 times	56 hours

- Flood and landslide in Rowa Khola in 2060 (30 July 2003) in powerhouse area caused the plant showdown for 19 days. The flood entered ventilation room, battery room of power station hampering the operation.
- The highest recorded flood in Marsyangdi River is 3850 m^3/sec on 2065 (30 August 2008) which caused the overhauling of units 1, 2 and 3.
- Design flood of weir is 9100 m^3/sec.
- Safety (fire fighting) is required. Inspection of headrace tunnel is required.

2.2 Upper Marsyangdi A Hydropower Project, Nyadi, Lamjung

General Introduction

Upper Marsyangdi A is one of the largest private sector hydropower projects that is in operation with annual design generation of 317 GWhr of energy. The headwork is located in Nagdi VDC and powerhouse is located in Bhulbhule of Lamjung district. It is RoR type scheme with installed capacity of 50MW. The net head is 113m. Design discharge is 48 m^3/sec and has two generation units. The project is developed by Sinohydro Sagarmatha Power Company (P) Ltd. The project came into operation in 26 September 2016 while the COD will be done by November 2016. In December 2010, the company and Nepal Electricity Authority signed Power Purchase Agreement. The total investment cost of the project is about US$ 165.9 million and the commercial operation period is 30 years.

Findings:

- Use of vortex chamber type sediment extractor for sediment removal for first time in Nepal. It is cylindrical system that separates the sediment with centrifugal force. Its sediment removal efficiency is 95% (200 micron) which is high in comparison to conventional gravity settling. Its cost is about 60% of conventional gravity settling; and also reduces O&M cost. Another benefit is that it requires less space. It is continues flushing system.

Figure 2-3: Votex settling basin and its outlet in Upper Marsyangdi A Hydropower project

- Earthquake on 25 April 2015 has no major impact on the hydropower.

2.3 Khudi Hydropower Project, Khudi Bazar

General Introduction

Khudi Hydropower project is small RoR type hydropower project with annual energy generation of 24.28 GWhr. The project is located in Khudi, Simpani and Ghanpokhara VDCs in Lamjung District. The installed capacity of the project is 4 MW (with two units of 2 MW each) with design discharge of 4.9 m^3/sec and gross head of 103m. The project was commissioned in December 2006. The project was developed by Butwal Power Company. The projected has PPA agreement with Nepal Electricity Authority for 25 years period. The construction period was from February 2005 to November 2006 and the cost of civil work is NRs. 164 million.

Findings:

- **Flood in 11 Bhadra 2065 (27 August 2008):** The flood caused severe damage to the Khudi Hydropower plant. Because of the flood in the Khudi River, the flow headwork and penstock was severely damaged. Similarly, the flood completely submerged the power-station and the electromechanical equipments by about 8 feets causing complete shutdown.

Figure 2-4: Flood mark of 27 August 2008 flood in Khudi Hydropower Station

- **Flood in 17 Asar 2073:** The flood caused damages in headworks.
- Damages in penstock pipe were observed during field visit.
- Leak in the turbine due to erosion from sediments was observed.

Figure 2-5: Leak in turbine

- Erosion in electro-mechanical parts were observed because of the sediments.

Figure 2-6: Erosion in electro-mechanical part

2.4 Middle Marsyangdi Hydropower Project, Lamjung

General Introduction

Middle Marsyandi Hydropower project is currently the third biggest hydropower plant in Nepal with annual energy generation of 398 GWhr. The power station is located near Besisahar in the Lamjung District in Central Development Region. It is a pRoR facility with rated capacity of 69MW and daily peaking capacity of 5hrs at maximum river discharge. The gross head of the plant is 110m. The project was completed on 2008. The project was financed jointly by Government of Germany, through Kreditanstalt fur Wiederafbau (KfW), Government of Nepal and Nepal Electricity Authority. The total project cost is NPR 27.6 billion on project Handover date July 23, 2010.

Findings:

- Huge sediment deposition in-front of Intake due to meandering nature of Marsyangdi river in upstream of intake. This is attributed to meandering nature of the river profile upstream of the intake. The intake position is in convex side of the left bank where there is high sediment deposition.

Figure 2-7: Areas of high sediment deposit upstream of the reservoir (red marked areas) and location of intake (blue marked area), (Source: NEA , 2016 b)

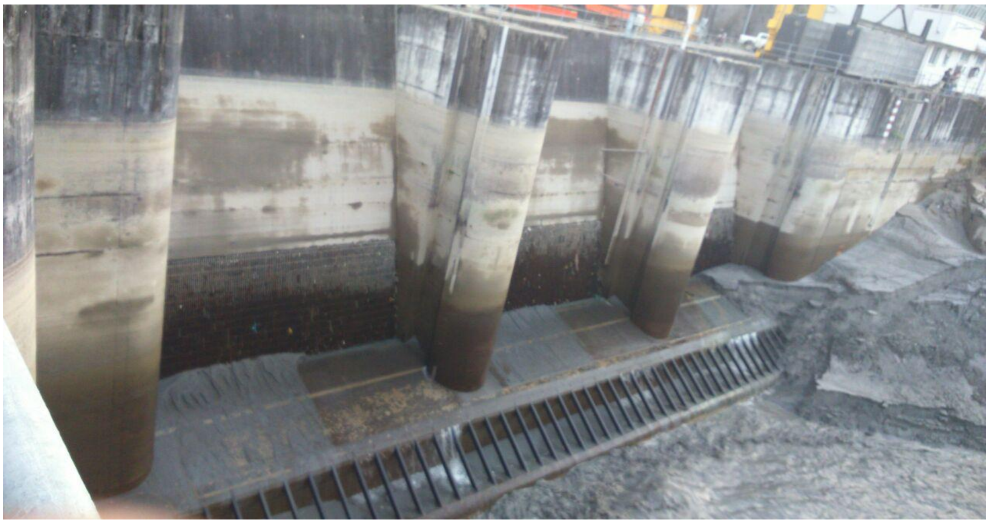

Figure 2-8: Deposition of sediment in and around intake trash rack (Source: NEA , 2016 b)

