TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

PULCHOWK CAMPUS

THESIS NO: M-174-MSESPM-2020-2023

Impact Study of the Hetauda-Dhalkewar-Inaruwa Transmission Line on the Operation of Integrated Nepal Power System

by

Ajay Shah

A THESIS

SUBMITTED TO THE DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ENGINEERING IN ENERGY SYSTEM PLANNING AND MANAGEMENT

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

LALITPUR, NEPAL

November, 2023

COPYRIGHT

TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

PULCHOWK CAMPUS

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

The undersigned certify that they have read, and recommend to the Institute of Engineering for acceptance, a thesis entitled "**Impact study of Hetauda-Dhalkewar-Inaruwa Transmission Line on the Operation of Integrated Nepal Power System**" submitted by Ajay Shah in partial fulfillment of the requirements for the degree of master of science in engineering in energy system planning and management.

Supervisor, Sanjaya Neupane
Assistant Professor,
Department of Mechanical and Aerospace Engineering,
Pulchowk Campus

Supervisor, Kamal Darlami
Assistant Professor,
Department of Mechanical and Aerospace Engineering,
Pulchowk Campus

External Examiner, Dr. Laxman Ghimire

Director,Alternative Energy Promotion Centre (AEPC)

Committee Chairperson, Dr. Sudip Bhattrai
Head of Department, Department of Mechanical and Aerospace Engineering, Pulchowk Campus

Date: November 27, 2023

ABSTRACT

Although Nepal has a significant hydroelectric resource, there is still a severe imbalance between the country's supply and demand for electricity. The lack of high-voltage transmission lines has made it difficult for the system operator to evacuate the power produced at a few plants, costing the utility money and making the system's power quality unreliable. Projects like the 576 KM long Hetauda-Dhalkebar-Inaruwa 400kV double circuit Transmission Line are experiencing protracted delays due to several problems, including the project's affected residents' reluctance to give up their land. Most of the generation for the Integrated Nepal Power System (INPS) is concentrated in the country's central mid-hills, stretching from Syangja-Baglung in the west to Dolakha-Ramechhap in the east. The construction of the Hetauda-Dhalkebar-Inaruwa (HDITL) 400kV double circuit Transmission Line of the length intended to route power suppliers that help to industrialize these areas helps to increase the national GDP as well as to get job opportunities in Nepal. The industrial area of the eastern park, such as the Biratnagar-Duhabi corridor, needs supply from the hetauda-dhalkewar substation. The current hydropower output must reach about 2300 MW, but without a high-voltage transmission line connected to the INPS system, it will be impossible to use the plant to its full potential. The construction of the 400kV double circuit Hetauda-Dhalkebar-Inaruwa (HDITL) transmission line will aid in reducing line losses while also improving grid stability. The HDITL line helps to export energy via the Dhalkewar-Muzaffarpur (D-M) 400 Kv line and transmit high-generation power, such as the Upper Tamakoshi of 456 MW directly from Khimti to Hetauda in 220 kV. Therefore, the construction of these lines contributes to the saving of about 400 MW of power, preventing further losses for both GoN and the Nepal Electricity Authority.

This research focused on determining the monetary value of the benefit in addition to calculating the amount of power and energy loss reduction in INPS due to the commissioning of HDITL. Following the collection of INPS data, a test model of the INPS was developed, and Digsilent Power Factory 15.1 was used to simulate power flow. The outcome indicates that the commissioning of HDITL can prevent a power loss of approximately 26.276 MW. The analysis also reveals that the commissioning of HDITL increased the total generation power factor in INPS from 0.88 to 0.99, also greatly enhancing the voltage profile.

ACKNOWLEDGEMENTS

The thesis, titled "Impact Study of Hetauda-Dhalkewar-Inaruwa Transmission Line on the Operation of Integrated Nepal Power System," completed under the close supervision of my supervisors, Assistant Professor Sanjaya Neupane and Assistant Professor Kamal Darlami, who constantly encouraged me to work hard on this research throughout the thesis's duration. Their valuable advice, suggestions, instructive guidance, and cooperative supervision have been crucial in sharpening and shaping the research work.

I want to express my gratitude to Associate Professor Nawraj Bhattarai, Ph.D., and Associate Professor Shree Raj Shakya, Ph.D., for their assistance in carrying out the research. I'd also like to thank Assistant Professor Sudip Bhattarai, Ph.D., Head of the Department of Mechanical and Aerospace Engineering, for creating a conducive environment for thesis work. Similarly, I'd like to express our heartfelt appreciation to all of the respected Department of Mechanical and Aerospace Engineering staff members who directly and indirectly assisted me in carrying out my research. I couldn't have finished the research without the help and guidance of Assistant Professor Dr. Samundra Gurung, who encouraged me to keep working. I would also like to thank the Nepal Electricity Authority (NEA), particularly the Load dispatch centre (LDC), for their assistance in data collection for the INPS-related system. I would like to thank Er. Prabesh Chandra Neupane and Gopal Yadav for their assistance, and motivation in the research work. Finally, I would like to express my gratitude to everyone who assisted me, both directly and indirectly, in completing the research work. Any flaws in this paper, however, are entirely mine.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

δ	:	Phase angle
AC	:	Alternating Current
HIDTL	:	Hetauda-Dhalkewar- Inaruwa Transmission Line
RPGCL	:	Rastriya Prasaran Grid Company Limited
DERs	:	Distributed Energy Resources
DG	:	Distributed Generation
ETAP	:	Electrical Transient Analyzer Program
FACTS	:	Flexible Alternating Current Transmission System
GA	:	Genetic Algorithm
GHz	:	Giga Hertz
I	:	Current
IEEE	:	Institute of Electrical and Electronics Engineers
Km	:	kilometers
kV	:	kilovolt
kVAR	:	kiloVolt Ampere Reactive
kW	:	kiloWatts
MATLAB	:	Matrix Laboratory
MW	:	MegaWatts
NEA	:	Nepal Electricity Authority
P	:	Active Power
p.u.	:	per unit
Q	:	Reactive Power
R	:	Resistance

CHAPTER ONE: INTRODUCTION

1.1 Background

The first hydropower plant built during Chandra Shumsher's rule is the foundation of the history of the Nepalese Power System. The 500 KW Pelton wheel generator, built in the Pharping hydropower plant with support from the British government in 1911, supplied electricity for the electrification of Singha Durbar, the royal palace. An estimated 83,000 MW is the theoretical total potential capacity of hydropower. 43,000 MW is the significant economical hydropower potential. The amount of energy purchased from NEA subsidiaries and Independent Power Producers (IPPs) was 1,976 GWh and 4,286 GWh, respectively. This represents an increase of 38.57% and 1,235.14% from 3,093 GWh and 148 GWh in FY 2020/21 (NEA, 2022). The successful commercial operation of the Upper Tamakoshi Hydropower Project, a national pride project created by the NEA Subsidiary, added 735 MW of power to Nepal's Integrated powered System last year. With this, the country's installed capacity has increased to 2,190 MW (NEA, 2022). The construction of the transmission line HDI double circuit 400 KV of the transmission line length from hetauda-Dhalkewar is 143KM and Dhalkewar to Inaruwa 145 KM, in total 288KM in single circuit and overall 576KM in the double circuit (NEA, 2022). Power Trade Agreement (PTA) has been inked with India, allowing the two countries to build TL interconnections and power exchange trading through governmental, public, and private enterprises. Despite having a large hydropower potential, Nepal is currently experiencing a severe power crisis. A PTA has been signed between India and Nepal, which allows for the trade of electricity as a commodity in a shared market. Improve INPS and run it in synchronized mode with the Indian Grid. Establish numerous strong HV cross-border links to alleviate Nepal's current power crisis by importing power from India. The same cross-border TL links permit further power export to India when Nepal anticipates surplus power needed to build South Asia's Regional Power Grid Requires Regional Cooperation (Integrated Nepal Power System, 2014).As part of the construction of the Hetauda-Dhalkebar-Inaruwa(HDI) 400-kV double-circuit transmission line, which is essential to strengthen Nepal's domestic power transmission system and facilitate electricity trade between Nepal and India. Nepal Electricity Authority(NEA) has stressed the importance of addressing obstacles to the project and has encouraged residents to take necessary steps to remove them, to avoid any further problems (The Himalayan, n.d.). This year, if the transmission line is not built, 400 to 500 megawatts of power will be lost every day. Large losses will arise from this for both the authorities and the country (The Himalayan, n.d.).

The 400-kV double-circuit Hetauda-Dhalkebar-Inaruwa (HDI) transmission line plays an important role in the steady, affordable, and trustworthy transfer of electrical energy by minimizing transmission losses and enhancing the INPS's (Integrated Nepal Power System) power quality. To trade excess energy in the day-ahead energy market, Nepal used the 400KV Dhalkewar-Muzaffarpur line, which connects to the Hetauda-Dhalkebar-Inaruwa (HDI) transmission line, improving the system's ability to transport electricity while also lowering line losses.The NEA - Hetauda-Dhalkebar-Inaruwa Transmission Line is a high-voltage transmission line that is a vital component of Nepal's power infrastructure. It aims to improve the reliability and efficiency of electricity transmission across the nation. This 400 kV transmission line is a collaboration between the Nepal Electricity Authority (NEA) and foreign partners to meet electricity demands while also fostering economic growth. Technical Specifications and Design: The transmission line extends roughly 288 kilometers, linking the Hetauda Substation in the central area to the Dhalkebar Substation and continuing further east to the Inaruwa Substation (NEA, 2022). To achieve low power losses and optimal load control, the design features high-capacity conductors, improved insulators, and modern monitoring devices. The transmission line's influence goes beyond its technical characteristics. It promotes regional energy integration and cooperation by facilitating energy commerce between Nepal and adjacent nations. Furthermore, the project promotes socioeconomic growth by offering job opportunities during the building and operating stages. It also offers a consistent power supply, therefore boosting local companies and enhancing citizens' general quality of life. Several sources back up this analysis. Official project reports from the Nepal Electricity Authority provide detailed information on the technical specifications, construction status, and projected outcomes of the NEA Hetauda-Dhalkebar-Inaruwa Transmission Line.

1.2 Problem Statement

While Nepal has enormous potential for hydroelectricity plant production, the country still faces energy deficiency during the dry season due to maximum power projects being of the river (ROR) type. Nearly one-third of the generation-only energy is produced as compared to the wet season. Because of the lack of storage-type power plants. As a result, to reduce this difficulty, the Indian power system must be interconnected in a synchronous mode of operation. Constructing the transmission line will allow the efficient transfer of electricity from the generation sources to the areas where it is needed. This would help meet the electricity demands of consumers and industries, preventing shortages and blackouts that could negatively impact economic activities and people's daily lives.

Additionally, building the transmission line can lead to various benefits:

- Avoiding Energy Losses: By providing a reliable and efficient means of power transfer, energy losses during transmission can be minimized, ensuring that a larger portion of the generated electricity reaches consumers.
- Enhancing Grid Stability: An improved transmission network can enhance the stability and reliability of the overall power grid, reducing the risks of voltage fluctuations and grid failures.
- Supporting Renewable Energy Integration: Transmission infrastructure is crucial for integrating renewable energy sources, such as wind and solar, which may be located far from the demand centers. This facilitates the transition to a more sustainable energy mix.
- Facilitating Economic Growth: A robust and dependable electricity supply can attract investments, promote industrial growth, and create job opportunities, contributing to the overall economic development of the country.

1.3 Objectives

1.3.1 Main objective

The main objective of the thesis is to determine the impact of the high voltage 400 kV transmission line(HDITL) on INPS.

