A CASE STUDY OF PHEWA HYDROPOWER PROJECT

Project Report II submitted in partial fulfilment of the requirements of Pokhara University for the degree of the Bachelor of Engineering

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It is certified that this project II, titled **"A CASE STUDY OF PHEWA HYDROPOWER PROJECT"** is the bonafide work of **Miss Santona Baral, Miss Bishnu Subedi, Miss Sandhya Thapa, Miss Sanchita Acharya, Miss Niruta KC, and Miss Kriti Kumari Sapkota, -**who carried out the project work under my supervision. According to the reported information the work reported herein doesn't form part of any other thesis or dissertation or project on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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ACKNOWLEDGEMENT

It is our great pleasure to submit this report on "**A CASE STUDY OF PHEWA HYDROPOWER PROJECT**" to the Faculty of Science and Technology in partial fulfillment of the requirement for the Bachelor's degree in Civil and Rural Engineering.

Completing this project has been a wonderful experience. The success of this project required a lot of guidance and assistance from many people, and we would like to express our deep gratitude to every individual for their support and coordination.

We would like to express our sincere gratitude and heartfelt thanks to our esteemed supervisor, **Er. Ananda Dev Bhatt,** of the School of Engineering, Pokhara University for providing his valuable support, positive suggestions and continuous guidance throughout the completion of this project. Accomplishing this project would have been impossible without his invaluable guidance..

We would like to extend our deep appreciation and acknowledgement to Dean, Professor Dr/Er. Rajesh Thagurathi, Faculty of Science and Technology, Professor, Er. Om Prakash Giri, Director of School of Engineering and Professor Er. Sanjay Baral, Program Co-Ordinator of Civil and Rural Engineering of Pokhara University for giving us this opportunity.

We would like to express thanks to Professor Er. Saugat Tiwari, Faculty of Science and Technology for providing support during the dissertation period.

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ABSTRACT

The study explores the operating system and working mechanism of "Phewa Hydropower project" located in Pardi, Birauta, Pokhara metropolitan city. It evaluates the current situation of different components of Phewa Hydropower Station in detail.

The Phewa Hydroelectric Project, is a notable hydroelectric facility located in Pokhara, Nepal commissioned in 1969. It is the first hydropower plant established in the region, marking a significant milestone in Nepal's hydroelectric development. The station is situated at Pardi, Birauta and utilizes water from the Phewa Lake, channeling it through a canal to the powerhouse. It operates as a canal drop-type power station with an installed capacity of 1 megawatt (MW), generated by four units, each producing 0.25 MW. Currently, two units are in operation and Unit No. 2 and 4 are not in operation due to problem in generator turbine coupling. The plant was designed to generate approx. 6.5 gigawatt-hours (GWh) of electricity annually, playing a crucial role in meeting local energy demands.

Thus, This report provides the summarization of every important parts of the Phewa Hydropower project, Birauta. This report mainly includes the location of the site, the description of the every component of Hydropower project like Headwork, Conveyance, Hydroelectric machines, etc. along with their Photographs, the observations made and the findings of the site. It includes general arrangement and layout of powerhouse as well.

This project group is sure that this report will be beneficial for the general study of the functioning of the Phewa Hydropower Station and its power generation mechanism. The group will also be delighted for any feedback and suggestion to upgrade this report.

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LIST OF ABBREVIATIONS

Symbol and abbreviation	Meaning
PMC	Pokhara Metropolitan City
MW	Megawatt
MWh	Megawatt-hour
GWh	Gigawatt-Hour
NEA	Nepal Electricity Authority
AD	Anno Domini
KW	Kilowatt
ROR	Run of the river
PROR	Peaking Run of the river
MIV	Main Inlet Valve
DoED	Department of Electricity Development
AEPC	Alternative Energy Promotion Centre
WECS	Water and Energy Commission Secretariats
USSR	Union of Soviet Socialist Republics

1. Introduction

1.1 Background

Hydroelectric power, or hydroelectricity, is basically a form of renewable energy that can be generated using natural forces such as gravity or flowing water. Hydropower has been recognized as a sustainable source of energy. Its benefits are that it is non-polluting as it releases no heat or noxious gases, it has low operating and maintenance cost, its technology offers reliable and flexible operation, and hydropower stations have increased efficiencies along with long life. The energy is dependent upon the hydrologic cycle of water, which includes evaporation, precipitation and the flow of water due to gravity. Gravity causes water to flow downwards and this downward motion of water contains kinetic energy, pressure energy and potential energy, which are used to produce rotational mechanical energy through turbines in powerhouse, which is further converted into electrical energy.

Hydropower is a cheap renewable source of energy with negligible environmental impacts. At a good site, hydropower can generate very cost effective electricity. These projects have low energy production cost considering the long effective lifetime of the plants, low operation and maintenance cost, greater efficiency than of the all major types of using non-renewable and renewable energy sources. It provides a reliable, efficient, safe and economic source of power for increasing effectiveness of the decentralized industries system.

The history of conversion of kinetic energy into mechanical energy dates back to two thousand years ago in ancient Greece when wooden waterwheels were used. Hydropower represents an important source of energy, accounting for one-fifth of the world's electricity supply. Most of the technically and economically feasible hydropower potential has been exploited in the developed countries and the developing countries, too, realizing the significance of this source of power for the higher sustained economic growth and development of their respective economies, have been embarking on the various phases of the hydropower development process.

Nepal has 83000 MW total hydropower potential out of which 44000 MW is technically feasible and about 42000MW is economically viable. The advent of small hydropower development in Nepal was Pharping Hydropower station in 1911 B.S with an installed capacity of 500KW as a first station in Nepal knowing immense importance of hydropower to fulfill the energy crisis. Nepal has established several programs related to energy and power under government and private sectors such as Nepal Electricity Authority (NEA), Water and Energy Commission Secretariats (WECS), Ministry of Energy, Department of Electricity Development (DoED), Alternative Energy Promotion Centre (AEPC) etc.