- Complete flushing of the reservoir is not permitted because left river bank will become unstable in case of complete flushing through spillways.
- No sediment monitoring mechanism (Online monitoring was installed but not operation. Due to high amount of sediment, the samplers get damaged frequently).
- Only mechanism to detect and shutdown of operation due to high sediment is lowering of surge tank water level due to creation of head difference (because of chocking). There are no specific criteria of sediment concentration for plant shutdown.
- Very high rate of wear and tear of turbine is recorded. Replacement of turbine is carried in every 2 years because of high sediment. This is quite high in comparison to Marsyangdi hydropower project.

Figure 2-9: Wear and tear in turbine components (Source: NEA, 2016 b)

- Six settling basins with BIERI system of flushing allows flexible flushing of sediments.
- Deposition in and around intake trash rack
- Sill beam and chute damage
- Ogees and spillways piers damages
- Desander flushing channel plates erosion
- Erosion in Runner and other turbine parts
- Frequent chocking in cooling water system, shaft seal system
- Other problems due to high sediment are Sill beam and chute damage, ogees and spillways piers damages, desander flushing channel plates erosion and frequent chocking in cooling water system, shaft seal system.
- Design flood is for 10,000 years return period flood.

2.5 Budhi Gandaki Hydropower Project, Gorkha and Dhading

Budhi Gandaki Hydropower Project is one of the promising and priority storage projects of Nepal. The project is located on the Budhi Gandaki River approximately 2km form its confluence with Trisuli river at Benighat. Currently, the Feasibility Study, Detailed design report and drawings have been completed. It is storage facility with rated capacity of 1200MW, dam height of 263m and gross storage volume of 4467 million cubic meters. The mean annual energy generated by BG HPP is 3383 GWh/year out of which 1408 GWhr is produced during the winter period from mid-December to mid-May. The project cost is estimated to be 2592 million USD (US$ 2160 per KW).

Figure 2-10: Budhi Gandaki River- Upstream of Dam Site

3 Conclusions

Following conclusions were derived from the field study.

Findings and discussions	Conclusions
Wear and tear of turbines of Marsyangdi Hydropower plant is less even though the sediment load in the Marsyangdi river is high. This is due to high sediment trapping of settling basin which is designed adequately for particle size of 0.125 mm.	Proper / adequate design consideration hence can considerably accommodate high range of sediment in terms of particle size and concentration. This supports the argument that 'robust' design can serve as good adaptation measure.
High sediment deposition was observed in Middle Marsyangdi hydropower intake area due to its improper location.	Appropriate study, site selection and design can help the hydropower plants to avoid such cases and influence sediment related impacts.
New technology for sediment removal in Upper Marsyangdi A hydropower has been adopted. This is beneficial as it can handle wide range of sediment load and has continuous flushing system. However, it is new and its performance has to be observed in coming years.	Adoption of new technology can be promising adaptation option for sediment handling in current and future condition.
Middle Maryangdi and Marsyangdi hydropower (both NEA owned) have design flood of 10,000 years return period. Currently, design flood for similar projects is taken as 1,000 years return period flood by private sectors. Considering the future consider of climate change, floods are expected to be higher in magnitude.	Adequate design consideration (like for 10,000 years return period flood) has handle more risk. This calls for revisiting of flood design standards used by private sectors.

4 References

NEA (2016) (a): Marsyangdi Hydropower Station, Presentation Slides, Nepal Electricity Authority

NEA (2016) (b): Middle Marsyangdi Hydropower Station, Presentation Slides, Nepal Electricity Authority

Annexes

Annex I: Resource persons

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Dr. Laxmi Prasad Devkota	Chairperson, Budhi Gandaki Hydropower Project Development Committee	Mobile No: 98510-10687	lpdevkota@yahoo.com
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Mr. Krishna Bahadur Rajbhat	Site Incharge, Kudhi Hydropower	Mobile: 98512-25183	xx

Annex II: List of Participants

PAC Members			
SN	**Position**	**Name**	**Institute**
1	Member	Mr. Ratna Mani Bhattarai, Program Director	National Planning Commission
2	Member	Mr. Sagar Gaotam	Under Secretary, MoE
Project Team			
3	M & E/ED	Dr. Jaya K Gurung	Executive Director, NDRI
4	TL	Dr. Divas B Basnyat	Team Leader, Study Team, NDRI
5	Hydro P Spec	Prof Hari Pandit	NDRI/IOE
6	Sr. Advisor	Dr Laxmi Prasad Devkota	NDRI
7	Admin/Finance Specialist	Roopa Bhandary	NDRI
8	Sr. Advisor	Dr. Nawa Raj Khatiwada	NDRI
9	RA	Dibesh Shrestha	NDRI
10	RA	Shiva Gopal Shrestha	NDRI
11	Photographer 1	Mr. Bijaya	
12	Photographer 2	Ms. Geeta	

Annex III: Project Brochure

Marsyangdi Hydropower project

Turbine Assembly and Accessories in Operation

Generators:

Type	Vertical shaft
Number	3
Capacity	30 MVA
Power factor	0.85
Voltage	11KV
Frequency	50HZ

Transformers:

Type	Signle phase
Number	9 + 1 No. Spare
Capacity	3 x 10 MVA (per bank)
Voltage ratio	11/132 KV

Commencement of construction : Falgun 2043 (Feb. 1986)
First impounding of reservior : Shrawan 2046 (Aug. 1989)