1.3.2 Specific Objectives

The specific objectives include:

- To determine grid loss estimation with or without the inclusion of the HDI 400KV transmission line.
- To estimate the voltage profile before and after the HDI line.
- To study the impact on Line loading with/without HDI line
- To study the financial viability of the project

1.4 Assumptions of the Research

The following assumptions underlie the research:

- Each 400 kV link with a capacity of 1000 MW is intended to operate in synchronous mode.
- The Dhalkebar-Muzaffarpur-400 kV link is designated for energy export from Nepal to India.
- Transformers in the system are assumed to be perfectly efficient.
- The Upper Tamakoshi hydropower system (456 MW) is categorized as a Slack/Reference Bus.
- Simulation utilizes Dig-silent Power Factory 15.1 software, with system data sources from LDC, NEA annual reports, and RPGCL for comprehensive simulation modeling.

1.5 Limitations of the Research

- The system does not take into account no-load conditions because of load rejection or blackout disruptions. The reliability assessment is not considered in the analysis. The current system is enhanced rather than the conductors being replaced as part of the analysis.
- The load flow study is limited to three-phase balanced systems.
- Load growth patterns and load models are not considered in the study.

CHAPTER TWO: LITERATURE REVIEW

According to Hari Man Shrestha's doctoral dissertation, 43,000 MW of Nepal's 83,000 MW of potential generation are commercially viable (Mishra, Karki, & Gyawali, 2014). To achieve this potential from the current 2190MW, massive engineering know-how and considerable improvements to Nepal's current electricity grid are required. Transmission line construction is essential to develop hydropower projects and mitigate Nepal's energy crisis (Rastriya Prasaran Grid Co Ltd (RPGCL), n.d.).

Despite having a considerable hydro potential, Nepal now experiences a power shortage because of a serious imbalance between the supply and demand for energy in the nation. The average annual increase in the annual peak electricity consumption is 9% (Mishra, Karki, & Gyawali, 2014) The majority of the generation for the Integrated Nepal Power System (INPS) is centered in the country's central mid-hills, which stretches from Syangja-Baglung in the west to Dolakha-Ramechhap in the east. The Duhabi-Biratnagar industrial corridor, for example, has a high electricity demand, which must be met by supplying it from Hetauda via the Dhalkebar substation. The Khimti-Dhalkebar Transmission Line (KDTL) is being built to transport electricity produced in the Tamakoshi-Bhotekoshi basin to Nepal's eastern region (Mishra, Karki, & Gyawali, 2014).

In addition to calculating the amount of power and energy loss reduction in INPS due to KDTL's commissioning, this research seeks to quantify the benefit's monetary worth. After the INPS data was gathered, a test model of the INPS was created, and power flow was carried out using the software. The outcome demonstrates that by commissioning KDTL, approximately 15.639MW Power loss can be avoided (Mishra, Karki, & Gyawali, 2014).

The demand in the future will not be met by the capacity that is currently available. Therefore, it is crucial for the country that this transmission line is built. The new transmission line will be installed as part of NEA's plan to address the rising demand from both businesses and households. GoN has committed to building a new electrical transmission line (Pandey & Nakarmi, 2014).To reduce the problem that exists throughout the building of transmission line projects owing to various uncertainty conditions, this study attempts to conduct a risk assessment of transmission line projects in Nepal while taking into account all the financial elements. The Monte-Carlo simulation has been used to examine various risks involved in the transmission line construction process and their impact on the project's net present worth to establish a successful independent transmission line project (Pandey & Nakarmi, 2014).

The power transferred from the project was compared to the predicted electricity consumption and load shedding for the Kathmandu Valley throughout the project (Pandey & Nakarmi, 2014).

Monte Carlo simulation has been used to analyze the risk factors that have been involved in multiple risk factor cases. A combination of numerous risk variables will be evaluated to determine the net present value and internal rate of return in various risk-possible situations. Similarly, the linear regression model was used to estimate demand to determine the project's appeal to the Kathmandu Valley. The study leads to the conclusion that an independent transmission firm in Nepal is economically viable (Pandey & Nakarmi, 2014).

The Nepalese electricity system continues to experience intermittent system failures and low voltage delivery as a result of inadequate and poorly planned transmission lines. The planned network of integrated systems is put through a variety of analytical approaches to ensure safe and dependable operation, including the import and export of goods with the best possible use of the generators by reducing transmission loss. To determine the optimum possible functioning, a steady-state power flow study is specifically performed and simulated in a computer model (Acharya & Shrestha, 2020). To determine the optimum possible functioning, a steady-state power flow study is performed and simulated in a computer model. According to the outcomes of the anticipated model for the various scenarios, the voltages of all significant substations and the line loadings of all significant transmission lines are all within acceptable ranges. By comprehending how the integrated national power system functions, it finds the most optimal operating condition and suggests a novel strategy for a strong and dependable transmission line expansion plan for meeting the country's peak load demand and delivering electricity for export to India (Acharya & Shrestha, 2020).

The summary of the literature is presented in Table 1.

Table 1: Summary of Literature Works

Title	Author(s)	Major Finding
Impact Study of Khimti-Dhalkebar 220 kV Transmission Line on the Operation of Integrated Nepal Power System(2014)	Hare Krishna Mishra, Nava Raj Karki, Netra Gyawali	This paper used the Khimti-Dhalkebar 220 kV Transmission Line to find the impact on INPS, analyze the losses on the grid with and without KDTL
Financial Risk Assessment of Transmission Line Projects in Nepal: A Case Study of Chilime-Trishuli Transmission Line Project	Dristi Pandey, Amrit Man Nakarmi	Financial Risk Assessment of Transmission Line Projects in Nepal was a paper that examined the use of the Monte-Carlo simulation for the establishment of a profitable independent transmission line project.
Operation of Integrated Nepal Power System on Injection of Upper Tamakoshi Hydroelectric Power Plant	Sujan Acharya , Rajendra Shrestha	Optimal evacuation of such a power plant of 456 MW requires a secure and reliable transmission network. The proposed network of integrated systems is subjected to various analysis techniques for secure and reliable operation including import and export belongings with optimum utilization of the generators by minimizing transmission loss.

LOAD FLOW ANALYSIS OF BHUTAN POWER SYSTEM NETWORK USING DIGSILENT POWER FACTORY SOFTWARE(2015)	Tshewang Darjay, Pooja Lepcha, Anju Rai & Cheku Dorji	This paper analyzed the network constraints like line outages, load profile, MW, and MVAR of the existing network.
CHALLENGES FOR CONSTRUCTION OF HIGH VOLTAGE ELECTRICITY TRANSMISSION LINE IN NEPAL(2020)	Suraj Regmi & Anand Mandal	This research aims to identify the main hurdles to constructing high-voltage transmission lines in the present perspective.
Impact Analysis of 220 kV And 400 kV Transmission Lines on The Integrated Nepal Power System(2020)	Ganesh Bhandari, Bishal Rimal & Sandeep Neupane	The present scenario of the power system of Nepal and their impact analysis. The load flow result of the existing 132 kV line shows that there are about 44.56 MW active power losses in the transmission line before any compensation techniques.
Integrated Nepal Power System (INPS)	Er. Shyam Kumar Yadav	Generation plan of INPS, Impact of Radial mode operation, Linking INPS with INDIAN POWER GRID, Cross Border 400 kV Link
TRANSMISSION SYSTEM DEVELOPMENT PLAN OF NEPAL	Rastriya Prasaran Grid Company Limited	Gon has envisaged developing 15GW of hydropower in 10 years and around 40GW by the year 2040.

Nepal-India Power Exchange: A Critical Review	Subhash K. Mishra	Background of the Nepal-India Power Exchange. Explain the rationale behind such an exchange, including energy demand and supply dynamics, potential benefits, and challenges

2.1 Classification of Transmission Voltage

Different voltage levels are employed in power systems for generation, transmission, and final distribution. The voltages used in a generation are typically 6.6kV, 11kV, 22kV, or 33kV. The voltages utilized in primary transmission include 66kV, 132kV, 220kV, and up to 400kV fall. Primary distribution voltage is either 6.6 kV or 11 kV, while secondary transmission voltages are 11 kV, 22 kV, or 33 kV. In NEPAL, the distribution voltage level for the final user is 230 V for single-phase systems and 400 V for three-phase systems. Power development status of Nepal.

2.2 Supply and demand situation

Including Upper Tamakoshi (456 MW), Likhu-IV (52 MW), Nyadi (30 MW), Likhu-A (24.2 MW), and other IPP projects, 717 MW of power is added to the INPS in this fiscal year (NEA, 2022). This enabled it to meet the system's rising demand, as well as to reduce power imports in the dry season to a certain amount and enable exports in the wet season. Compared to the prior FY 2020/21, the volume of imported power has reduced by 45%. Peak demand and total energy consumption both grew by 19.8 and 24.5 percent, respectively. As new generations are added to the system, its aged transmission network becomes unable to transport power to load centers. Relying on the system circumstances, the transmission line Hetauda-Bharatpur 132 kV, Damauli- Bharatpur 132kV, BharatpurKawasoti-Bardghat132 kV, LekhnathSyanga-Kaligandaki A, MarsyangdiBharatpur 132 kV, Duhabi-Anarmani 132 kV were being functioned almost in full capacity continuously, that might have started the power cut in certain areas (NEA, 2022). The current power development status of Nepal is shown in Figure 1.

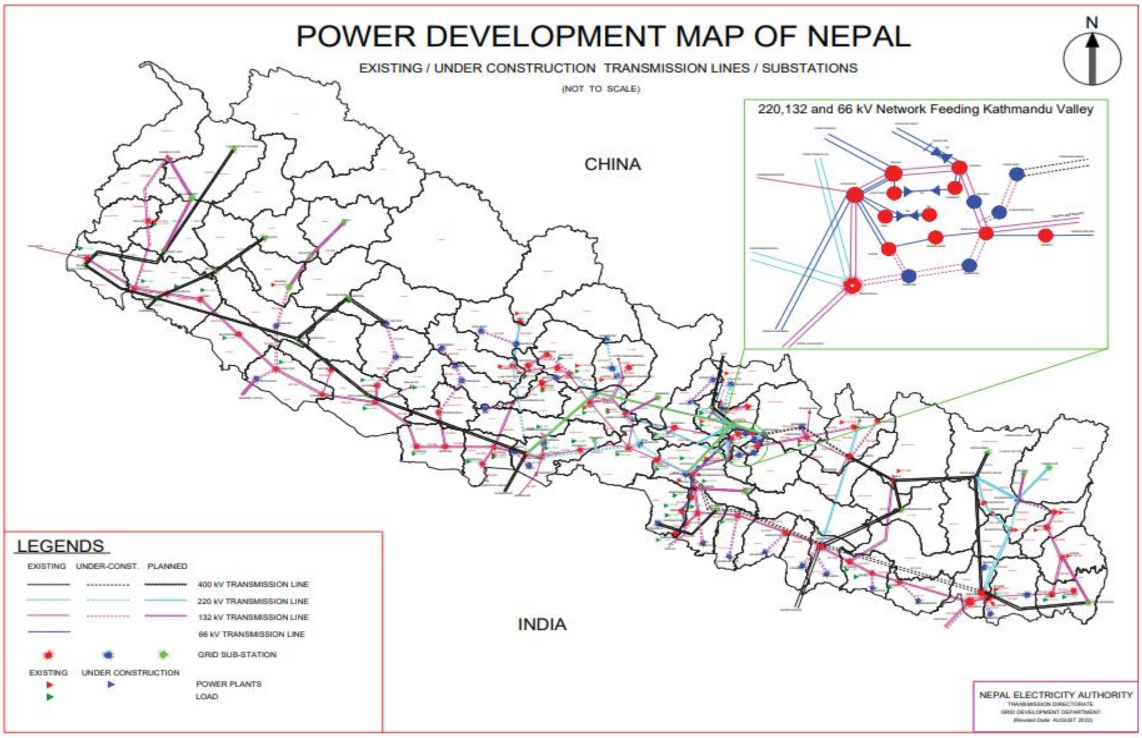


Figure 1: Power Development Map of Nepal

2.3 METHODS OF COMPUTATION TECHNIQUES

By determining line loadability and doing a contingency analysis simulation model in power factory software, load flow research was conducted. The load flow analysis was performed using certain assumptions, and the modified INPS system collected data accordingly. The effect analysis was conducted utilizing HDI line several cases that were either connected to or disconnected to the INPS system.The stability of the simulation-based system performance study.