1.2 Hydropower Development in Nepal

Nepal, being a developing country, is facing a lot of challenges to raise its economic status. To achieve the sustainable development of any country, it is necessary to use its available natural resources. Nepal is endowed with rich hydropower resources which is the major source of renewable energy. Hence, the major achievements in the socio-economic development of Nepal could be possible through power harnessing of the water resource.

In Nepal, the first hydropower plant was established at Pharping (500-KW) in 1911, 29 years after the world's first plant was established, during Prime Minister Chandra Shamsher Rana's time to meet the energy requirements of the members of the ruling class. It is fascinating to note that Nepal had such an early start in the hydropower generation. After the establishment of the first hydropower plant (500 MW) in 1911, the second hydropower plant (640 KW) was established at Sundarijal in 1936. Similarly, Panauti (2400 KW) Hydropower Station came into operation in 1965.

The completion of Dhankuta Hydropower Station (240 KW) in 1971 was regarded as the bench mark of small hydel development of Nepal. The establishment of small hydel development board in 1975 was another milestone under which several small hydro schemes such as Jhupra (345 KW), Doti (200 KW), Jumla (200 KW) etc. were made during 1975 to 1985. Nepal Electricity Authority (NEA), established 1985, responsible for generation, transmission and distribution of electric power brought the revolution in hydropower development. Many potential sites for hydropower generation had identified by private consultancies and companies in collaboration with NEA.

Prior to 1960, all the hydropower stations were constructed through grant aid from friendly countries like the USSR (Panauti), India (Trishuli, Devighat, Gandak, Surajpura- Koshi) and

China (Sunkoshi). Since 1970, hydropower development took a new turn with the availability of bilateral and multilateral funding sources. From 1990s, subsequent to the adoption of the policy of economic liberalization, hydropower development took yet another turn with the private sector entering the arena. After formulating Hydropower Development Policy – 1992 by government of Nepal, many private sectors are involving towards power development. In order to encompass projects of various scales intended for domestic consumption as well as to export hydropower, the former policy was replaced by the Hydropower Development Policy 2001 to provide further impetus to active participation of private sectors.

Development of hydropower in Nepal is a very complex task as it faces numerous challenges and obstacles. Some of the factors attributed to the low level of hydropower development are lack of capital, high cost of technology, political instability, and lower load factors due to lower level of productive end-use of electricity and high technical and non-technical losses.

Table 1: Development of Hydropower Projects in Nepal (1911-1989)

S.N	**Hydropower Projects**	**Commissioned Year**	**Capacity (KW)**	**Cumulative Generation(KW)**	**Type**	**Located District**
1	Pharping*	1911	500	500	RoR	Kathmandu
2	Sundarijal	1936	640	1140	RoR	Kathmandu
3	Panauti	1965	2400	3540	RoR	Kavre
4	Phewa	1967	1088	4628	RoR	Kaski
5	Trisuli	1967	24000	28628	RoR	Nuwakot
6	Dhankuta	1971	240	28868	RoR	Dhankuta
7	Sunkosi	1972	10050	38918	RoR	Sindupalchowk
8	Jhupra	1977	345	39263	RoR	Surkhet
9	Dhading	1978	32	39295	RoR	Dhading
10	Tinau	1978	1024	40319	RoR	Rupendehi
11	Gandak	1979	15000	55319	RoR	Nawalparasi
12	Baglung	1981	200	55519	RoR	Baglung
13	Doti	1981	200	55719	RoR	Doti

14	Phidim SHP	1981	240	55959	RoR	Panchthar
15	Gorkhe	1982	64	56023	RoR	Ilam
16	Jumla	1982	200	56223	RoR	Jumla
17	Jomsom	1982	240	56463	RoR	Mustang
18	Kulekhani 1	1982	60000	116463	Storage	Makwanpur
19	Devighat	1983	14100	130563	RoR	Nuwakot
20	Syangja	1984	80	130643	RoR	Syangja
21	Helambu	1985	50	130693	RoR	Sindupalchowk
22	Seti,Pokhara	1985	1500	132193	RoR	Kaski
23	Salleri	1986	400	132593	RoR	Solukhumbu
24	Kulekhani 2	1986	32000	164593	Storage	Makwanpur
25	Chame	1987	45	164638	RoR	Manang
26	Manang	1988	80	164718	RoR	Manang
27	Tehrathum	1988	100	164818	RoR	Tehrathum
28	Taplejung	1988	125	164943	RoR	Taplejung
29	Chaurjhari	1989	150	165093	RoR	Rukum
30	Ramecchap	1989	150	165243	RoR	Ramachhap

(Source: https://www.nrb.org.np)

1.3 Hydropower Potential of Nepal

Nepal, lying between India and China against the impressive Himalayas, comprises of the most diverse climatic ranges and physical environment in the world. From the Gigantic plains at about 70m altitude, to the Mt. Everest at 8,848 m altitude, there is only the distance of about 170 km. These slopes are the steepest slopes in the world resulting high Hydropower potential. Because of the existence of snow feed perennial rivers, several tributaries and countless streams, Nepal, is considered as the World's 2nd richest country in the gross hydropower potential.

Gross hydropower potential of Nepal is 83,000 MW- based on a 1966 PhD of Dr. Hari Man Shrestha. However, another more scientific study lead by Prof. Narendra Man Shayk has shown that Nepal has a total potential to generate 53,000 megawatts of hydropower. *(Source: Er. K.P. , "History of Hydropower Development in Nepal")*. Another study reveals 42,000 MW is assessed to be economically feasible and 44,000 is technically feasible *(Source: NPC, 1985)*. Approximately 6000 big and small rivers have been identified in Nepal's territory carrying about 174×109m³ of surface run off annually (0.5% of total surface run off of the world)

Table 2: Hydropower Potential of Nepal (in million KW)

S.N	**River Basins**	**Theoretically feasible**	**Technically feasible**	**Economical feasible**
1	Saptakoshi	22.35	11.40	10.48
2	Karnali	34.60	24.36	24.00
3	Gandaki	17.95	6.73	6.27
4	Mahakali	1.58	1.13	1.13
5	Others	3.07	0.98	0.98

(Sourc:, C. K. Sharma, Water Resources in Nepal)

2. Significance of the study

This study has two main significances.

a. It gives detail information on the layout of hydropower plant and about its components with their working mechanism.
b. This study might be helpful as important reference study for the next hydropower project to be built having similar terrain and similar case to Phewa hydropower project.