Commissioning Date:

Unit"1 27 Marga 2046 Dec. 12, 1989
Unit"2 23 Kartik 2046 Nov. 8, 1989
Unit"3 14 Ashwin 2046 Sep. 30 1989

Commercial Operation Started

Unit"1 12 Poush 2046 Dec. 27, 1989
Unit"2 22 Marga 2046 Dec. 7, 1989
Unit"3 20 Kartik 2046 Nov. 30, 1989

Total Running Hours

Hours	Unit 1	Unit 2	Unit 3
Till Chaitra 2072	183961.87	189441.67	189567.4

Energy Generaed (KWH) and Plant factor

Fiscal Year	Generated Units	Plant Factor
FY-2046/047 (1989/090)	23,24,33,600	38.45%
FY-2047/048 (1990/091)	34,88,82,100	57.72%
FY-2048/049 (1991/092)	41,33,62,800	68.39%
FY-2049/050 (1992/093)	40,20,20,900	66.51%
FY-2050/51 (1993/094)	42,35,09,600	70.06%
FY-2051/052 (1994/095)	44,98,08,500	74.42%
FY-2052/053 (1995/096)	48,39,28,200	80.06%
FY-2053/054 (1996/097)	46,52,75,200	76.98%
FY-2054/055 (1997/098)	44,99,59,300	74.44%
FY-2055/056 (1998/099)	47,1925,500	78.08%
FY-2056/057 (1999/00)	45,76,68,000	75.72%
FY-2057/058 (2000/01	43,09,86,300	71.30%
FY-2058/059 (2001/02)	38,61,33200	62.88%
FY-2059/060 (2002/03)	33,39,21,000	55.24%
FY-2060/061 (2003/04)	24,46,50,000	40.48%
FY-2061/062 (2004/05)	33,56,53,200	55.53%
FY-2062/063 (2005/06)	36,94,16,300	61.12%
FY-2063/064 (2006/07)	40.15.68,300	66.44%
FY-2064/065 (2007/08)	41,27,99,800	68.29%
FY-2065/066 (2008/09)	40,48,05,200	66.97%
FY-2066/067 (2009/10)	40,50,04,900	67.01%
FY-2067/068 (2010/11)	42,31,61,300	70.01%
FY-2068/069 (2011/12)	44,58,99,400	73.77%
FY-2069/070) (2012/13)	45,01,36,000	74.47%
FY-2070/071 (2013/14)	46,16,88,100	76.38%
FY-2071/072 (2014/15)	47,29,81,920	78.25%
	Total 10,57,77,44,020	**Units**

Cumulative Energy Generation (kwh)

Date	Energy KWh.	Remarks
Till Ashad 2072	10,57,77,44,020 Units	

Major Events

1. Shaft Seal Water was managed from Rowa Khola for alternative arrangement during rainy season when Marsyangdi River Water include a lot of Silts.
2. New Control Room for Weir Control was Built in 1993.
3. Gantry Crane and Racking Machine were installed in Dam Site in FY 049/50.
4. Trifurcation Works in Power House was completed in 2054 summer for solving load fluctuation in Units. At same period Sill 4 was built between Intake nad Compensating Poundage.
5. On 14th Shrawan 2060, Flood and Land Slide in Rowa Khola swept away many vehicles, a bridge in Prithbi

Power House Control Room

Rajmarga Near Power house. Flood entered into Ventillation Room, Battery Room etc of Power Station distrubing operation of Power Station for 19 days.

6. Debris from Rowa Khola entered also into Tailrace Tunnel of which no. 2 was Cleaned in 2060 Shrawan, Bhadra and Cleaning of Tailrace Tunnel No. 1 and 3 were completed in 2063 Falgun.
7. In 2061 Jestha, electnonic Governors were changed into Digigal Governor in all 3 units.
8. In 2064 Magh, Flashover took place in Duresca Bus Bar of Outgoing Feeder of Unit 2. Those Duresca bus Bar was Replaced by 800 mm^2 Copper Power Cables.
9. On 14th Bhadra 2065, a flood of 3850 Cumecs recorded in Marsyangdi river which is the highest so far. Latest overhauling of Unit 1, Unit 3 and Unit 2 took place in 2064 Poush, Magh; 2065 Bhadra, Asoj and 2065 chaitra, 2066 Baishak reseectively.
10. The esisting CT's of 400/1Amp on outgoing 132 kv line to Suichatar and Bhratpur were replaced by CT's of 600/1 Amp in Falgun 2068.
11. New data communication link between powerhouse and Damsite have been established.
12. Weir control system modernization work completed in fiscal year 069/070.
13. Complete GIS sub-station refurbishment work completed in fiscal year 070/071.
14. Complete Digital Excitation modernization work of all three units completed in fiscal year 071/072.

Weir Site

NEPAL ELECTRICITY AUTHORITY

MARSYANGDI HYDRO POWER STATION

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INTRODUCTION

The Marsyangdi Hydro Power Station is currently Nepal's Second Largest Hydro Power Station with designed annual generation of 462.5 GWh. Commissioned in 1989, it is a Run Off River type Power Station having total Rated Capacity of 69 MW & daily Peaking Capacity for 4 hours when the river discharge is minimum. The Power Station uses potential of Marsyangdi River on a river sectioin of 13km where the Gross Head of about 95m is available. The plant was inaugurated in the month of February, 1990.

LOCATION

The Marsyångdi Hydro Power Station has been constructed on the right bank of Marsyangdi River of Gandak Basin. The site lies on the Kathmandu-Pokhara Highway at Aanboo Khaireni Village Development Committee Ward No. 8 of Tanahun District, about 120 Km west of Kathmandu at 84"30' east longitude and 27.55 north latitude.