2.4 Technical Terms Related to the Study

2.4.1 Load Dispatch Centre

The grid connects all of the producing stations in parallel in the interconnected power system. It is critical to synchronize all of these generators for the most cost-effective functioning. The load dispatch center is an organization in charge of coordinating all power plants. The Load dispatch center is the most important link between all the parts of the system (ELECTRICAL ARTICLE, n.d.). The LDC coordinates, plans, controls, and monitors electricity consumption and generation. The LDC connects generation, transmission, and distribution, allowing the electrical consumer's power demand to be coordinated.

The load dispatch center's goal is to:

- It protects the system.
- An islanding facility
- Optimal resource utilization
- Demand forecasting and estimation
- of power quality of the power supply transmitted via the regional grid stable.
- System frequency control
- Assist in the fast restoration of the system following any disturbances.
- Consistent transmission system operation
- Aligning power generation and demand

2.4.2 Integrated Nepal Power System

The Nepali electrical power system, known as the Integrated Nepal Power System (INPS), is in charge of giving its consumers a dependable and affordable supply of electrical energy. In order to guarantee a continuous supply of energy and prevent problems like load shedding, which can have serious negative effects on the utility and end users' social and economic well-being, the power system's sufficiency and dependability are essential. Research has been done utilizing several reliability indices, especially LOLE (Loss of Load Expectation) and EENS (Expected Energy not Supplied), to evaluate the sufficiency of the Integrated Nepal Power System[1]. The dependability indices were examined independently for each of the three zones into which the INPS was divided by the research. Real data from the Nepal energy Authority (NEA), the main utility in charge of supplying energy in Nepal, was utilized for the research. This included load and generating statistics.The study conducted the reliability analysis using digsilent power factory software, and MATLAB programming and found the results to be quite satisfactory, representing the present condition of the INPS. This research is essential in understanding the current state of the power system and identifying areas where improvements may be needed to ensure an adequate and reliable electricity supply in Nepal.

In summary, the Integrated Nepal Power System (INPS) is the power system responsible for supplying electrical energy to customers in Nepal. Adequacy and reliability assessments have been conducted using different reliability indices, and further research is available to explore the topic in-depth (Bharat Chetry1).

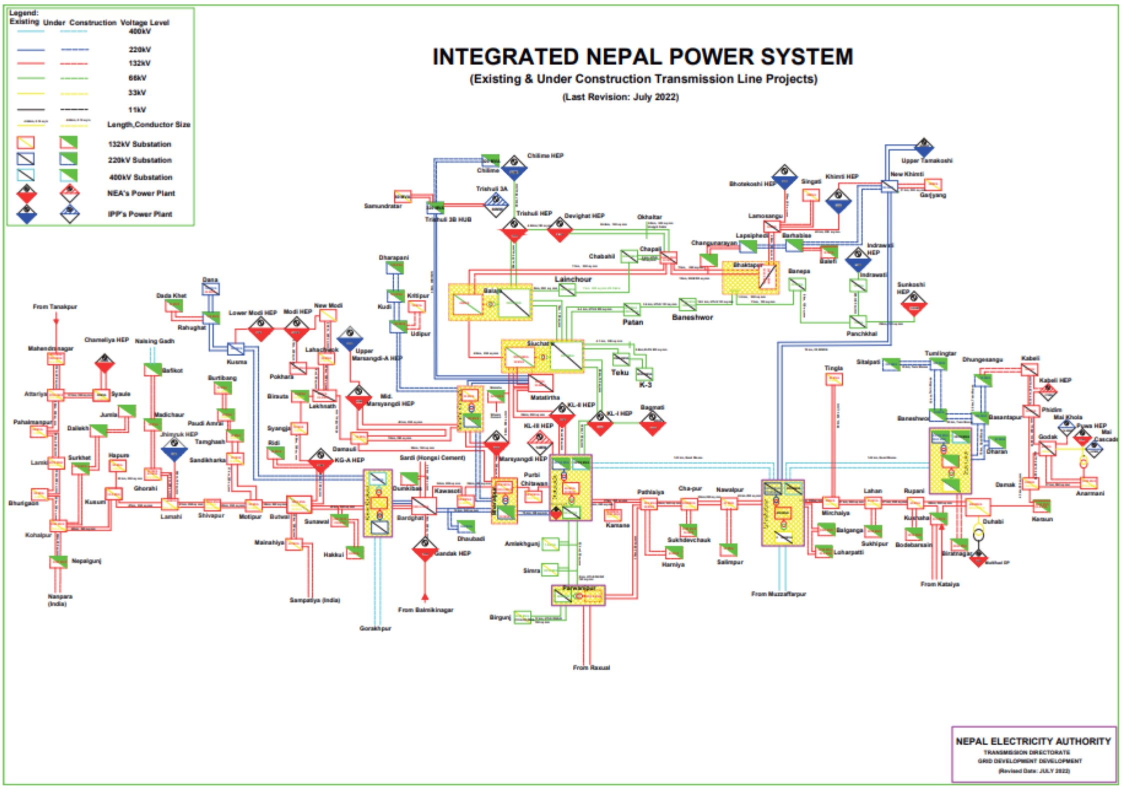


Figure 2: Integrated Nepal Power System

2.4.3 Load flow studies with digsilent power factory software

A load flow study, also known as power flow analysis, is a crucial analysis performed in power systems to determine the steady-state operating conditions of the network. It calculates the voltage magnitudes and angles, active and reactive power flows, and other electrical parameters at various buses in the system.

DIgSILENT PowerFactory is a software tool used for power system analysis, and it offers several load flow calculation methods, including the n-R method. The n-R method is an iterative numerical technique that aims to converge to a solution that satisfies all power flow equations in the system. The "n" in n-R represents the number of variables in the system, which typically includes voltage magnitudes and angles at various buses. The n-R method in DIgSILENT PowerFactory is implemented as an enhanced non-decoupled Newton-Raphson solution technique with current or power mismatch iterations. It is capable of handling both balanced and unbalanced load flow scenarios for coupled AC and DC grids. The algorithm exhibits excellent stability and convergence properties, ensuring accurate results under various conditions.

Some key features of load flow analysis using DIgSILENT PowerFactory include:

- State-of-the-art numerical solvers for fast and robust convergence from arbitrary starting points.
- Active/reactive power and voltage regulation options, such as SVC (Static Var Compensator), shunt, and tap controllers.
- Station- and network control features, including Q(U)-, cos phi (P)-, Q(P)-, and droop characteristics.
- Local and remote control options for efficient management of the power system.
- Distributed slack by load and generation, which allows for more realistic modeling of the system.
- Consideration of active and reactive power limits, including voltage-dependent generator capability curves, to reflect the real-world behavior of generators.
- Accurate modeling of induction machines and voltage-dependent load models to improve the accuracy of the load flow results.
- User-definable load flow controller models, provide flexibility in customizing the analysis.
- Simple load/generation scaling and automated feeder load scaling for balanced and unbalanced scenarios.
- Determination of "power at risk" helps identify critical areas in the power system.

- Consideration of temperature dependency and reporting against continuous and short-term thermal ratings, including dependencies on ambient temperature, wind speed, or solar irradiance.

  The software offers tools for comparing power networks' behavior and analyzing line outages, load profiles, and power losses under different scenarios.

  In summary, the load flow study with the n-R method in DIgSILENT PowerFactory provides a comprehensive and powerful tool for analyzing power system networks, ensuring efficient and reliable operation under various operating conditions.

  The load flow, also known as power flow, is a fundamental analysis performed in electrical power systems to determine steady-state operating conditions. The load flow analysis is used to calculate the voltages, currents, and power flows in the network. It ensures that the power system operates within acceptable limits and that all devices are operating within their rated capacities.

  The load flow equation is a set of power balance equations that describe the relationship between voltages, currents, and power in the electrical network. For a given power system with 'n' buses (nodes), the load flow equations are typically represented in polar coordinates (magnitude and angle) as follows:

  For each bus 'i' (where i = 1, 2... n):

1. Voltage magnitude equation: $V_i = |V_i| * \exp(j * \delta_i)$ Equation 2.4-1
2. Active power equation (P): $P_i = |V_i| * \sum(|V_j| * (G_{ij} * \cos(\delta_i - \delta_j) + B_{ij} * \sin(\delta_i - \delta_j)))$ Equation 2.4-2
3. Reactive power equation (Q): $Q_i = |V_i| * \sum(|V_j| * (G_{ij} * \sin(\delta_i - \delta_j) - B_{ij} * \cos(\delta_i - \delta_j)))$ Equation 2.4-3

   Where:

- V_i is the voltage at the bus 'i' (complex number in polar form).
- δ_i is the voltage angle at the bus 'i'.
- $|V_i|$ is the magnitude of the voltage at the bus 'i'.

- j is the imaginary unit (√(-1)).
- G_{ij} is the conductance of the transmission line between buses 'i' and 'j'.
- B_{ij} is the susceptance of the transmission line between buses 'i' and 'j'.

The load flow equation is a system of nonlinear equations, as the bus voltages and angles are interconnected. These equations are solved iteratively using numerical methods like the Newton-Raphson method or the Gauss-Seidel method until the system reaches a balanced and stable state.

By solving the load flow equations, engineers and system operators can determine the operating conditions of the power system, identify potential issues (such as voltage violations or overloading), and take corrective measures to ensure the secure and efficient operation of the electrical grid.

In a load flow study, the power loss in a transmission line can be calculated using the following equation:

$P_{loss}=\sum_{lines}(P_{line}-P_{injection})$ Equation 2.4-4

Where:

Ploss is the total power loss in the system.

Pline is the real power (active power) flowing through a specific transmission line.

Pinjection is the total real power injected into the buses connected by that line.

The power system's transmission lines are all taken into account in this equation. By subtracting the real power that is flowing through a line from the real power that is being injected at its two ends, it determines the power loss for each line.

In mathematical terms, for a line between buses i and j:

$Pline=Pij+Pji$ Equation 2.4-5

$Pinjection=Pi-Pj$ Equation 2.4-6

Where:

Pij is the real power flow from bus i to bus j.

Pji is the real power flow from bus j to bus i.

Pi is the real power injection at bus i.

Pj is the real power injection at bus j.

The sum of these calculated losses for all of the transmission lines in the network is then the total power loss. A load flow study involves solving the system's equations repeatedly to determine the bus voltages and angles that satisfy the power flow equations; the power losses are the outcome of these calculations. The aforementioned equation provides insight into system efficiency and losses while helping to quantify the power losses in each line.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Research Approach

The research approach is based on a careful analysis of the technical and financial elements of transmission lines, including voltage control, voltage profile enhancement, and line loss reduction. The outcomes of the INPS system simulation modeling were carried out with the aid of the dig-silent Power Factory 15.1 software. through simulation, validation, and comparison analysis, the specific line loss, loadability curve, short circuit analysis, and load flow in dig- silent are examined. Different case studies are conducted in the case of the Nepalese power system, which is integrated and connected to the HDI line. The analysis of the influence on the INPS network's load flow, voltage profile loadability, and implementation of the final result and counsel.

3.2 Methodology

The research approach is separated into many stages, which are briefly mentioned below.Figure 3 depicts a flowchart of the process.

- Literature review
  - The study of a variety of books and articles helped us understand the current situation with distribution feeders. The notion of gathering facts and information originated with several written works. The mathematical formulation underwent analysis and investigation. The parameters that are needed for simulation and computation were thoroughly investigated and scrutinized.
  - Data Collection

  The data of Standard INPS system connected load install capacity transmission line, conductor types voltage rating, etc wascollected.

- Simulation and Algorithm

  PowerFactory is a major power system analysis software tool that may be used to examine generation, transmission, distribution, and industrial systems.