3. Literature Review

3.1. Introduction to Hydropower Plant

Hydro Power Plant is an electricity-producing plant in which the water is an essential fuel, the potential energy is being converted into kinetic energy and kinetic energy is further converted into mechanical and into electrical energy with the help of a turbine and mortor.

3.1.1. Advantages and disadvantages

The main advantages of the hydro plant are:

a. It does not consume water so it is a renewable source of energy.
b. It does not produce any harmful by-product and hence has no adverse effect to the environment.
c. Power is continuously available according to the demand.
d. It produces the full capacity within few minute so it fulfills the peak demand.
e. No fuel and limited maintenance is required, so the running cost is low (compared to the thermal power and nuclear power).
f. It has higher energy conversion factor of about 90% which is very higher in comparison to other sources of the energy.

The main disadvantages of the hydro plant are

a. Sites that are well situated to the harnessing of water power and also close to the location where the power can be economically exploited are not common.
b. There is always a maximum useful power output available from a given hydropower site which limits the level of expansion of the activities which make the use of the power.
c. Most of the hydro power plants are located far from the city so the transmission cost becomes high.

3.1.2. Classification of Hydropower plant

1. On the basis of storage capacity
   - ROR/PROR river plants
   - Storage plants

2. On the basis of head available

- Low head plant (<15m)
- Medium head (15-50m)
- High head plant (>50m)

But in Nepal, most of the projects are constructed at huge elevation difference between the headwork site and powerhouse site so following classification is considered appropriate:

- Very Low head plant (up to 15m)
- Low head plant (below 60m)
- Medium head plant (60 to 150m)
- High head plant (150 to 350m)
- Very high head plant (>350m)

3. On the basis of capacity (In context of Nepal)

- Micro hydropower project (up to 100KW)
- Mini hydropower project (100-1000KW)
- Small hydropower project (1000-25000KW)
- Medium hydropower project (25MW to 100MW)
- Large hydropower project (above 100MW)

4. On the basis of its function

- Base load power plant
- Peak load power plant

3.2. Hydropower status in Nepal

- First hydropower generation- Pharping hydropower financed by British government, completed in 1960 B.S. 2 units of 250 kW each, Total 500 kW
- Second hydropower generation- 1991 B.S., 640 kW to supply electricity to Kathmandu valley
- Some of the present operating hydropower projects and also some proposed hydropower projects in Nepal are as listed below:

Table 3: Major Hydropower Plants in Nepal

Name	Capacity (MW)	Name	Capacity (MW)
Trishuli	24.00	Devighat	14.10
Sunkoshi	10.05	Kulekhani 2	32.00
Kulekhani 1	60.00	Upper Modi (GITEC)	14.00
Khimti khola (HPL)	60.00	Jhimruk (BPC)	12.30
Bhotekoshi (BPKC)	36.00	Kaligandaki (A)	144.00
Chilime (CPC)	20.00	Marsyangdi	69.00
Gandaki	15.00		

(Source; https://en.wikipedia.org/wiki/List_of_power_stations_in_Nepal)

Table 4: Some small project plants

Name	Capacity (MW)	Name	Capacity (MW)
Tatopani, Myagdi	2.00	Panauti	2.40
Seti, Pokhara	1.50	Phewa ,Pokhara	1.088
Hewa, Butwal	1.024	Chatara	3.20
Aandhikhola (BPC)	5.10	Indrawati (NHPC)	7.50
Piluwa khola (AVHP)	3.00	Sunkoshi (sanima)	2.60

(Source: https://en.wikipedia.org/wiki/List_of_power_stations_in_Nepal)

Table 5: Planned & Proposed projects

Name	Capacity(MW)
Rawa khola	2.30
Naugargad (Darchula)	1.80
Khudi (KHL)	3.50
Daram khola (GHP)	5.00
Chaku khola (A.power)	1.50
Thoppal khola	1.40
Lower Nayagdi (BHN)	4.50
Molung khola	1.20
Gandigad (Doti)	1.80
Mailing (MPC)	5.00
Upper khimti	4.00
Lower Indrawati	4.60
Mardi khola	1.40

(Source: https://en.wikipedia.org/wiki/List_of_power_stations_in_Nepal)

3.3. Components of Hydropower project

The major components of a hydroelectric plant are as follows.

a) Reservoir
b) Dam
c) Spillway
d) Headrace canal
e) Surge tank
f) Forebay
g) Penstock
h) Main inlet valve
i) Power house
j) Tailrace canal

a) Reservoir

The reservoir is a large body of water that stores water for the hydropower plant. It is created by building a dam across a river to hold back and collect water. This stored water provides a constant supply for generating electricity. The reservoir also helps regulate the flow of water, ensuring the plant has enough water even during dry periods. Additionally, it helps control flooding by storing excess water during heavy rains, making it an important feature for both power production and environmental management.

b) Dam

The dam is a massive wall built across a river to block the flow of water. By holding back the water, the dam creates a reservoir and raises the water level, increasing its potential energy. This energy is later converted into electricity when the water is released. The dam plays a key role in controlling water flow, managing floods, and maintaining a steady water supply for the plant. Some dams also include special openings called spillways to safely release extra water when the reservoir becomes too full.

c) Spillway

A spillway is an essential safety feature of a dam in a hydropower plant, designed to release excess water from the reservoir when it reaches capacity. During heavy rainfall or when the water inflow exceeds the dam's storage capacity, the spillway ensures that the excess water is discharged safely downstream, preventing the dam from overflowing or becoming damaged.