HISTORICAL BAQCKGROUND

During the period of construction of Kathmandu-Pokhara Highway in 1966 AD, Chinese Technicians had pointed out the possibility of Hydrppower generation in Marsyangdi River.

The Feasibility Study of the Project was carried out in the fiscal year 1978/079 with the financial grant assistance of the Government of Federal Republic of Germany. As a result of discussion with World Bank and KFW, detailed Investigation, Design, preparation of tender documents were carried out under the financial grant assistance of the Government of Federal Republic of Germany. The construction of the Project was started in fiscal year 1985/086 with the Co-financing of IDA, KFW, SFD and KFAED. Additionally ADB has financed the construction of the 132 KV Transmission Lines.

INVESTMENT

The project has been built by Nepal Government at a total cost equivalent to approximately US $ 221.57 million in 1989 with the financing by various organizations as follows:

IDA	US$	96.00 million
KFW	US$	93.00 million
KFED	US$	9.5 million
SFD	US$	11.5million
ADB	US$	4.36 million
Nepal Gov.	US$	7.21million

The amount contributed by KFW has been given as a grant and the other amounts are as a soft loan to Nepal Government upon completion. Nepal Government handed over the project to NES at a total cost of NRs. 5,318,764,000/- at the interest rate of 10.25% for 30 years. From year 2064/65 the interest rate has been dropped to 8.5 percent.

MAIN FEATURES

A. WEIR AND WATERWAYS

A Concrete Weir of about 102m length has been constructed to divert the Marsyangdi River. Five Stel Radial Gates are provided in the weir to control water discharge designed up to the flood of 9100 m3/sec. Out of those 5 Radial Gates, three are of 16m wide and 13.8m high and remaining two are of 16m wide 14.8m high with flaps.

The water diverted then enters 400m long and 75m wide De-silting Basin through a Concrete Sill. While flowing throuth the De-silting Basin at a minimum velocity all silts above 0.125mm size setles down in the basin. Silt deposited in the basin is regularly flushed through 44m wide Flushing Structure provided iwth two 16m wide 15.8m high Steel Radial Gates with Flaps. Water from the Compensating Poundage enters the Headrace Tunnel through the 11.5m high and 11m wide Bell-mouth type Intake Structure. The Headrace Tunnel is 6.4m in diameter and 7119m in length and it is Concrete Lined.

At the end of headrace Tunnel a 56m high and 20.5m diameter Throttle type Surge Tank is constructed. The main purpose of Surge Tank is to reduce the effect of Water Hammer, Which occurs during the sudden closing of power generation, thus avoiding the entry of air inside the Tunnel. Water from Headrace Tunnel enters the Turbine throuth the underground Steel Lined Pressure Shaft connected through a Trifurcation to a manifold of three branches.

B. POWER HOUSE

The Power House is Semi-underground type with three shafts to house Generating Equipments. The 14.4m diameter and 38m depth shafts are concrete lined and interconnected by a Gallery. Three Francis type. Turbines are installed in Powerhouse each with a capacity of 26 MW. Each Turbine is coupled with 30MVA, 11KV Generator. Electricity generated from the Generating units is stepped up to 132 KV by 11/132 KV Single Phase Transformers. It is connected with central grid with GIS type Indoor Switchgear housed in Powerhouse itself. This type of Switchgear was installed for the first time in Nepal and has the advantae of minimum space and low operation and maintenance cost.

After generation of electricity, the used water is then diverted to the Marsyangdi River through Draft tubes. Tailrace tunnels and Outlet structures.

C. TRANSMISSION SYSTEM

Marsyangdi Power Plant is connected to the Central Grid system with two single Circuit 132 KV Transmission lines 83 and 25 Km in length which links the Power Plant with Suichatar Substation in Kathmandu and Bharatpur Substation in Chitwan respectively.

STAFFS

At present, 75 No. Permanent, 24 No. Myadi & 11 No. Daily wages in total 110 number of staffs are working in the Power Station. Technical staff includes a Station Manager, a Senior engineer, 5 engineers, 2 Assustabt engineers and non-technical Staff include one Assistant Director and one administrative officer.

SALIENT FEATURES OF THE POWER STATION

Catchment Area	3850km^2
Average Annual Discharge	210m^3/s
Gross reservior Storage Capacity	$3.20 \times 10^6 m^3$
Volume of daily Poundage	$1.5 \times 10^6 m^3$
Surface area at maximum Operating Level	62ha
Maximum Flood Discharge	3850m^3/s
Minimum Flood Discharge	33m^3/s
Total estimated Sediment Transportation	29.6×10^6 ton/year

POWER HOUSE BUILDING

Semi-underground type with three shafts for Generating Equipments.

Shafts: (ground floor to bottem of shaft)

Height	38m
Diameter	14.4m

above the ground level

Length	86m
Width	25m
Height	13m

CONTROL BUILDING

Length	29m
Width	27m
Height	21m

TAILRACE TUNNEL

Three rectangular with circular vault as crown tunnels with gates

Length	30m, 35m, 40m
Height	4.5m
Width	4.5m

Inspection of Runner and Guide Vanes

POWER PRODUCTION

Power plant is operated as Run off River plant with daily Peaking Capacity.

Power generated form three units of rated	23MW each
Total annual Designed energy production	462.5 GWh

TECHNICAL DATA OF EQUIPMENT

Turnines	
Tupe	Francis
Number	3
Rated Turbine Discharge	30.5 m3/s
Rated Speed	300 rpm
Rated Output	26 MW
Head Range (except during flood time)	89.5 to 95.0m

Middle Marsyangdi Hydropower Project

Major repair and maintenance work

The problem of erosion caused due to silt concentration is high in MMHPS. The major affected parts are: chute, sill beam of radial gate; sliding plates, fixed plates and sluice gate of desander; and turbine parts at powerhouse. Inspection and repair of sill beam and desander is generally done each year.