  It includes typical functions as well as very sophisticated and advanced applications like wind power, distributed generation, real-time simulation, and performance monitoring for system testing and supervision. PowerFactory is simple to use, completely Windows compatible, and combines dependable and adaptable system modeling skills with cutting-edge algorithms and a one-of-a-kind database idea. PowerFactory is also well suited to highly automated and integrated solutions in your commercial applications due to its flexibility in scripting and interface.

- Load Flow study

  The system was simulated and load flow was performed.

- Simulation

Following the results, the system with an impact of HDI 400 kV Transmission line length of 576 km was developed. The analysis was performed using technical characteristics of the INPS such as voltage profile, voltage regulation, losses, voltage drop, percentage impedance loading, and financial factors before and after analysis. Following a thorough examination, the final result was confirmed and concluded based on the techno-financial parameters before and after the HDL injection of INPS into the System. Report Writing, Presentation, and Research paper publication. The final report and presentation were both completed.

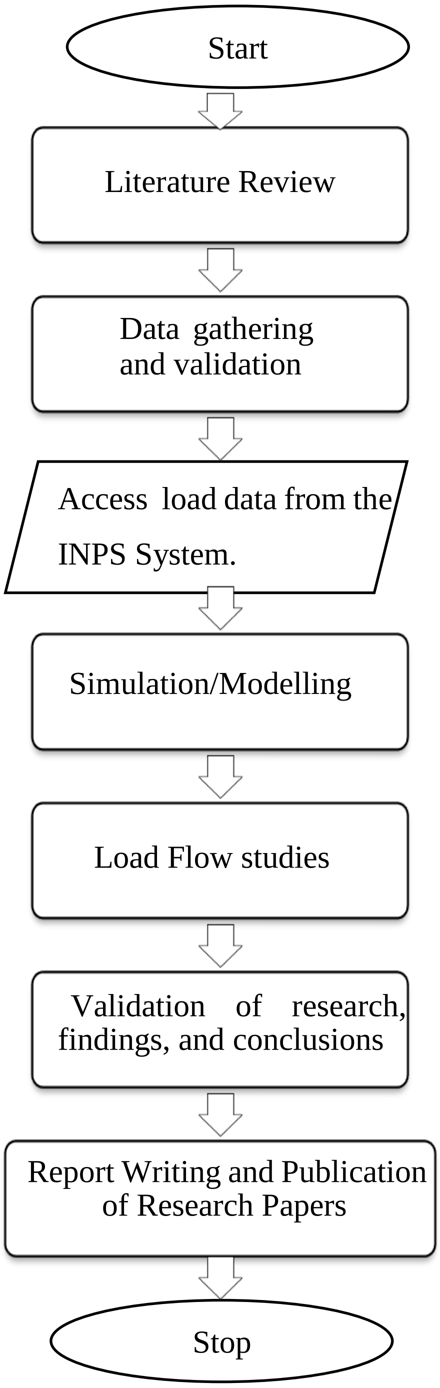


Figure 3 Research methodology

3.3 Flowchart of the proposed method

The flowchart of Newton- Raphson method starts with read line data, Bus data and the tolerance of ΔP and ΔQ. First assume all the buses except the slack bus, bus voltage 1PU and angle 0^0.Then check the convergence criteria if the systems is converged then calculate the bus parameter and line parameter in load flow study if not then go to the next step for checking the bus count that is all of the bus count is done or not. If not then the increase the bus count and find the jacobian matrix then after find the error vector matrix with the help of jacobian matrix then, update the old assume voltage and phase angle after the all the bus count is done then calculate the bus and the line parameter. The flow chart for the proposed N-R method is shown in Figure 4: General Methodology of the Load Flow study.

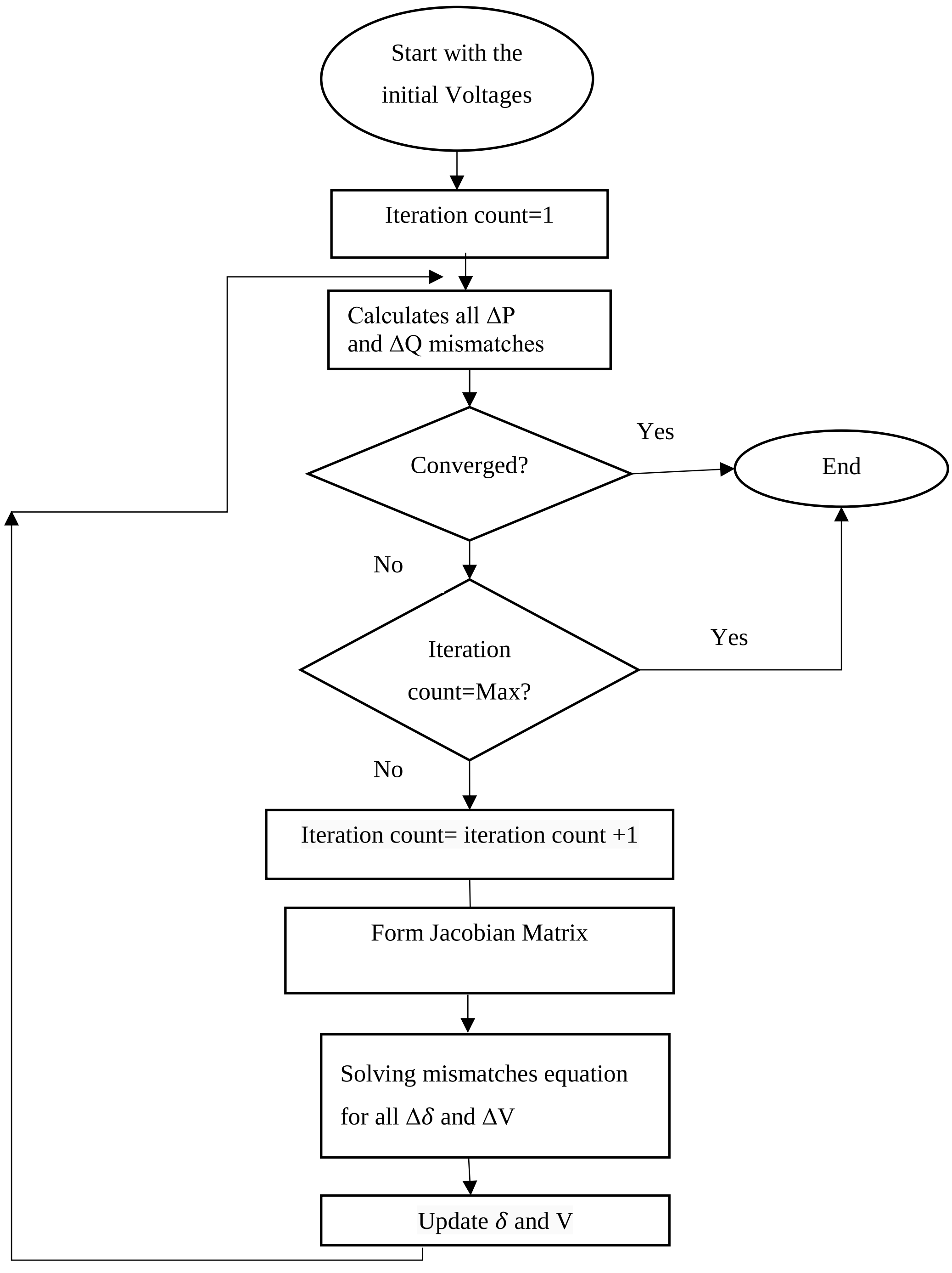


Figure 4: General Methodology of the Load Flow study

3.4 Algorithm of INPS System

- Start
- Define Study Objectives and Scope
- Collect Data and System Information
- Gather High-Voltage Transmission Line Data
- Collect System Load Data
- Obtain Generator Information
- Acquire Network Topology
- Simulation and Analysis
- Load Flow Analysis
- Apply Load Flow Methods (e.g., Newton-Raphson)
- Determine Bus Voltages, Angles, and Power Flows
- Short-Circuit Analysis
- Perform Fault Analysis (e.g., Symmetrical Components)
- Assess Fault Levels and Impacts
- Stability Analysis
- Evaluate Transient Stability and Voltage Stability
- Identify Critical Contingencies
- Assess High-Voltage Line Impact
- Voltage Profile Analysis
- Analyze Voltage Levels and Deviations
- Evaluate Voltage Support from the Line
- Power Flow Redistribution
- Analyze Power Flow Changes Due to Line Addition
- Identify Overloading or Underutilization
- Stability Impact

- Evaluate Stability Margins and Constraints
- Assess Impact on Transient and Voltage Stability
- Mitigation and Recommendations
- Optimal Power Flow
- Perform OPF to Optimize Generation and Dispatch
- Identify Generation or Transmission Upgrades
- Reactive Power Compensation
- Determine the Need for VAR Support and Compensation
- Recommend SVCs, STATCOMs, Capacitors, etc.
- Line Upgrades or Additions
- Assess Need for Line Upgrades or New Lines
- Evaluate Costs and Benefits
- Environmental and Social Impact Assessment
- Evaluate Environmental and Social Impacts
- Compliance with Regulations and Standards
- Decision-Making and Reporting
- Summarize Findings and Recommendations
- Present Impact Analysis Report
- End

3.5 Computational Approaches Used in Assessment

The research was done using a specific algorithm as part of the Digsilent power factory 15.1 simulations and modeling program. Data from the simulation was retrieved and interpreted utilizing Microsoft Excel 2016, graphs, and other tools needed for the analysis of the simulation results.

3. 6 Methodology Tools

3.6.1 Load flow study to find the power losses

The goal of load flow analysis is to determine a power system's steady-state operating conditions, which include calculating voltages, currents, and power flows at various buses and transmission lines. The equations provided are used in load flow analysis to calculate power flows and network losses.

The equations are broken down as follows:

The voltage at Each Bus (Vi): The first step in load flow analysis is to determine the magnitude and angle of the voltage at each bus in the power system. These voltages are denoted as Vi, where "i" represents the bus number. For generator buses, the voltage magnitude Vi is typically assumed to be constant and specified for load buses. Vi is calculated for each bus based on the complex power injection and admittance (Y) at that bus:

$$(P + jQ) / (V * Y^*) = Vi$$

Where:

Vi is the complex voltage at bus i. P and Q are the active and reactive power injections at bus i. V is the voltage magnitude at bus i. Y* is the complex conjugate of the bus admittance.

Power Loss in Lines (SLoss): The algebraic sum of the line power flows in both directions determines the power loss in a transmission line between buses i and j. This is denoted as SLoss:

$$S_{loss} = S_{ij} + S_{ji}$$

Sloss represents the power lost as heat due to transmission line resistance. It takes into account both active and reactive power losses.

The load flow analysis solves these equations iteratively for all buses and lines in the power system to ensure power balance and voltage constraints are met. The goal is to achieve a stable and balanced power network operating condition.

3.6.2 Financial analysis tools

3.6.2.1 Payback period(PBP)

The amount of years needed to recoup a project's investment is known as the payback time.

$$\text{Payback period (PBP)} = \text{minimum year} + \frac{\text{Unrecover amount}}{\text{Next year cash flow}}$$

3.6.2.2 Internal rate of return(IRR)

The internal rate of return (IRR) is a financial research measure used to assess the profitability of potential investments. The IRR is the discount rate in a discounted cash flow analysis that lowers the net present values (NPV) of all cash flows to zero [2].

$$NPV = \sum_{1}^{n} A_i / (1 + r)^n$$

Equation 7

3.7 Case Study Taken into Account in the Analysis

A list of the installed hydropower capacity of the INPS system can be found in Appendix A, and the length of the transmission line can be found in Appendix B.

3.8 Process of Documenting and Presenting the Findings

The findings of the research have been presented in a formal thesis paper that has been produced in accordance with the criteria of the Department of Mechanical and Aerospace Engineering at the Institute of Engineering's Pulchowk Campus.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Grid loss estimation

4.1.1 Study Case I considers an INPS without a HDI 400 kV transmission line

As indicated in Figure, the first study case is intended to be applied to an integrated Nepalese power system (INPS) without an HDI 400Kv transmission line. The B.S. 2079/080 power demand and generation scenario has been analyzed. The load flow solution calculates power loss. provided it consists of 30 generators, 58 load buses, 9 transformers, and 160 lines (branches) as shown in Figure 5.