d) Headrace canal

A headrace canal is typically a man-made waterway used in the context of hydroelectric power generation. It channels water from a natural source (like a river or reservoir) toward the intake of a power station. The water carried through the headrace canal is usually directed to a turbine to generate electricity. The canal itself is designed to ensure a controlled flew of water, and its construction can be quite complex, involving the use of sluices, gates, and sometimes tunnels, to manage water levels and flow rate.

e) Surge tank

A surge tank is a vertical tank connected to the penstock in a hydropower plant. It helps control water pressure and flow during sudden changes in turbine operation. When the flow decreases suddenly, the surge tank absorbs excess pressure, and when the flow increases, it provides extra water. This prevents pressure surges, protects the system, and ensures smooth operation.

f) Forebay

A forebay is a basin area of hydropower plant where water is temporarily stored before going into intake chamber. The storage of water in forebay is decided based on required water demand in that area. This is also used when the load requirement in intake is less. We know that reservoirs are built across the rivers to store the water, the water stored on upstream side of dam can be carried by penstocks to the power house. In this case, the reservoir itself acts as forebay

g) Penstock

The penstock is a large pipe or tunnel that carries water from the reservoir or intake structure to the turbine. As the water flows through the penstock, it builds up pressure because of the height difference between the reservoir and the turbine. This pressure increases the energy of the water, turning it into fast-moving water that powers the turbine. Penstocks are designed to handle high water pressure and minimize energy loss during the flow.

h) Main inlet valve

The main inlet valve typically refers to a valve that controls the flow of water (or another fluid) into a system, such as a plumbing or irrigation system. It's usually located where the main water line enters a building or facility. By controlling this valve, you can stop the flow of water to the entire system for maintenance, repairs, or emergencies.

i) Power house

The powerhouse is the building that houses the key machinery of the hydropower plant, including the turbines, generators, and control systems. It is designed to provide a safe and secure environment for the operation of the plant. The powerhouse also includes a control room, where operators monitor and manage the plant's performance. This ensures that all components are working together efficiently to produce electricity.

- Turbine generator

  A turbine generator combines a turbine and a generator**.** The turbine spins when water flows through it, converting water energy into mechanical energy. This motion turns the generator, which produces electricity. Together, they convert the energy of flowing water into electrical power.

- Transformer

  A transformer is a device that changes the voltage of electricity. In a hydropower plant, it increases the voltage of the electricity generated by the turbine to make it suitable for long-distance transmission. This helps reduce energy loss during transportation and ensures the electricity reaches homes and businesses efficiently.

j) Transmission line

A transmission line carries the electricity from the power plant to the grid and then to consumers. Once the electricity is generated and transformed into high voltage, transmission lines transport it over long distances. These lines are designed to minimize energy loss during the journey, ensuring that electricity arrives at its destination efficiently and with minimal waste.

k) Tailrace canal

The tailrace is the final stage in the water's journey through the hydropower plant. It is a channel that carries water away from the draft tube and releases it back into the river or a downstream body of water. The tailrace ensures that the used water flows away from the plant without causing backflow or disturbances to the system. It helps maintain the proper functioning of the hydropower plant while returning the water to its natural course.

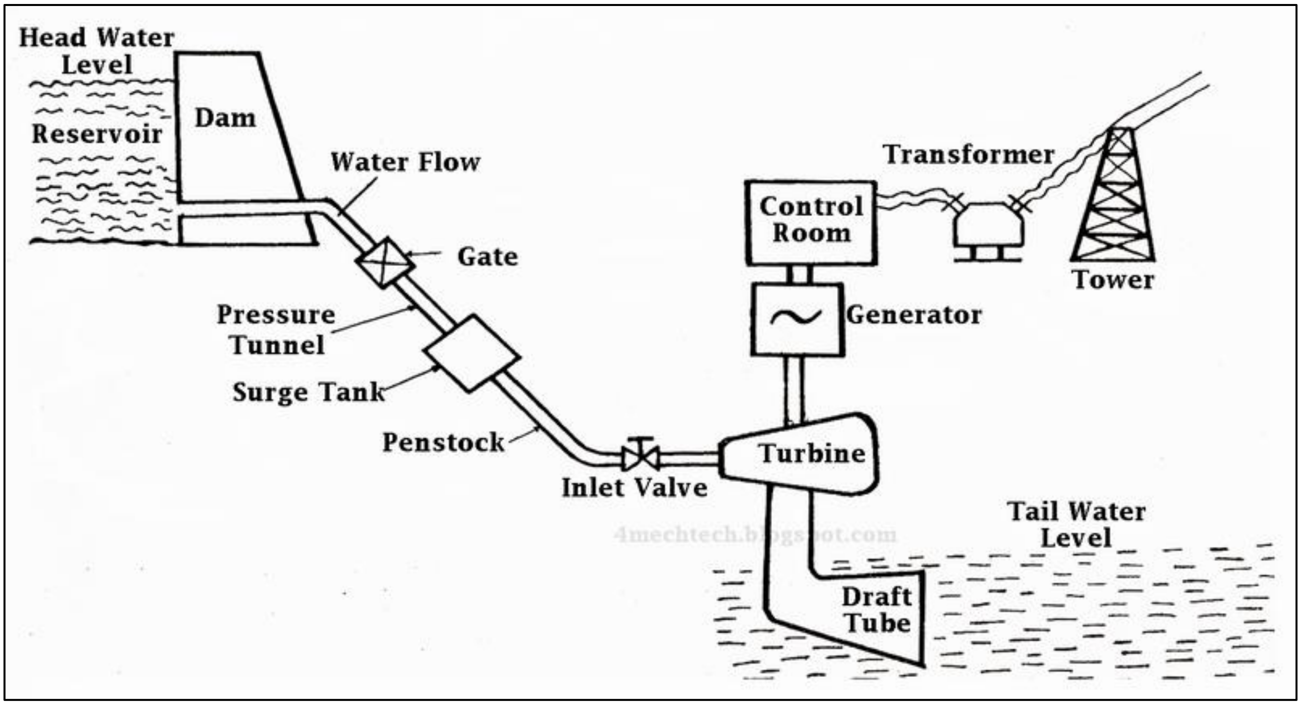

Figure 1: Layout of Hydropower plant

(Source:https://www.researchgate.net/figure/A-general-layout-of-hydro-power-plant_fig2_225102466)

3.4 Past studies on "Phewa Hydropower project"

There have been limited studies on "Phewa Hydropower Project". Existing studies have primarily focused on broader aspects, such as A Review of Hydropower Projects in Nepal – by ResearchGate in 2017, Phewa Hydropower Project – by Nepal Water Resource Portal in 2022 and Performance Analysis and Rehabilitation Prospective of Aged Small Hydropower Plant–A Case Study of Fewa Hydropower Plant (1MW) – by Mahesh Bashyal, Laxman Poudel in 2021.