The inspection of runner and other turbine parts is done once a year and complete overhauling of one unit is also carried out each year.

The underwater turbine parts (facing plates and wearing rings) of MMHPS were initially hard coated while the guide vane and runner blades were soft coated to minimize the erosion rate. Presently, thermal spray coating is done in wearing rings (band side & crown side) of runner during overhauling.

Similarly, left bank rip rap gabion protection work was carried out for 15 days starting from 2071/10/09. The plant was shut down during that period.

Online sediment monitoring system

Due to high concentration of sediment, the funding agency has proposed and installed online sediment monitoring instruments at Headwork's Intake as well as at Turbine Inlet. These devices display and store real time data regarding sediment size and ppm value.

Unit/Plant shutdown due to Overhauling/emergency maintenance/ Outage

Unit 1

S. N.	Shutdown Date	Shutdown Period (Days)	Maintenance Type
1	2067-05-18	3	2 days Shutdown due to problem in Guide Vane Operating Ring
2	2067-08-02	15	Minor Refurbishment
3	2068-10-13	37	Overhauling
4	2070-05-14	3	Minor Refurbishment
5	2070-11-16	10	Minor Refurbishment
6	2071-10-09	15	15 Days plant shutdown for left bank gabion protection work
7	2071-12-05	26	Overhauling

Unit 2

S. N.	Shutdown Date	Shutdown Period (Days)	Maintenance Type
1	2067-08-11	11	Minor Refurbishment
2	2068-04-04	7	Software problem (Forced Outage)
3	2068-10-15	14	Minor Refurbishment
4	2069-04-25	4	Minor Refurbishment
5	2069-10-17	27	Overhauling
6	2071-10-09	19	15 Days plant shutdown for left bank gabion protection work and U2 refurbishment
7	2072-11-25	34	Overhauling

MMHPS Power House

Benefits to Local

During construction, the project has constructed many schools, colleges, temples, health posts, roads, water supply and also has provided job to many Locals. During the operation phase of the plant it is providing regular maintenance on the road, street lights from Power House to Fedikuna. Similarly the plant has been supporting programs like 'Hariyo Ban' which carries afforestation jobs.

Contacts

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Nepal Electricity Authority
Generation Directorate
Middle Marsyangdi Hydropower Station
Siundibar, Lamjung

MMHPS Dam and Reservoir

Introduction

Middle Marsyangdi Hydropower Station (MMHPS) has been generating electricity by diverting water of Marsyangdi River which is originated from Tilicho Lake and flows from Himalaya towards south crossing Manang, Lamjung and Tanahu District, finally joining into river Trishuli at Aanbu Khaireni, Mugling. MMHPS has an installed capacity of 70MW and designed annual generation of 398 GWhr.

MMHPS is a daily pondage run off river hydropower with daily peaking capacity of 5 hrs at minimum discharge.

The project was completed on 2008 and was inaugurated on December 14, 2008. The commercial generation started one month later.

Location

MMHPS is located near Besisahar in the Lamjung District (Gandaki Zone), about 170Km west of Kathmandu and on the right bank of the Marsyangdi river. The Damsite is 35 km and the powerhouse site is 27 Km from Dumre to the North.

Investment

The Government of Germany, through Kreditanstalt fur Wiederafbau (KfW), Nepal Government and Nepal Electricity Authority had jointly financed the project. The total cost of the project was NRs. 27.6 Arab till on project handover date- 23rd July, 2010.

Contractors during construction

Sector	Contractor
Civil works- Lot C	Dywidag- Dragados- CWE Joint Venture(DDC JV)
Electrical Equipment works-Lot E	Alstom Power
Mechanical Equipment- Lot M	Voith Siemens
Hydraulic Steel Structure- Lot HSS	VA-Tech
Switchyard	Areva
132 Switchgear- Lot SS2	Alstom
Transmission line- Lot TRL	SAG
Camp Construction	Tundi Lama JV
Appliances	SAKO Engineering
Furniture	Bindeswori

Salient Features of the PowerStation

General	
Type of project	Run off river with daily pondage for 5 hours peaking
Maximum gross head/net head	110m/98m
Total length of water ways	5940m
Power and Energy	
Installed capacity	70 MW
Annual average energy(designed)	398 GWh
Hydrology	
Catchment Area	2,729 km^2
Reservoir	
Minimum/ Maximum operating level	621.0 masl/626.0 masl
Live storage volume	1.65 million m^3
Dam	
Type of dam	Combined concrete gravity and rock fill dam
Spillway capacity	4,270 m^3/s (Design flood 10,000 years return period)at headwater level of 626.0 masl
Spillway gates(3)	Radial gates, W×H= 12.00m × 19.54 m
Energy dissipation	Roller bucket
Intake structure	
Type	Submerged tunnel intakes with trash racks and gates
Desander basins	
Type	Underground desander in caverns
Length/ Width/Height per cavern	130m/ 15m/27m
Number of basins	6 accommodated in 3 caverns, i.e. 2 in each
Length/width /height per basin	100.75m/7.50m/25.1m
Flushing operation	Vertical flushing; BIERI system
Power Tunnel and Surge Tank	
No. of adits	5
Diameter	5.4m
Power Tunnel(low pressure line)	
Length	5,230m (between desander outlet and surge tank)
Surge tank	
Type	Vertical, circular surge tank, underground, concrete lined with throttle
Net diameter	20m, orifice Ø2.90m
Height	45m
Power Tunnel(High Pressure Line)	
Length	225m(between surge tank and discharge measurement chamber)
Lined tunnel diameter	4.60 m
Lining	Steel
Penstock	
Number, Type	1, concrete castes steel pipe(cut and cover)
Diameter penstock/bifurcation-manifold	Ø4.6m/ Ø3.0m to Ø240m
Length	212-218m(between discharge measurement chamber and turbine inlet valve)
Switchyard at MMHPS	
Type	Open- air switchyard at el. 540.0 masl
Dimension(L×W)	43m×50m
Turbines	
Number and Type	2 Francis, vertical shaft
Rated Discharge	42.4 m^3/s
Rated output	37,928 kW
Rated speed	333.33 rpm
Generators	
Number and type	Two, 3-phase synchronous
Rated output	39 MVA
Power factor	0.85-0.90
Transmission line	
Route	Middle Marsyangdi HPS- Marsyangdi HPS(Lower Marsyangdi)
Nominal voltage/ length/size	132kV,38.2km, cardinal