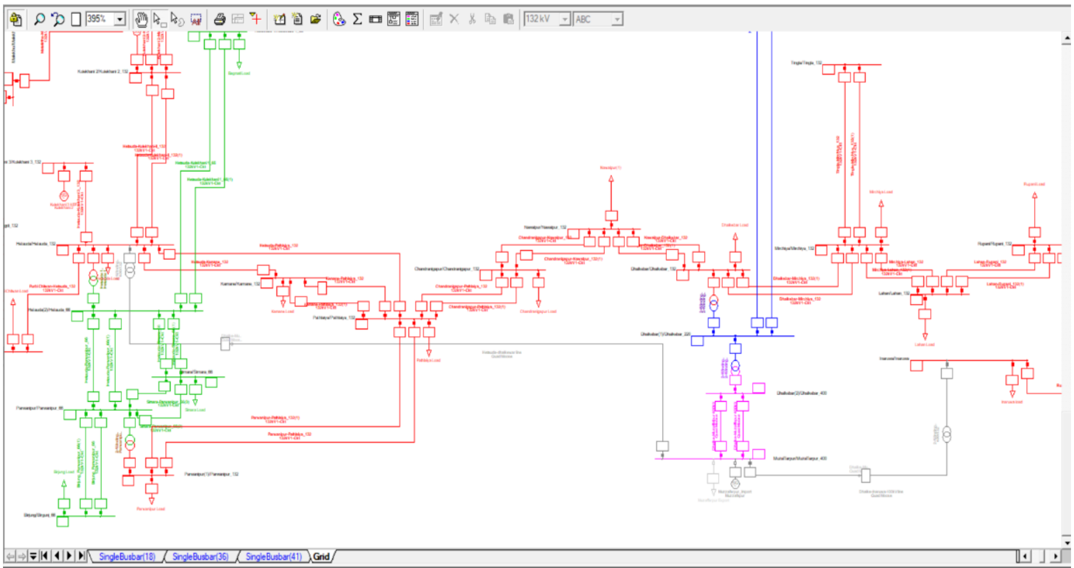


Figure 5: INPS system without HDI line

4.1.2 Study Case II considers an INPS with a HDI 400 KV transmission line

As indicated in Figure, the first study case is intended to be applied to an integrated Nepal power system (INPS) with HDI 400Kv transmission line. The B.S. 2079/080 power demand and generation scenario has been analyzed. The load flow solution calculates power loss. provided it consists of 30 generators, 58 load buses, 11 transformers, and 162 lines (branches) as shown in Figure 6.

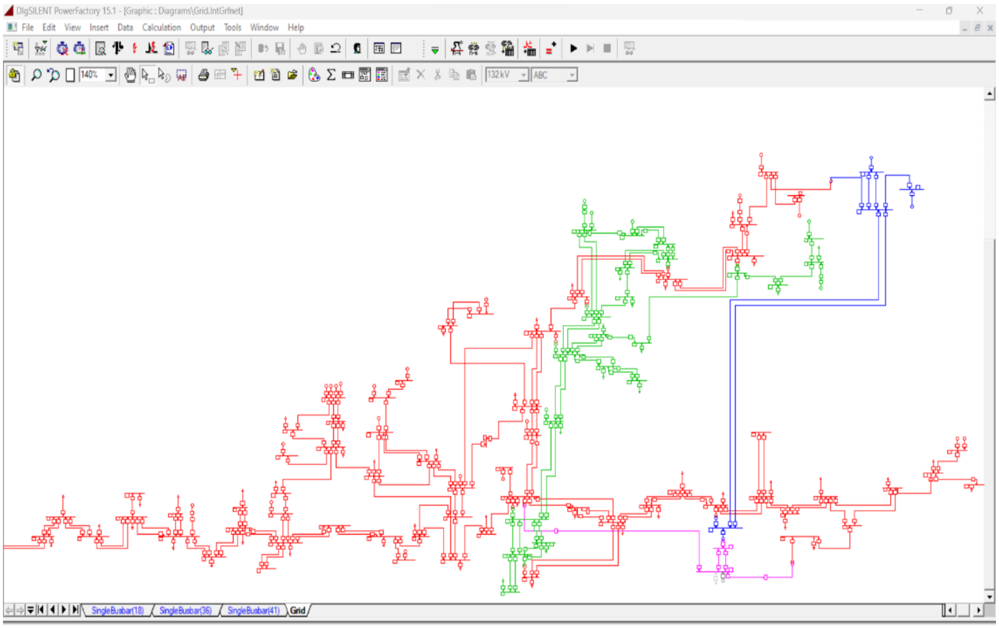


Figure 6: INPS with HDI 400KV Transmission Line

4.1.3 Load Flow

It was successful in identifying the most beneficial response when the INPS data were examined and fed into the built model.

4.1.4 Results for the Line test system without HDI transmission

Using the software Dig-silent Power Factory 15.1, INPS load flow has been run without the use of HDI transmission line. Load flow provides information on power loss. On a total generated power of 1000.21 MW, INPS transmission losses totaled 55.31 MW. Table 1 displays the results of the power flow.

```
-----------------------------------------------------------------------------------------------------------------------------------
|                 |                                                              |  DIgSILENT   | Project:                         |
|                 |                                                              | PowerFactory |----------------------------------
|                 |                                                              |   15.1.7     | Date:  01/08/2023                |
-----------------------------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------------------------------------
| Load Flow Calculation                                                                                               Grid Summary |
-----------------------------------------------------------------------------------------------------------------------------------
|    AC Load Flow, balanced, positive sequence                    |  Automatic Model Adaptation for Convergence          No         |
|    Automatic Tap Adjust of Transformers             No          |  Max. Acceptable Load Flow Error for                            |
|    Consider Reactive Power Limits                   No          |     Nodes                                           0.00 kVA   |
|                                                                 |     Model Equations                                 0.00 %     |
-----------------------------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------------------------------------
| Grid: Grid                System Stage: Grid            | Study Case: Study Case               | Annex:                    / 1  |
-----------------------------------------------------------------------------------------------------------------------------------
| Grid: Grid                Summary                                                                                               |
|                                                                                                                                   |
| No. of Substations     93         No. of Busbars       93         No. of Terminals     1497      No. of Lines          160       |
| No. of 2-w Trfs.       9          No. of 3-w Trfs.     0          No. of syn. Machines 30        No. of asyn.Machines  0         |
| No. of Loads           58         No. of Shunts        0          No. of SVS           0                                        |
|                                                                                                                                   |
| Generation          =     1000.21  MW          696.75  Mvar     1218.96  MVA                                                     |
| External Infeed     =        0.00  MW            0.00  Mvar        0.00  MVA                                                     |
| Inter Grid Flow     =        0.00  MW            0.00  Mvar                                                                      |
| Load P(U)           =      944.90  MW          708.67  Mvar     1181.12  MVA                                                     |
| Load P(Un)          =      944.90  MW          708.67  Mvar     1181.12  MVA                                                     |
| Load P(Un-U)        =       -0.00  MW            0.00  Mvar                                                                      |
| Motor Load          =        0.00  MW            0.00  Mvar        0.00  MVA                                                     |
| Grid Losses         =       55.31  MW          -11.93  Mvar                                                                      |
| Line Charging       =                         -271.57  Mvar                                                                      |
| Compensation ind.   =                            0.00  Mvar                                                                      |
| Compensation cap.   =                            0.00  Mvar                                                                      |
|                                                                                                                                   |
| Installed Capacity  =     1373.64  MW                                                                                            |
| Spinning Reserve    =      161.65  MW                                                                                            |
|                                                                                                                                   |
| Total Power Factor:                                                                                                               |
|   Generation        =        0.82  [-]                                                                                           |
|   Load/Motor        =  0.80 / 0.00  [-]                                                                                          |
|----------------------------------------------------------------------------------------------------------------------------------|
```

Figure 7:Summary sheet of INPS system without HDI line

4.1.5 Results for the Line test system with HDI transmission on INPS

Using the software Dig-silent Power Factory 15.1, INPS load flow has been run with the use of HDI transmission line. Load flow provides information on power loss. On a total generated power of 973.93 MW, INPS transmission losses totaled 29.03 MW, and the installed capacity was found to be 1373.64 with a spinning reserve of 187.92 along with an improved total load factor of the generation of 0.99. Table 1 displays the results of the power flow.

```
DIgSI/info - ------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------------------------------------
|                |                                                         |  DIgSILENT   | Project:                       |
|                |                                                         | PowerFactory |--------------------------------
|                |                                                         |    15.1.7    | Date:  01/08/2023              |
---------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------------------------------------
| Load Flow Calculation                                                                                      Grid Summary |
---------------------------------------------------------------------------------------------------------------------------
|     AC Load Flow, balanced, positive sequence              |   Automatic Model Adaptation for Convergence          No     |
|     Automatic Tap Adjust of Transformers         No        |   Max. Acceptable Load Flow Error for                        |
|     Consider Reactive Power Limits               No        |      Nodes                                           0.00 kVA |
|                                                            |      Model Equations                                 0.00 %   |
---------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------------------------------------
| Grid: Grid                 System Stage: Grid          | Study Case: Study Case              | Annex:                / 1 |
---------------------------------------------------------------------------------------------------------------------------
| Grid: Grid                 Summary                                                                                      |
|                                                                                                                         |
| No. of Substations     93        No. of Busbars       93        No. of Terminals     1497      No. of Lines          162 |
| No. of 2-w Trfs.       11        No. of 3-w Trfs.     0         No. of syn. Machines 30        No. of asyn.Machines  0   |
| No. of Loads           58        No. of Shunts        0         No. of SVS           0                                   |
|                                                                                                                         |
| Generation          =    973.93  MW        150.80  Mvar     985.54  MVA                                                |
| External Infeed     =      0.00  MW          0.00  Mvar       0.00  MVA                                                |
| Inter Grid Flow     =      0.00  MW          0.00  Mvar                                                                 |
| Load P(U)           =    944.90  MW        708.67  Mvar    1181.12  MVA                                                |
| Load P(Un)          =    944.90  MW        708.67  Mvar    1181.12  MVA                                                |
| Load P(Un-U)        =     -0.00  MW          0.00  Mvar                                                                 |
| Motor Load          =      0.00  MW          0.00  Mvar       0.00  MVA                                                |
| Grid Losses         =     29.03  MW       -557.87  Mvar                                                                 |
| Line Charging       =                     -714.11  Mvar                                                                 |
| Compensation ind.   =                        0.00  Mvar                                                                 |
| Compensation cap.   =                        0.00  Mvar                                                                 |
|                                                                                                                         |
| Installed Capacity  =   1373.64  MW                                                                                     |
| Spinning Reserve    =    187.92  MW                                                                                     |
|                                                                                                                         |
| Total Power Factor:                                                                                                     |
|   Generation        =        0.99  [-]                                                                                  |
|   Load/Motor        =  0.80 / 0.00  [-]                                                                                 |
|-------------------------------------------------------------------------------------------------------------------------|
```

Figure 8: Grid summary with HDI transmission line On INPS

4.1.6 Comparison of Grid power losses with the highest ten transmission lines

The impact of a high voltage 400 kV transmission line on the operation of INPS is that significantly reduced the line losses. The top ten lines (branches) are compared and get damak- godak 132 kV line loss reduced with the HDI line connected to INPS from 4719.415 kW to 574.7908 kW. Likewise, another line duhabi- damak 132 kV line loss was reduced from 3210.955 kW to 2.84 kW. The dhalkewar-mirchiya 132 kV line loss was reduced from 2517.547 kW to 126.08 kW. The rupani – duhabi 132 kV line loss was reduced from 2553.933 kW to 508.45 kW. Similarly, the top ten line nawalpur- dhalkewar 132 kV loss was reduced from 372.2739 kW to 90.45 kW.