This lack of specific investigation highlights the need for this report, which seeks the detailed study on "Phewa Hydropower Project" including its salient features, components, layout, and present condition of the project as well as the recommendations emphasizing proper operation.

4. Objectives

The general objective of this study is to explore the operating system of “Phewa Hydropower project” located in Birauta, PMC.

The specific objectives of this study are as follows:

a) To study about the general layout of Hydropower Plant.
b) To study about different components of hydropower plant and generation of power.
c) To evaluate the operating system and working mechanism of different hydropower components of “Phewa hydropower project”

5. Scope of the study

The scope of this project is to conduct a comprehensive case study of the Phewa Hydropower Project, focusing on the operation and present condition of its components. The project aims to provide insights into the design, functionality, challenges, and potential improvements for the hydropower plant.

The scope of the study includes the following:

a) Technical Assessment:
   i. Analyze the general layout and key components of the hydropower plant.
   ii. Evaluate the operational mechanism and function of various components.
   iii. Analysis of Nepal's Hydropower Development and Potential.

b) Reconnaissance Survey:
   i. Conduct on-site inspections of Phewa hydropower plant.
   ii. Observe and evaluate the present condition of different components of the project including turbines, generators, dams, spillways etc.

c) Conditional assessment of components
   i. Detail study of components.
   ii. Identify areas requiring immediate maintenance or rehabilitation to ensure the plant's longevity.

iii. Propose recommendations for ensuring compliance with updated standards and guidelines.

This project provides a detailed understanding of the Phewa Hydropower Project, identifies its operation process and challenges, and proposes recommendations to ensure its long-term efficiency and sustainability.

6. Study limitations

The limitations of the study are as follows:

a) This study failed on obtaining proper design data as per our objective.
b) This study failed on obtaining real-time performance data and assessing the present condition of the plant due to limited studies performed and poor documentation.
c) There was not enough data available for comparative study between its present and past operational evaluation due to aging infrastructure and inconsistent maintenance records.

7. Methodology

We had started with desk study followed by field survey and investigation. The information collected was analyzed for studying different components of hydropower project like headwork, headrace canal, forebay, penstock, powerhouse and tailrace from the reference study of Phewa Hydropower Project.

This Case Study report was prepared from the systematic approach of collection, analyzation, and interpretation of data involving following steps:

a) Desk Study:

Under this phase, collection and review of topographical maps, existing available literature, guidelines were carried out. Historical records and technical documents related to the Phewa Hydropower Project were evaluated and studied. Activities for the fieldworks were planned and the time of field visit was scheduled.

b) Reconnaissance Survey

Phewa Hydropower Project site was visited in order to gather firsthand observations and insights. The general layout of the hydropower plant including the dam, canal, and powerhouse, was observed. The major components of the hydropower plant : turbines, generators, spillways, penstocks etc. were identified and evaluated.

c) Primary data collection

For the primary data, The project site was visited. Required data and salient features of the hydropower project were collected from the engineers present on the site. The plant operators, and management personnel working there were also interviewed and the information gathered were included in the report. The project's design, challenges, and performance were also evaluated with the help of engineers present in the site.

d) Secondary information assessment

For the secondary survey, the research papers, journals, articles and published reports were studied thoroughly. The internet search was carried out throughout the study process. Every data collected from the study were analyzed in details and improvised to obtain the qualitative result.