This plant also consists of 10/12.5MVA power transformer to facilitate grid connection of local IPPs. It has greatly reduced the frequent outages used to occur while connecting them to grid via 33kV Dumre-Udipur line.

Machine Floor

Energy generated and station Chiefs up to date

Annual design generation: 397,590 MWhr

Fiscal Year	Annual Energy Generated (MWhr)	Station Chief
065/066	168,999.80	Mahendra Raj Adhikai
066/067	390,037.40	
067/068	377,151.30	
068/069	425,344.20	Ram Kumar Yadav
069/070	428,082.19	
070/071	434,171.71	Chandra Shekhar Chaudhary
071/072	457,318.09	Rajesh Kumar Pandey
072/073	435,558.76	

Note: Generation for FY: 065/066 was started only since Magh.

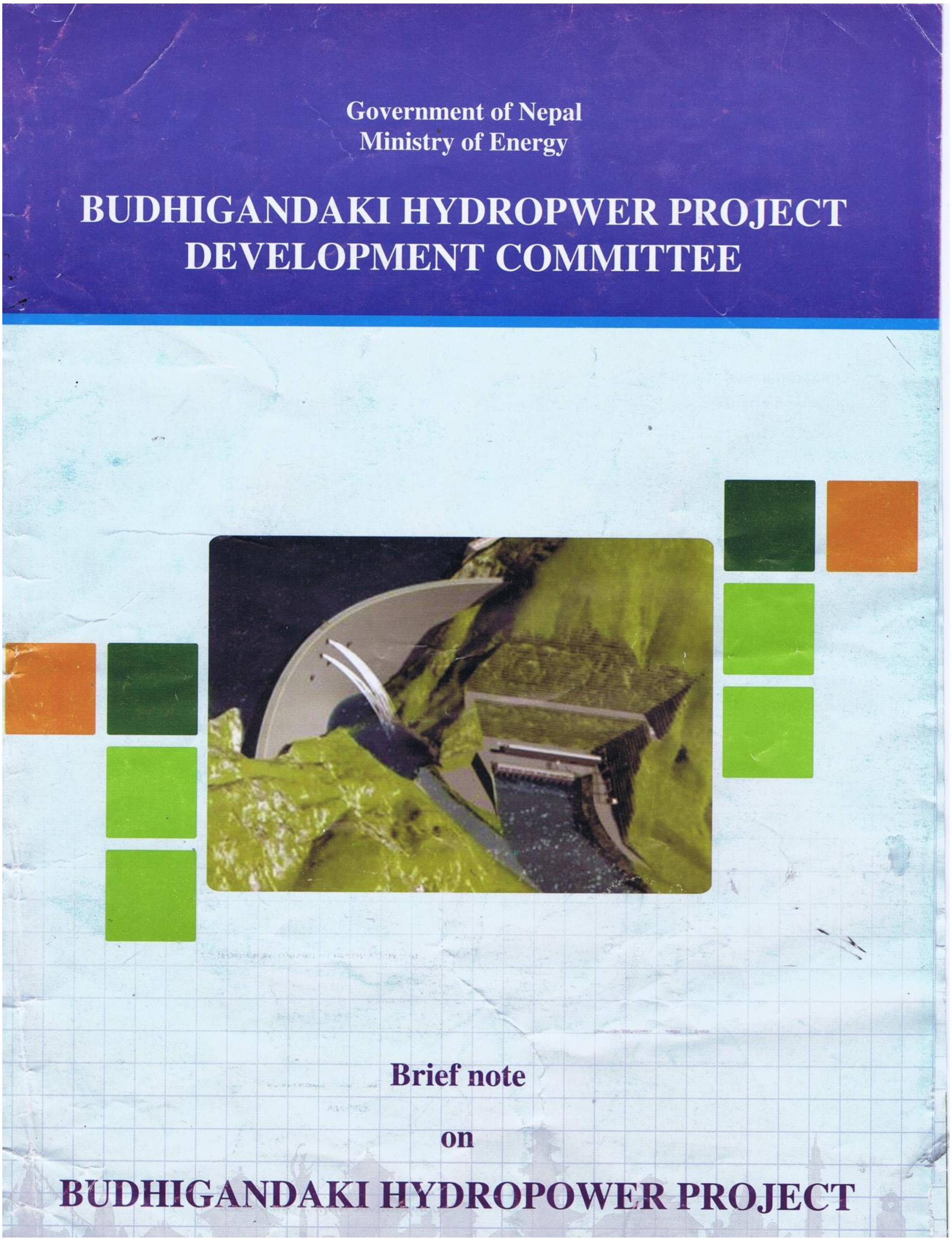
Total cumulative generation

Upto Asar 31, 2073, the total cumulative generation is 3118.02 GWhr, where contribution from Unit1 and Unit2 are 1636.92 GWhr and 1481.09 GWhr respectively. Similarly, the total running hour of Unit 1 and Unit2 are 55500.90 Hrs and 49739.0 Hrs respectively.