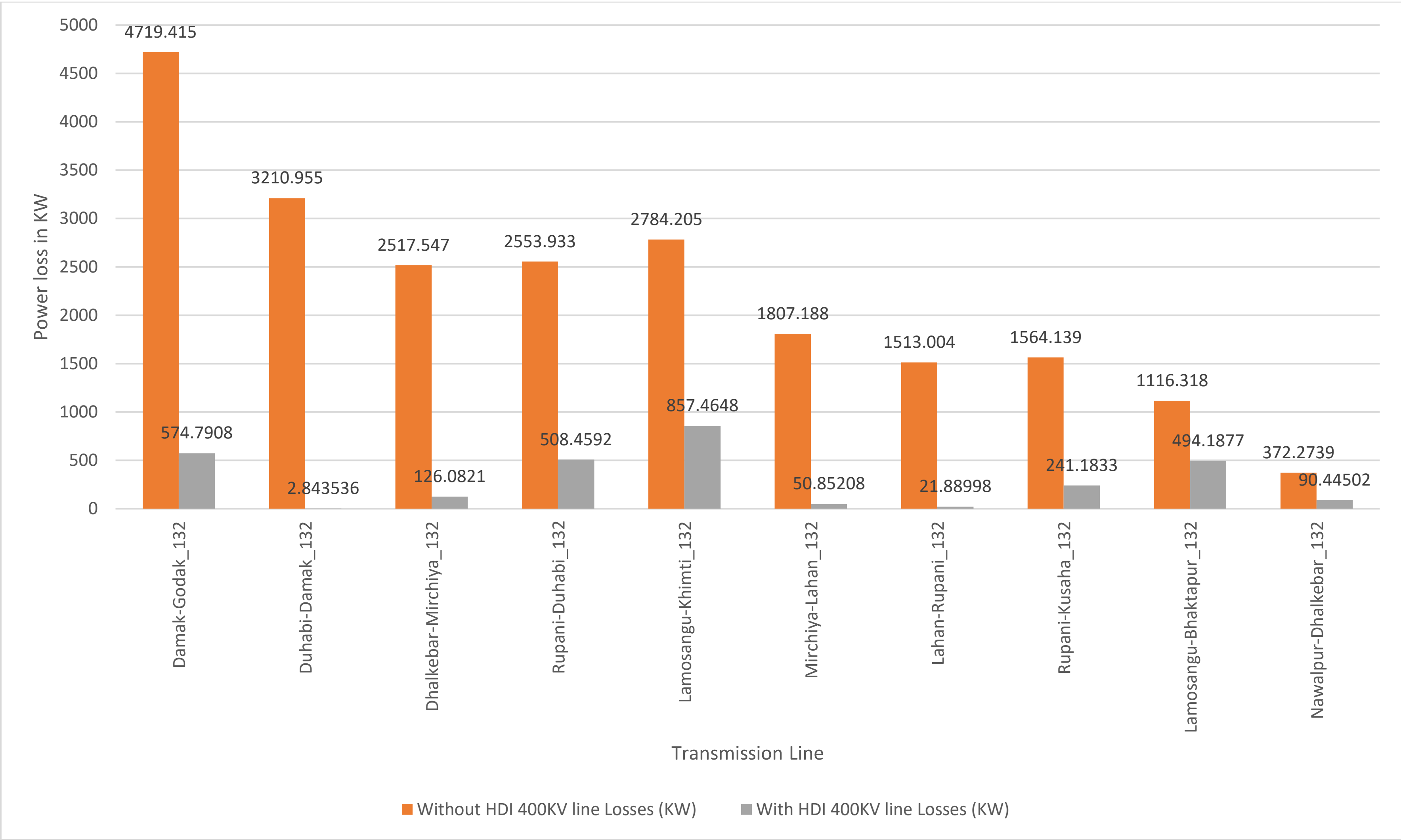


Figure 9: Highest Power losses in the Ten branches(Lines)

4.2 Voltage profile improvement connected to HDI 400 kV line

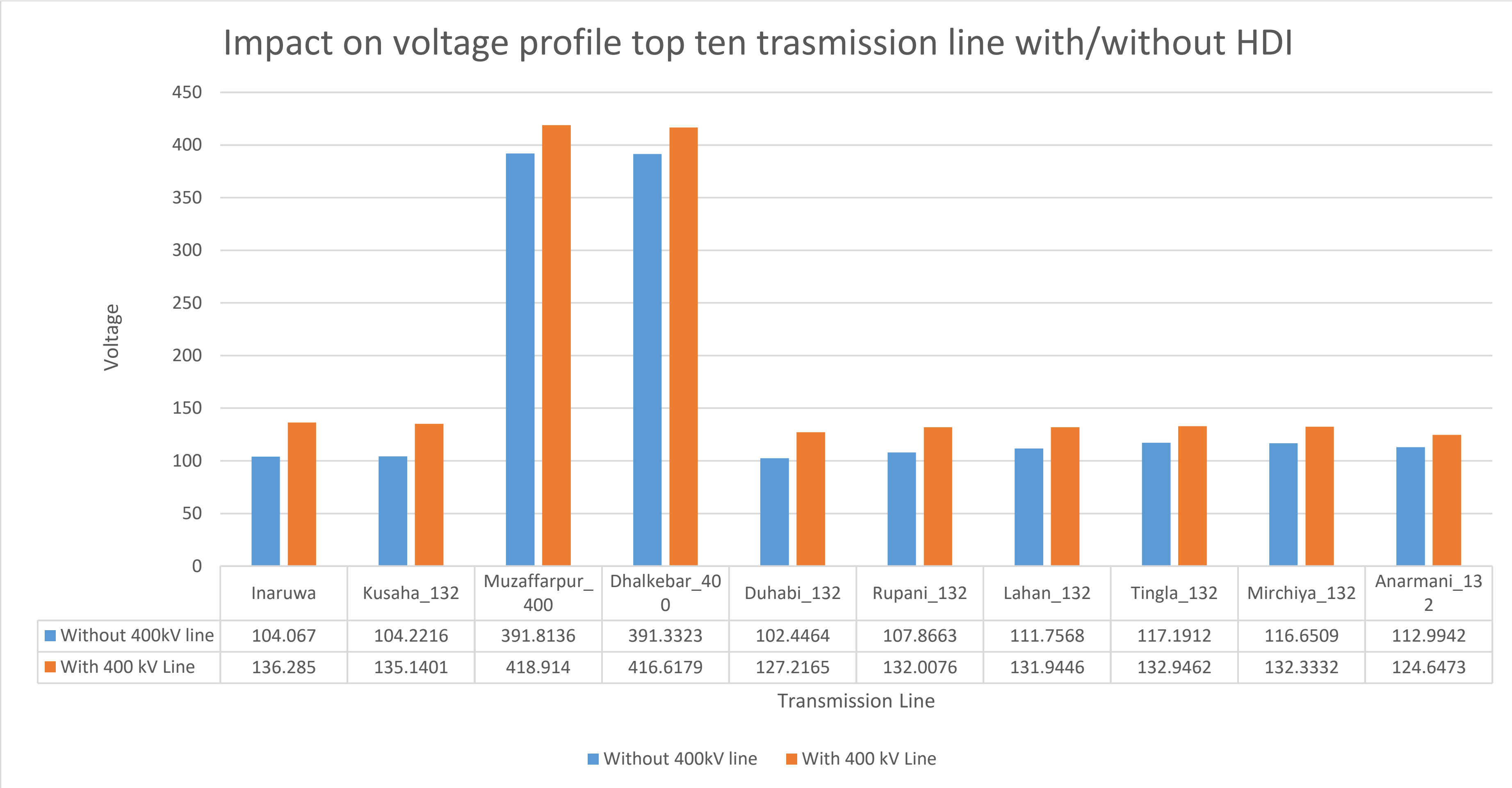
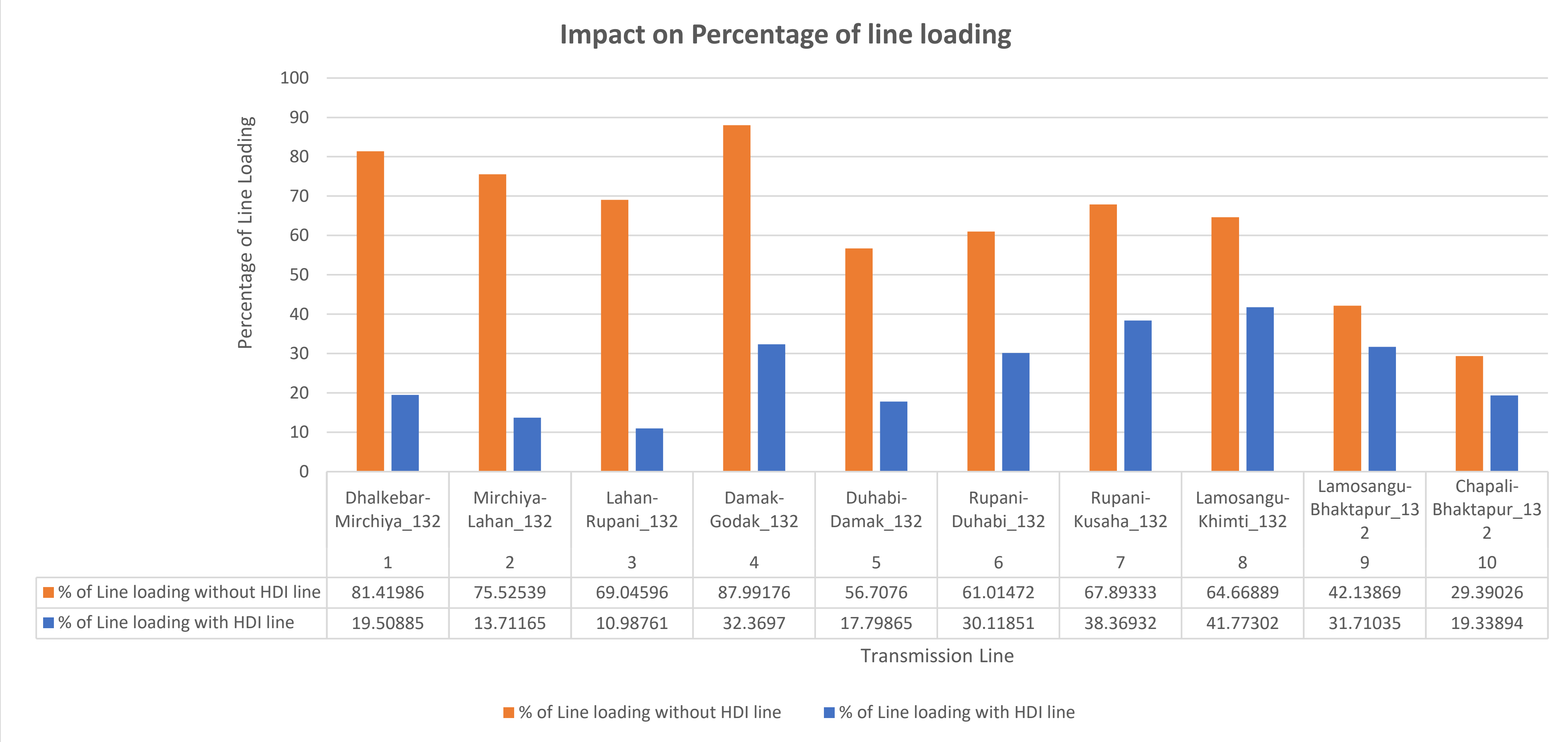


Figure 10: The impact on the voltage profile of the top ten transmission lines

4.3 Impact on % of Line loading on Highest 10 Branches



	1	2	3	4	5	6	7	8	9	10
	Dhalkebar-Mirchiya_132	Mirchiya-Lahan_132	Lahan-Rupani_132	Damak-Godak_132	Duhabi-Damak_132	Rupani-Duhabi_132	Rupani-Kusaha_132	Lamosangu-Khimti_132	Lamosangu-Bhaktapur_132	Chapali-Bhaktapur_132
% of Line loading without HDI line	81.41986	75.52539	69.04596	87.99176	56.7076	61.01472	67.89333	64.66889	42.13869	29.39026
% of Line loading with HDI line	19.50885	13.71165	10.98761	32.3697	17.79865	30.11851	38.36932	41.77302	31.71035	19.33894