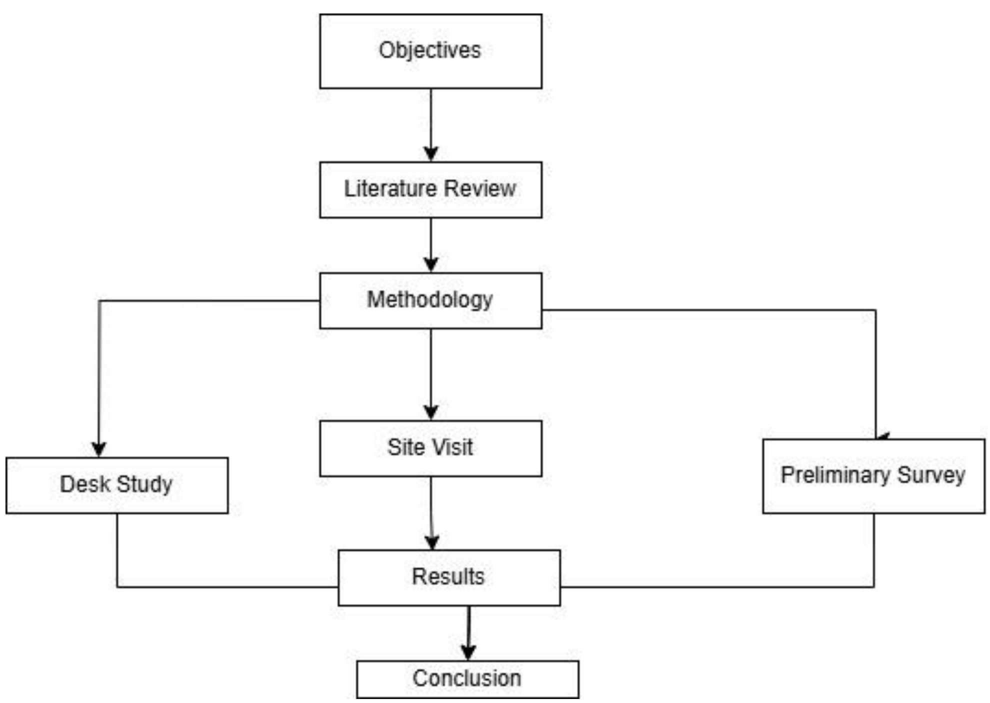

Figure 2: Methodology

8. Result and Discussion

8.1. Phewa Hydropower Project

8.1.1. Introduction

Phewa Hydropower Station is a canal drop type power station having an installed capacity of 1.0 MW erected at the end of Phewa Canal which was mainly constructed to irrigate land in the vicinity of Birauta. The project utilizes the water discharge from Phewa Lake to generate electricity. The lake is stream-fed with a dam regulating the water reserve. Phewa hydropower station is located in Pardi, Birauta, Pokhara-17 with an annual design generation of 6.5 GWh. *(NEA, 2016).* It consists of 4 units horizontal Francis turbines each of 0.25 MW capacity. But currently, only two units are working as Unit No. 2 and 4 are not in operation due to problem in generator turbine coupling. It consists of four sets of generators with brush-type excitation system, each producing 250 kW at the generator terminal.

Phewa Hydropower project was commissioned in 12 June, 1969 AD and developed jointly by Government of India and Government of Nepal thus marking above 56 years in operation. The cumulative generation of the station had reached 99.52 GWh till 2077/78 B.S from its first run.

The public encroachment of power canal leading to power house is a concern for normal operation regardless of the availability of generating units. The main Canal starts from the barrage which is located at one end of Phewa Lake at a popular tourist destination called Dam site. This canal after traversing some distance is branched at Ram Mandir to form main and branch canal. The main canal heads to the East for irrigation and branch canal heads to the South for both power and irrigation.

Figure 3: Phewa Powerhouse

Figure 4: Phewa dam

8.1.2 Location of the project

The Phewa Hydropower Project is situated in the Kaski District of Gandaki Province, Nepal. The project is located in the city of Pokhara, approximately 200 kilometers west of Kathmandu. It utilizes the Phewa Lake, a popular tourist destination in Pokhara, as its primary water source. The Phewa lake extends from 83°48'1.93" east to 83°58'13.18" east as well as 28°11'37.83" north to 28°17'27.30" north. The reservior has a planimetric area of 122.5 km^2,with an elevation ranging from 793 meters to 2508.81 meters.

The Phewa dam is located at the coordinate of 28°11'43.40" N and 83°58'04.22" E. The main canal extends 730 meters, starting from one end of Phewa Lake and reaching up to Ram Mandir Chowk. Similarly, Power canal spans 1000 meters, connecting Ram mandir chowk to forebay of the plant. Additionally, a 150-meter-long penstock connects the forebay to the Phewa powerhouse. The Phewa powerhouse is situated at the coordinate of 28°10'50.07" N latitude and 83°58'18.62" E longitude.

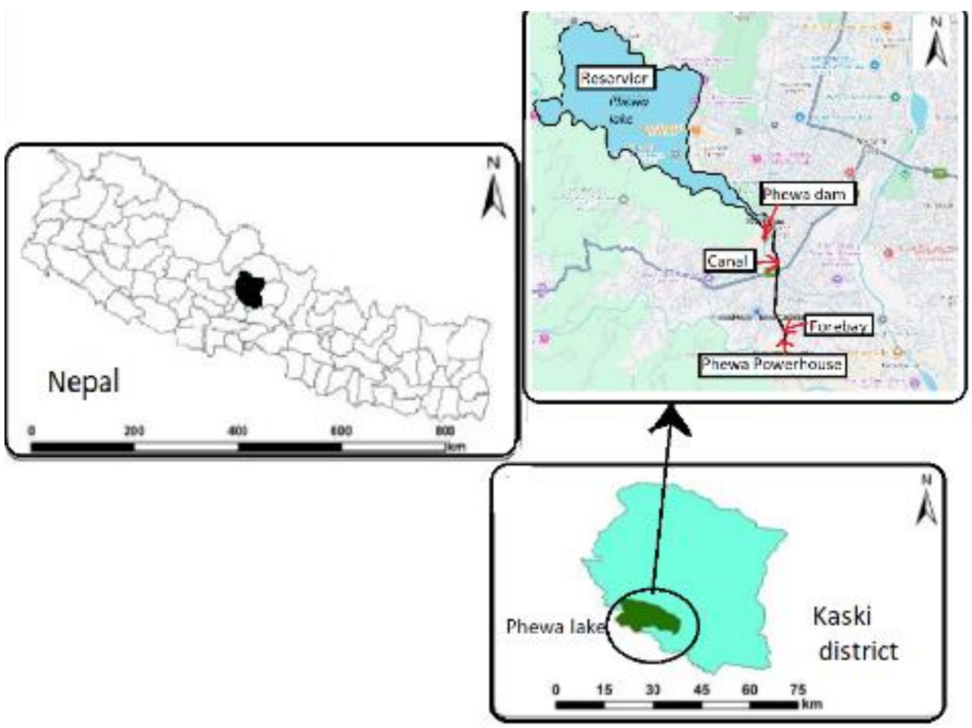

Figure 5: Location of the site

8.1.3 Salient Features

Table 6 : Salient Features of Phewa Hydropower project

	Description	**Parameters**
1.	**Project Name**	Phewa Hydropower Project
2.	**Location**	
	Latitude	28°10'47.6"N to 28°11'44.6"N
	Longitude	83°58'16.7"E to 83°58'04.0"E
	District	Kaski
	Metropolitan	Pokhara
3.	**Type of power plant**	
	Type	Canal drop type
4.	**Hydrology**	
	Catchment area	122.53 sq.km.
	Mean Annual Discharge	2 m^3 /sec
	Design Discharge	2 m^3 /sec
	Design Flood Discharge	4.55 m^3 /sec
5.	**Canal**	
	Main canal length	730 m, open type
	Power canal length	1000 m
6.	**Penstock**	
	Type	Surface type
	Material	Cast Iron pipe
	Numbers	2
	Diameter	660 mm
	Length	150 m
7.	**Tailrace canal**	
	Type	Rectangular
	Length	50 m