Staffs

Currently, there are altogether 70 staffs which includes one Station Chief, five section chiefs (Mechanical, Electrical, Civil, Account and Administration), Engineers, officers, and other technical and administrative staffs.

Budhi Gandaki Hydropower Project



Government of Nepal
Ministry of Energy

BUDHIGANDAKI HYDROPWER PROJECT DEVELOPMENT COMMITTEE

Brief note

on

BUDHIGANDAKI HYDROPOWER PROJECT

1. BRIEF INTRODUCTION

1.1. Background

Out of the total installed capacity of 787 MW in the Integrated Nepal Power System (INPS), the Kulekhani HEP (1 and 2) (60 MW + 32 MW = 92 MW) is the only storage hydropower plant capable of seasonal regulation. The existing peaking capacity is insufficient to meet the peaking demand in the system. This is shown by the severe capacity and energy shortage during the dry season. Most of the plants that are being implemented or committed/planned are Run of River (ROR) plants. With the addition of more ROR plants, there will be an increasing surplus of energy during the wet season and a deficit in the dry season. The seasonal fluctuation of water discharge in the rivers of Nepal is the main cause for this imbalance. The dry season flow becomes almost one tenth of flows in the wet season. As a result, INPS will continue to be a sub-optimal system in the absence of peaking plants, resulting in the spilling of water during the wet season at ROR plants and capacity deficit during the dry season. A storage project of sufficient capacity is an ideal remedy for such a situation.

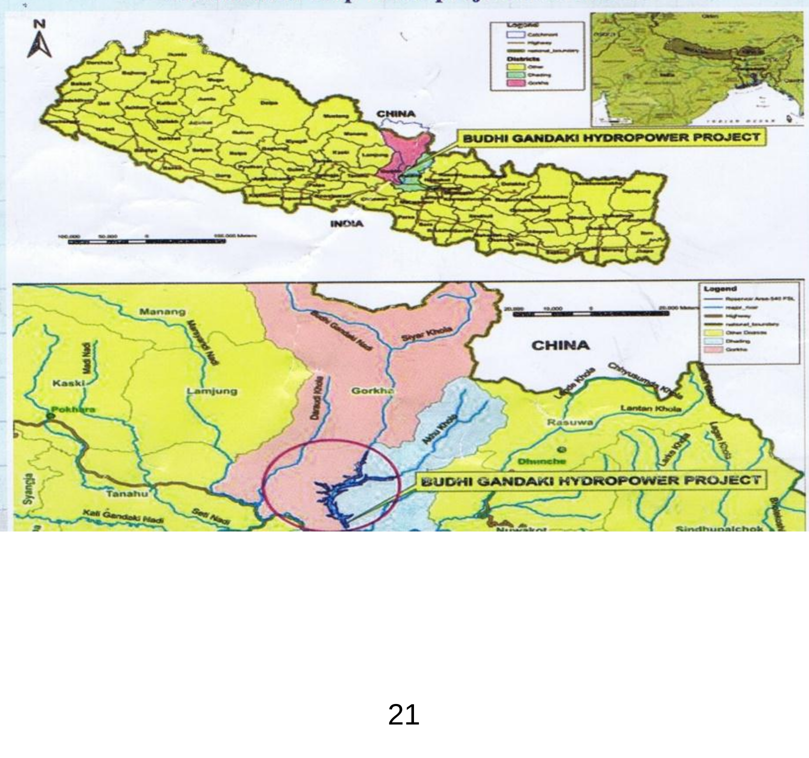
1.2. Recall of the Project location and context

The Budhi Gandaki Hydropower Project is located on the Budhi Gandaki River, approximately 2km from its confluence with Trishuli River at Benighat. Benighat can be accessed by the Prithivi Highway linking Kathmandu and Pokhara about 80km from Kathmandu. The Project area lies in the districts of Gorkha and Dhading of Western and Central Development Region of Nepal.

The Budhi Gandaki Hydroelectric Project is a large seasonal storage-type project able to fully store the monsoon inflows and release them later during the dry months. Therefore this Project responds perfectly to the urgent need of power regulation, especially during the dry season from mid-December to mid-May.

A prefeasibility study of this project was carried out in 1983-1984 by the Government of Nepal. It recommended designing a 225m high rockfill dam with clay core, in a narrow and steep valley, retaining a reservoir of 3,320 hm3 with its FSL at El. 520. The underground powerhouse connected to the reservoir by a 276m long headrace tunnel was designed with four Francis turbines rated for a net head of 185m and a discharge of 4 x 107.5 m3/s thus providing a total installed capacity of 600MW and generating an average annual energy of 2,495GWh. The study concluded that the project has a high energy potential, large storage volume, and favorable location and access in Central Nepal near the main load center.

The location map of the project is as under:



Till date, the Feasibility Study, Detailed Engineering Design Report/Drawings and preparation of Tender Document of this project have been completed in all respect. Based on the Final Detail Design Report, the salient features of the project are as under:

SALIENT FEATURES

1. Reservoir

Full Supply Level (FSL)	El. 540 masl
Maximum Flood Water Level	El. 542 masl
Reservoir upper boundary incl. 3m freeboard	El. 545 masl
Minimum Operating Level (MOL)	El. 496 masl
Minimum Operating Level Ultimate (MOL.ult.)	El. 467 masl
Minimum Reservoir Level (MRL)	El. 440 masl
Reservoir Bottom Level	El. 326 masl
Gross Capacity (at FSL)	4 467 Mm3
Active storage between FSL and MOL	2 226 Mm3
Reserve Live Storage between MOL and MOL.ult.	952 Mm3
Conservation volume between MOL.ult. and MRL	582 Mm3
Dead Storage between MRL and reservoir bottom	708 Mm3
Surface Area (at FSL)	63 km^2
Surface Area (at MOL)	39 km2