Figure 11: Impact on HDI line on Line loading

4.4 Financial analysis of the HDI 400 kV transmission line

4.4.1 Payback period(PBP)

Rainy season PPA rate	4.8	per kWh
Dry season PPA rate	8.4	Per kWh
Weighted average PPA rate	6.6	per kWh

Substation costs and transmission line Costs(million)		
	USD	NPR
For the construction of 400 kV GIS substation at Dhalkebar	17.58	220.33
construction of 400 kV GIS substation at Hetauda and Inaruwa	28.4	410.5
Hetauda-Dhalkebar-Inaruwa 400kV Transmission Line	170	
	$ 215.98	630.83
In NPR@ 1 USD= 132 NPR in 21/09/2023)	28,698.34	630.83
Total Investment	**29,329.17 NPR**	

Year	Cash flow(in million) NPR	PVF, 10%	PV	Cumulative PV
0	-29329.17	1.00	-29329.17	-29329.17
1	7008.00	0.91	6370.91	-22958.26
2	7008.00	0.83	5791.74	-17166.52
3	7008.00	0.75	5265.21	-11901.31
4	7008.00	0.68	4786.56	-7114.75
5	7008.00	0.62	4351.42	-2763.33
6	7008.00	0.56	3955.83	1192.50

PBP= 5.70 years

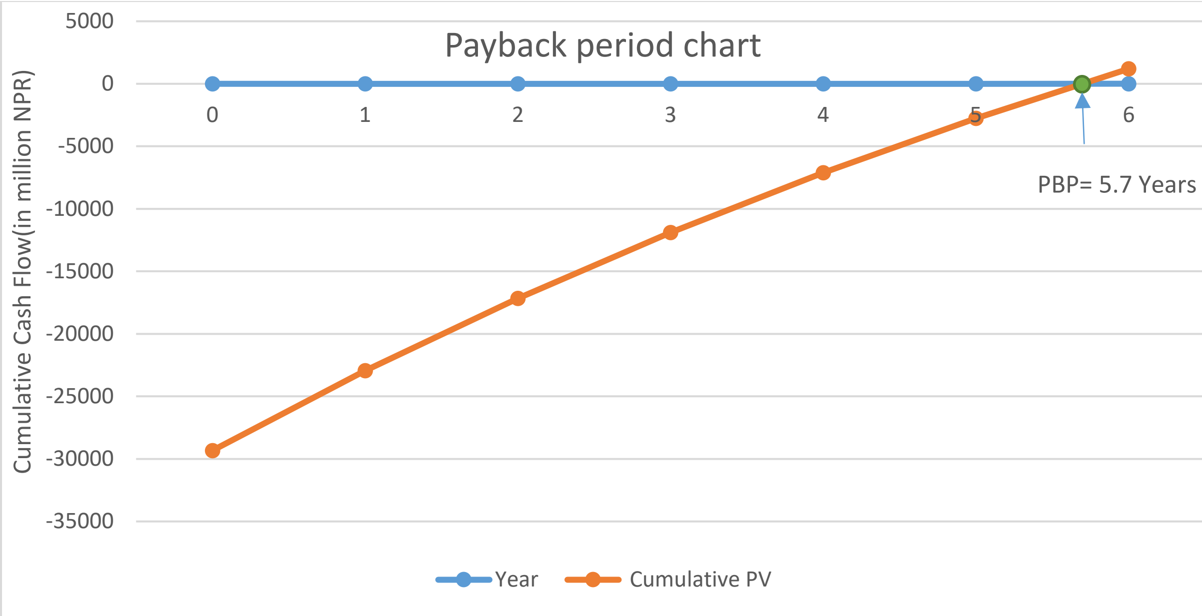


Figure 12 Payback period of HDI line

The project's payback period was found to be 5.70 years when 10% of the project's discounted rate was considered.

4.4.2 Internal rate of return(IRR)

4.4.2.1 Simple IRR calculation

The internal rate of return for the project was found to be 11% when the project's MARR was thought to be 10%, indicating that it is an investment that will yield a positive IRR. The Base MARR considered with averge of the top 20 commercial bank that taken from appendix F.

Year	0	1	2	3	4	5	6
Cash flow(in million) NPR	-29329.17	7008.00	7008.00	7008.00	7008.00	7008.00	7008.00

IRR=11.38%

4.4.2.2 incremental Internal rate of return(IRR)

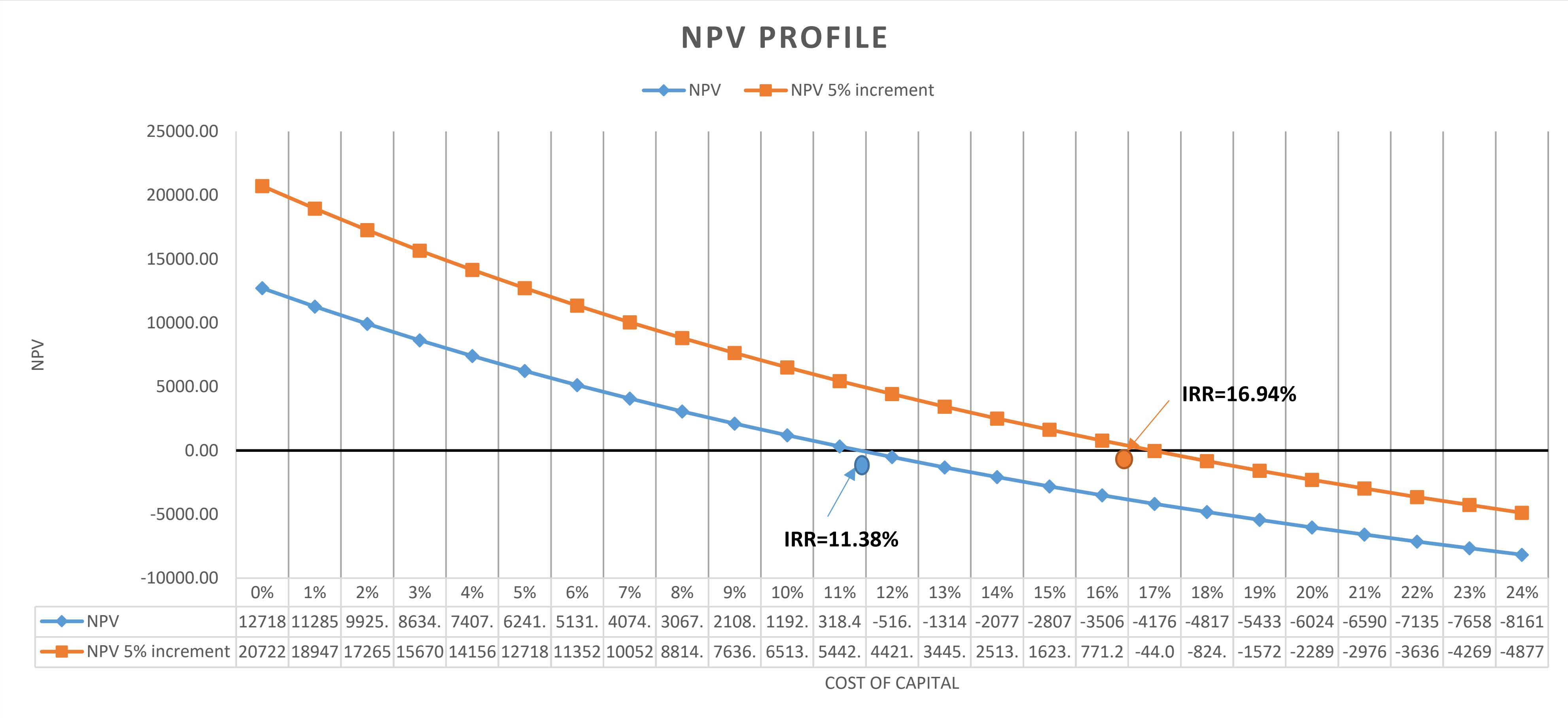
The internal rate of return was found that it was 16.94% after the annual profit increased by 5%. which is more the MARR, which indicates that the project being financially feasible..

Year	0	1	2	3	4	5	6
Cash flow(in million) MNPR	-29329	7008	7008	7008	7008	7008	7008
Incremented by 5% annually Cash flow(in million) NPR	-29329	7358.4	7726.32	8112.64	8518.27	8944.18	9391.39

IRR=16.94%

4.4.3 NPV Profile

The NPV against the discount rate graph plots with equal annual income and incremented by 5 %. The graph of NPV profile shown in *Figure 13*.



	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%
NPV	12718	11285	9925.	8634.	7407.	6241.	5131.	4074.	3067.	2108.	1192.	318.4	-516.
NPV 5% increment	20722	18947	17265	15670	14156	12718	11352	10052	8814.	7636.	6513.	5442.	4421.

	13%	14%	15%	16%	17%	18%	19%	20%	21%	22%	23%	24%
NPV	-1314	-2077	-2807	-3506	-4176	-4817	-5433	-6024	-6590	-7135	-7658	-8161
NPV 5% increment	3445.	2513.	1623.	771.2	-44.0	-824.	-1572	-2289	-2976	-3636	-4269	-4877

Figure 13: NPV profile

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The major cessations or findings of this analysis or research work are listed below:

- Comparing the Test model on INPS with and without HDITL, the Result shows that Transmission loss saving by connecting HDITL to INPS is 26.28MW, and energy loss saving per year will be 149638.3 MWh assuming 0.65 loss of load factor.
- The system Spinning reserve also increased to 187.92 MW from 161.65MW with connecting HDITL.
- Research done in KDTL results shows that Transmission loss saving by connecting KDTL to INPS is 15.639MW and energy loss saving per year will be 89048.46 MWh assuming 0.65 loss of load factor. power demand and generation scenario of B.S. 2070/071 has been considered
- Comparing the finding of research on KDTL (15.639MW loss saving based) with, the finding on the research of HDITL. It shows the findings obtained in this research work to be valid.
- Study shows that problems like voltage sag and line loss in INPS can be reduced and power transfer capability increased using a High-voltage Transmission line.
- The simulation result shows a significant improvement in the total system power factor of generator 0.99 from 0.82 with connecting HDITL.
- The transmission line loss reduced from 5.529% to 2.98% with conncting HDITL on INPS.
- The research's analysis reveals a significant decrease in transmission line power loss of almost 26.28 MW, and an annual energy loss savings of 149638.3 MWh.
- The project seems financially feasible according to factors like the payback period, the IRR method, and the NPV profile.

- The issue of generating power below its maximum capacity can be addressed by effectively utilizing high-voltage transmission lines and substations. By efficiently managing the transmission and distribution of power, surplus energy can be exported to other areas, contributing to a more optimized power generation process.

5.2 My Major achievement with this research study

- This study showed a significant decrease in transmission line power loss of almost 26.28 MW and a yearly energy loss savings of 149638.3 MWh.
- When connecting HDITL on INPS, the transmission line loss decreased from 5.529% to 2.98%, indicating increased line reliability and revenue generation.
- As stated in the simulation result, the generator's total system power factor increased significantly from 0.82 to 0.99 when the HDITL was connected. that indicates improved system performance and decreased system loss.
- With the addition of HDITL, the system's spinning reserve increased to 187.92 MW from 161.65 MW. This reserved generation capacity can be used to make up for power outages or frequency dips for a certain period of time.
- When 10% of the project's discounted rate was taken into account, the project's payback period was determined to be 5.70 years, and its internal rate of return was discovered to be 11.38%.
- The simulation's findings demonstrated that connecting an HDI line improved the system's voltage profile, decreased overall grid loss, and decreased the percentage of line loading. As a result, the system's reliability increased when the HDI line connected to an INPS.