8.	**Powerhouse**	
	Type	Hydroelectric power station
	Size(L*B*H)	36*45*12.5 m^3
	Gross Head	74.68 m
	Net Head	74.68 m
	Design flow	2 m^3/sec
	Capacity	1 MWh
9.	**Turbines**	
	Type	Horizontal Francis
	Number of units	4
	Rated flow	0.496 m^3/sec
	Rated speed	1000 rpm
10.	**Generator**	
	Type	Synchronous
	Capacity	250 KW/unit
	Voltage	0.4 KV
	Power Factor	0.99
	Type of Excitation System	Self
11.	**Transmission line**	
	Conductor Type/Size	Unknown
	No. of circuit	1
	Length	5 km
	Voltage level	11 kV
12	**Transformer**	
	Number of transformer	4
	Rated Capacity	350 KVA
	Primary voltage level	0.4KV
	Secondary voltage level	11 KV
	Type of cooling	Water cooling

(Source: Seti Hydropower office)

8.1.4 Layout of Phewa Hydrower project

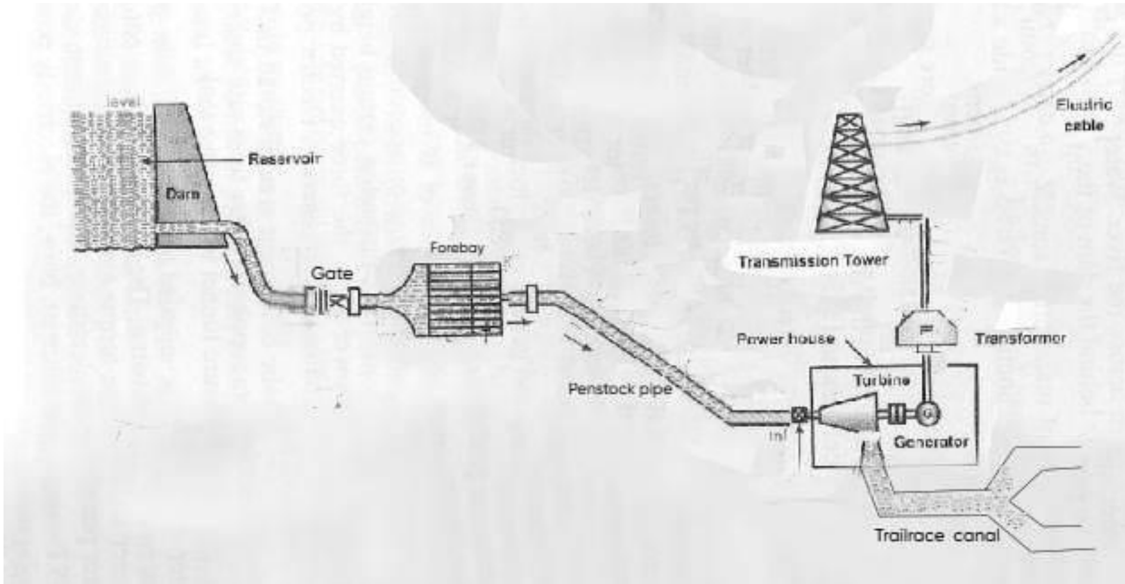

Figure 6: Layout of Phewa Hydropower project.

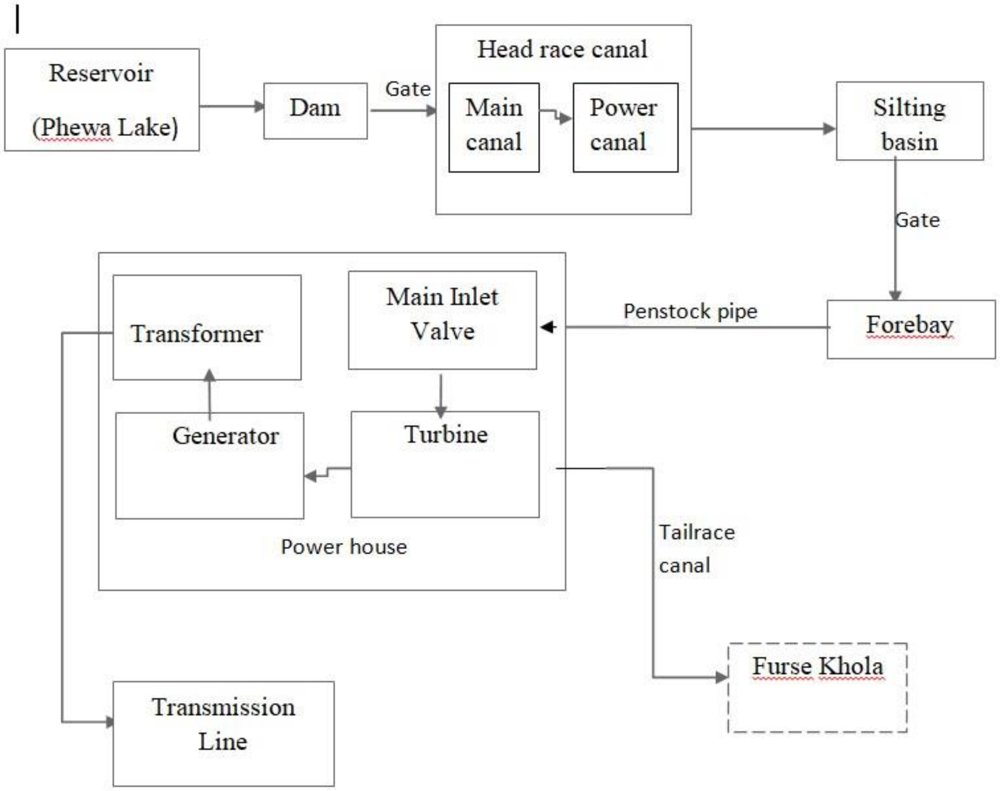

Figure 7: Flowchart of components of Phewa Hydropower project.