2. Hydrology

Catchment Area	5 005 km2
Long Term Average Flow	222 m3/s
Construction Flood (20 years)	3 070 m3/s
Design Flood Discharge (10 000 years)	6 260 m3/s
GLOF	3 000 m3/s
LDOF	5 200 m3/s
Probable Maximum Flood	9 800 m3/s

3. Sedimentology

Sediment inflow	9.8 million m3/year
Active storage loss after 50 years	7%
Active storage loss after 100 years	13%

4. Diversion System

Design Flood	3 070 m3/s
Tunnel section, lining	Horseshoe exc., inner circular concrete lining
Number of tunnel	2
Diameter	12 m
Lengths	
DT N°1	408m
DT N°2	438m
Crest Elevation of D/S Cofferdam	El. 332.50 masl

5. Dam

Type Concrete double curvature arch	
Crest Level	El. 542masl + 1.1m u/s parapet
Maximum Height (above dam foundation)	263 m
Crest Length / Width at base/ at crest	760 m / 80m / 8m
Upstream and Downstream Slopes Variable	
Construction materials:	
Conventional Vibrated Concrete (CVC)	1.92 million m3
Roller Compacted Concrete (RCC)	3.84 million m3
Total Concrete Volume	5.75 million m3

6. Spillway

Type	Orifice gated spillway with flip bucket
Number of bays	6
Bay dimensions	Width 5.6 m – Height 8.4 m
Crest Level	1 at El.515 masl / 2 at El.495 masl 2 at El.470 masl / 1 at El.460 masl
Design Flood (Routed)	6 280 m3/s for PMF, 4 690 m3/s for Q10000
Gate Type	Radial gate with hydraulic hoists
Gate size	5.6 m x 8.4m, Six gates

7. Waterway and Powerhouse

Intake structures	Bell mouth intake structures close to the dam on the left abutment
Total Rated discharge	6x112=672 m3/s
Number of intake	6
Invert Level of Intake	El. 450masl HRT invert level at El.455.60masl
Gate Size- Stoplog and wheelgate	Span = 4 m / Height = 6m
Headrace Tunnel HRT:	
Number of HRT	6
Intake Tunnels	Ø 6m Concrete lined circular 107m Horseshoe Exc. Section
Headrace Tunnels	Ø 5.3m circular Steel lined 22mm From 87m for Unit 6 to 165m for Unit 1 Horseshoe Exc. Section
Pressure Shaft	Ø 5.3m circular Steel lined 28 to 45mm 140m high Circular Section
Penstock	Ø 5.3m circular Steel lined 45mm

	From 352m (unit 6) to 365m (unit 1)
	Horseshoe Exc. Section
Powerhouse and transformer building	Type: Outdoor in the left bank
Width, Length and Height	W 40 m x L 185 m x H 40 m
GIS building and potyard	Adjacent PH on platform at El.342
Width, Length and Height	W 60 m x L 112 m x H 15 m

8. Generating Equipment

Turbine:	
Type	Francis Type, vertical axis,
Number of units in final stage	6
Net Head at Rated Water Level	200 m
Rated Discharge in finale stage	6 x 112 = 672 m3/s
Installed Capacity	6 x 200 MW = 1 200 MW
Mean Annual Energy	3 383 GWh
Winter dry season Energy	1 408 GWh
Summer wet season Energy	1 975 GWh
Firm Power during dry season	from 1 200 MW 8h/day in Dec.
	to 934 MW 9h/day May
Firm Power during wet season	from 918 MW 7h/day in June.
	to 928 MW 4h/day Nov.
Turbine Rated Speed	230.8 rpm
Normal Tailwater level with 6 units in operation	El. 323.30 masl
Generator:	
Type	Vertical shaft revolving
Capacity in final stage	6 x 235 MVA = 1 410 MVA

9. Transmission Lines

Number	2
Voltage	400 kV
Circuit	Double circuit
Conductor	Quad Bundle MOOSE
Length BG HPP to Naubise	40.3 km
Length BG HPP to Hetauda	58.7 km

10. Substations

Number	2
Location	1 in Naubise and 1 in Hetauda

11. Costs

Total Capital cost	2 592 MUSD
Environmental and Social Cost	612 MUSD
Civil Works	1 263 MUSD
HEM and E&M	571 MUSD
HV lines	33 MUSD
Infrastructures and roads	55 MUSD
Engineering and Administration	57 MUSD

12. Economic & Financial parameters

Economical Internal Rate of Return EIRR	
Medium load demand forecast scenario	12.9%
High load demand Forecast scenario	13.8%
Financial Internal Rate of Return FIRR	8.2%
Average energy cost	US¢ 6.4/kWh
Energy Tariff	
For financing with	
80% soft loan at 2% and 20% equity	
Return on Equity 15%	US¢ 9.3/kWh.
Return on Equity 12.9%	US¢ 7.6/kWh
Corresponding FIRR	9%

13. Benefits

Energy sales from Budhi Gandaki HPP	see 12.
Downstream flood reduction	+50% from Jan. To May
Downstream increase of mean dry season flow of	
Naranyani river at Devghat and Gandak Barrage	

14. Manpower requirement

Foreign	300
Skilled	570
Semi-skilled	1 140
Unskilled	3 990
Total	6 000

Annex IV: Photographs

Field Visit Team in Marsyandgi Hydropower Station

Test Tunnel at Budhi Gandaki HEP Dam Axis

Weir Structure of Middle Masrsyangdi HEP

Downstream of weir structure of Upper Marsyangdi A

Leakage in Penstock Pipe in Khudi HEP

Presentation in Marsyangdi Hydropower Station

Control room of Upper-Marsyangdi A HEP