8.1.5 Conditional Assessment of components of Phewa Hydropower project

Technical and economic life of civil structural components of hydropower plant is found to be on the range of 80-100 years while power house electrical and mechanical components is on the range of 40-60 years.

The various components of Phewa Hydropower preject with their present conditional status are listed as:

a) Dam:

- There are four intake gates in the dam.
- The number of gates to be opened and closed is determined according to the amount of water present in the lake. Various cracks could be seen and leakage was observed on all sides of the gates even in the closed position. The hoisting system was in poor condition. Both embedded part and the gate panel were found to be corroded.

Figure 8: Phewa Dam

b) Headrace Channel:

- Headrace channel was rectangular in shape with concrete and stone masonry lining.
- The stone masonry lining was damaged in some stretches facing the slope stability problems. Also, The concrete of the concrete lined canal has suffered from surface scouring, reinforcement being exposed so was in need of maintenance**.**

Figure 9: Canal bifurcation

Figure 10: Headrace canal

c) Forebay:

- Forebay structure has suffered from the aging, scouring of the concrete surface and some cracks in the structure.
- Embedded guide frames of the gate were found to be exposed due to deteriorated concrete walls
- . Gate panels as well as the exposed surface of the embedded steel structures were found to be corroded.

The condition of hoisting system in gates was very poor and need immediate maintenance. Water leakage could be seen from the remarkable gap between side rubber seal and side sealing frame.

Figure 11: Forebay

d) Trash Rack and Trash Rack Cleaning Mechanism:

- The problem of floating debris was quite evident as the water flows through open canal. Also, the rack was not cleaned on regular basis. So, modern trash rash cleaning machine was required.

Figure 12: Floating debris in main canal

e) Penstock Pipes:

- The two sets of surface type penstock made up of cast iron of 660 mm diameter and 150 m length each were used.
- It was observed that the penstocks were in good condition with proper painting. There were some sign of corrosion but no leakage was observed so far.

Figure 13: Penstock pipes

f) Power house and Equipment Foundations:

- The design consideration of hydroelectric power plant type power house is as follows:
    - Size: 36*45*12.5 m3
    - Gross head : 74.68 m
    - Net head : 74.68 m
    - Design flow : 2m3/sec
    - Capacity : 1 MWh

- Due to vibrations suffered by base concrete on running of equipment for over 50 years, it may require reinforcements. The machine foundation from the Main Inlet Valve (MIV) to the Draft Tube Bottom level need to be demolished and re-constructed as per new equipment's dimensions.

Figure 14: Phewa Powerhouse

g) Main Inlet Valve:

It was in poor condition. It has severe corrosion, bad sealing, and low efficiency under manual operation. Heavy leakage could be seen in the valve.

Figure 15: Main Inlet Valve

h) Turbine:

- There were four horizontal Francis type of turbines present in the powerhouse, with rated flow 0.496 m3/sec and rated speed 1000 rpm ,among which only two were working.
- Unit no 2 and 4 were not in operation due to problem in generator turbine coupling. Also, There was a substantial water leakage through shaft seal and head cover. Guide vanes had suffered a heavy wear over the years; therefore, the unit efficiency has decreased significantly and operates below rated output. Turbine runners have undergone some pitting due to cavitation. Guide bearing of turbine has also suffered severe wear. On operation, the shaft vibrates, which affected the units' stability.

Figure 16: Turbine Generator unit

i) Generator:

- The synchronous type generators with capacity 250 KW/unit ,voltage 0.4 KV ,power factor 0.99 were found.
- Generators were aged with deteriorated insulation quality and wear and tear problem in the bearings, frequent rise up of bearing temperature. Also, among four generators units, only two were in operation.

j) _Transformer:

- There were four step up transformers with rated capacity of 350 KVA,primary voltage 0.4 KV,and secondary voltage level 11 KV.
- Transformers were suffering from some oil leakage, poor insulation, and surface corrosion, increased no-load and load loss.

Figure 17: Transformer

k) Switch yard:

- The transmission line was conductor type, of length 5 KM and voltage 11 Kv.
- It was found that the electricity produced from Phewa Hydropower project was transmitted to Kundahar through transmission line. The wire in switchyard panel had problems of poor insulation.

Figure 18: Switch yard

l) Crane:

It was quite old and was full of rust. It can be modernized with latest features.

Figure 19: Crane

m) Tailrace:

The tailrace was observed to be in proper condition. The tailrace might need to be modified with the change in design for submergence for draft tube during rehabilitation.

Figure 20: Tailrace

Thus from the plant diagnosis and conditional assessment of Phewa Hydropower project, rehabilitation assessment implementation is highly recommended.

9. Conclusion

a) This study successfully achieved its objectives by providing a comprehensive understanding of the general layout and operational principles of a hydropower plant.
b) It also summarizes the working mechanism of different components of hydropower plant and how each of them contributes in generation of power.
c) This study provides in- depth evaluation of the “Phewa Hydropower project”, shed light on its operating system offering valuable insights into its efficiency and functionality.

The study has covered the required data and statistics from several published literatures and field data collected by the locals as well as the authorized personnel.

10. Recommendation

From the case study analysis of Phewa Hydropower project, it is highly recommended that the concerned organization prioritize rehabilitation, renovation, and modernization efforts. Additionally, an optimal capacity upgrade, including the determination of the most efficient number of power-generating units, should be considered to enhance the project's overall performance and efficiency. Regular Maintenance and Monitoring of the components like turbines, generators and control system is recommended so as to ensure optimal performance and longevity of the Phewa Hydropower station.

11. References

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12. Annexes

Figure 21: Site visit to Phewa Hydropower Station

Figure 22 : Reservior of Phewa Hydropower Station : Phewa lake

Figure 23: Inside view of Phewa Power house

Figure 24 : Annexes