5.3 RECOMMENDATIONS

The study can be expanded to include load growth patterns and load models.Feeder reconfiguration, in addition to strategically positioning capacitor banks and adding DERs to the system, can aid in lowering losses. Similar research can be conducted for the Khimti-Dhalkebar 220 kV Transmission Line to determine the impact on INPS and analyze grid losses with and without KDTL. Further harmonics and contingency analysis of INPS before and after HDI transmission line injection can be performed.Solar and wind power plants can be implemented to improve system reliability. Nepal should promote alternative energy through tax breaks, financing, and other incentives. The fact that Nepal is vulnerable to earthquakes and landslides, which could disrupt hydropower plants at any time, the nation needs to diversify its energy mix to ensure energy security.

REFERENCES

(n.d.). Retrieved from Rastriya Prasaran Grid Co Ltd (RPGCL): https://www.rpgcl.com/pages/about-us

Mishra, H. K., Karki, N., & Gyawali, N. (2014). Impact study of Khimti-Dhalkebar 220 kV Transmission Line on the .

Pandey, D., & Nakarmi, A. M. (2014). Financial Risk Assessment of Transmission Line Projects in Nepal:. *Department of Mechanical Engineering, Institute of Engineering, Central Campus, Pulchowk.*

Acharya, S., & Shrestha, R. (2020). Operation of Integrated Nepal Power System on Injection of.

Authority, N. E. (n.d.). *NEA Hetauda-Dhalkebar-Inaruwa Transmission Line Project Report.*

Bharat Chetry1, N. R. (n.d.). Adequacy Assessment of Integrated Nepal Power System.

ELECTRICAL ARTICLE. (n.d.). Retrieved from https://articleelectrical.blogspot.com/2018/12/load-dispatch-centre.html

Garrison, R. H., Noreen, E. W., & Brewer, P. C. (2014). *Managerial Accounting.* New York: The McGraw-Hill Companies .

http://xplaind.com/. (n.d.). Retrieved from http://xplaind.com/.

Infrastructure:, S.-E. I.-S. (n.d.). Case Study of NEA Hetauda-Dhalkebar-Inaruwa Transmission Line. Energy Development .

(2014). *Integrated Nepal Power System.*

investinganswers.com. (n.d.). Retrieved from http://www.investinganswers.com.

Investopedia. (2021, April 16). *How Does Financial Accounting Help Decision-Making?* Retrieved June 16, 2021, from Investopedia: https://www.investopedia.com/ask/answers/041515/how-does-financial-accounting-help-decision-making.asp

Investopedia. (2021, June 19). *Investopedia*. Retrieved from Economic Value Added- EVA: Investopedia: http://www.investopedia.com/terms/e/eva.asp

Lamichhane, B. (2021). Analysis of Nepalese Power System: Issues and Challenges.

McElheran, A., & Midland, C. (2021, June 3). *EVA for E&P Companies: A Challenging Measure*. Retrieved June 18, 2021, from https://www.meridiancp.com/: https://www.meridiancp.com/insights/eva-for-ep-companies-a-challenging-measure/

NEA. (2022). *A YEAR IN REVIEW-FISCAL YEAR 2021/2022.*

The Himalayan. (n.d.). Retrieved from https://thehimalayantimes.com/business/construction-of-transmission-line-stalled-for-six-years

Van Horne, J. C., & Wacowhicz, J. J. (2009). *Fundamentals of Financial Management* (13 ed.). New Delhi: Pearson Prentice Hall.

PUBLICATIONS

N. B. Gautam *et al.*, "International Journal of Advanced Engineering Transient Stability Analysis of Power System Using ETAP," vol. 06, no. 01, pp. 2586–7652, 2023, [Online]. Available: http://ictaes.org

ORIGINALITY REPORT

Ajay Shah

ORIGINALITY REPORT

17%

SIMILARITY INDEX

PRIMARY SOURCES

1	www.nea.org.np Internet	187 words — 2%
2	elibrary.tucl.edu.np Internet	184 words — 2%
3	www.digsilent.de Internet	117 words — 1%
4	www.saarcenergy.org Internet	65 words — 1%
5	eprints.maths.manchester.ac.uk Internet	62 words — 1%
6	www.coursehero.com Internet	59 words — 1%
7	www.nepjol.info Internet	46 words — 1%
8	doed.gov.np Internet	42 words — 1%
9	financedocbox.com Internet	41 words — < 1%

APPENDIX A: List of hydropower and installed capacity

The following are the results of the integration of performing research hydropower and installed capacity data obtained from the Load dispatch center, as specified in Section 3.5.

TABLE A-1: HYDROPOWER AND THEIR INSTALLED CAPACITY CONNECTED WITH INPS SYSTEM

S.N.	Name of hydropower	Installed Capacity (MW)
1	Solu Khola Dudhkoshi(86)	86.000
2	Super Dordi (54)	54.000
3	Likhu-IV(52.4)	52.400
4	Upper Marsyangdi "A"(50)	50.000
5	Upper Bhotekoshi Khola(45)	45.000
6	Super Madi (44)	44.000
7	Mistri Khola(42)	42.000
8	Upper Kalanga Gad(38.46)	38.460
9	Upper Balefi (36)	36.000
10	Nyadi(30)	30.000
11	Likhu Khola A(29.04)	24.200
12	Lower Likhu(28)	28.000
13	Dordi(27)	30.000
14	Upper Madi(25)	25.000
15	Kabeli B-1(25)	25.000
16	Singati Khola(25)	25.000
17	Upper Dordi (25)	25.000
18	Solu Khola(23.5)	23.500
19	Upper Chaku A(22.2)	22.200
20	Tallo Hewa Khola(22.1)	22.100
21	Sanima Mai Khola(22)	22.000
22	Bagmati Khola Small(22)	22.000
23	Lower Modi (20)	20.000
24	Middle Modi (18)	18.000
25	Kalanga Gad(15.33)	14.900
26	Hewa Khola A(14.9)	14.900
27	Thapa Khola(13.6)	13.600
28	Madkyu Khola(13)	13.000

29	Dordi12)	12.000
30	Jhimruk Khola(12)	12.000
31	Upper Khimti(12)	12.000
32	Upper Mai Khola (12)	22.00
33	Namarjun Madi(11.88)	11.880
34	Lower Khare(11)	11.000
35	Lower Modi 1(10)	10.000
36	Makari Gad(10.0)	10.000
37	Mithila Solar PV Electric Project(10)	10.000
38	Other IPP Total	85.000
39	Kabeli Corridor	240.000
	Total IPP	**922.140**
1	Upper Tamakoshi(456)	456.000
2	Khimti Khola(60)	60.000
3	Chilime(22.1)	22.100
	Total NEA SUBSIDIARIES	**538.100**
1	KGA(144)	144
2	Middle MRS(70)	70
3	MRS(69)	69
4	U Trisuli 3A(60)	60
5	CHM(30)	30
6	NEA SOLAR(25)	25
7	TRI(24)	24
8	GDK(15)	15
9	DEVI(14.1)	14.1
10	MODI(14)	14
11	SUN(10.05)	10.05
12	PUWA(6.2)	6.2
13	Other NEA Small	8.5
	Total ROR	**489.85**
1	KL1(60)	60
2	KL2(32)	32
3	KL3(14)	14
	Total STORGE	**106**
1	MULTI F(39)	39
2	HTD DIE(14.41)	14.4
3	MRS DI()	2
	Total THERMAL	**55.4**
	TOTAL SYSTEM LOAD (ACTUAL)	**2111.49**

TABLE A-2: LINE LENGTH AND OTHER DETAILS CONNECTED WITH THE INPS SYSTEM

S.N.	Name of hydropower	Installed Capacity (MW)
1	Solu Khola Dudhkoshi(86)	86.000
2	Super Dordi (54)	54.000
3	Likhu-IV(52.4)	52.400
4	Upper Marsyangdi "A"(50)	50.000
5	Upper Bhotekoshi Khola(45)	45.000
6	Super Madi (44)	44.000
7	Mistri Khola(42)	42.000
8	Upper Kalanga Gad(38.46)	38.460
9	Upper Balefi (36)	36.000
10	Nyadi(30)	30.000
11	Likhu Khola A(29.04)	24.200
12	Lower Likhu(28)	28.000
13	Dordi(27)	30.000
14	Upper Madi(25)	25.000
15	Kabeli B-1(25)	25.000
16	Singati Khola(25)	25.000
17	Upper Dordi (25)	25.000
18	Solu Khola(23.5)	23.500
19	Upper Chaku A(22.2)	22.200
20	Tallo Hewa Khola(22.1)	22.100
21	Sanima Mai Khola(22)	22.000
22	Bagmati Khola Small(22)	22.000
23	Lower Modi (20)	20.000
24	Middle Modi (18)	18.000
25	Kalanga Gad(15.33)	14.900
26	Hewa Khola A(14.9)	14.900
27	Thapa Khola(13.6)	13.600
28	Madkyu Khola(13)	13.000
29	Dordi12)	12.000
30	Jhimruk Khola(12)	12.000

31	Upper Khimti(12)	12.000
32	Upper Mai Khola (12)	22.00
33	Namarjun Madi(11.88)	11.880
34	Lower Khare(11)	11.000
35	Lower Modi 1(10)	10.000
36	Makari Gad(10.0)	10.000
37	Mithila Solar PV Electric Project(10)	10.000
38	Other IPP Total	85.000
39	Kabeli Corridor	240.000
	Total IPP	**922.140**
1	Upper Tamakoshi(456)	456.000
2	Khimti Khola(60)	60.000
3	Chilime(22.1)	22.100
	Total NEA SUBSIDIARIES	**538.100**
1	KGA(144)	144
2	Middle MRS(70)	70
3	MRS(69)	69
4	U Trisuli 3A(60)	60
5	CHM(30)	30
6	NEA SOLAR(25)	25
7	TRI(24)	24
8	GDK(15)	15
9	DEVI(14.1)	14.1
10	MODI(14)	14
11	SUN(10.05)	10.05
12	PUWA(6.2)	6.2
13	Other NEA Small	8.5
	Total ROR	**489.85**
1	KL1(60)	60
2	KL2(32)	32
3	KL3(14)	14
	Total STORGE	**106**
1	MULTI F(39)	39
2	HTD DIE(14.41)	14.4
3	MRS DI()	2
	Total THERMAL	**55.4**
	TOTAL SYSTEM LOAD (ACTUAL)	**2111.49**

S.N.	Name of the Line (From Ith bus to Jth bus)	Type	Length in KM	Type of Phase Conductors
1	Anarmani-Damak_132	132kV 1-Ckt	**27**	Bear 132
2	Attariya-Pahalmanpur_132	132kV 1-Ckt	**38**	Bear 132
3	Attariya-Pahalmanpur_132(1)	132kV 1-Ckt	**38**	Bear 132
4	Balaju-Chapali_132	132kV 1-Ckt	**11**	Bear 132
5	Balaju-Chapali_132(1)	132kV 1-Ckt	**11**	Bear 132
6	Balaju-Lainchour_66	132kV 1-Ckt	**2**	Panther 66
7	Balaju-Trishuli_66	132kV 1-Ckt	**29**	Dog 66
8	Balaju-Trishuli_66(1)	132kV 1-Ckt	**29**	Dog 66
9	Baneshwor-Bhaktapur_66	132kV 1-Ckt	**11**	AAAC Silvasa
10	Bardghat-Kawasoti_132	132kV 1-Ckt	**34**	Panther132
11	Bhaktapur-Banepa_132	132kV 1-Ckt	**11**	Wolf 66
12	Bharatpur-Damauli_132(1)	132kV 1-Ckt	**39**	Wolf 132
13	Bharatpur-Purbi Chitwan_132	132kV 1-Ckt	**35**	Panther132
14	Bhotekoshi HP-Lamosangu_132	132kV 1-Ckt	**31**	Dog 132
15	Birjung_Parwanipur_66	132kV 1-Ckt	**12**	Wolf 66
16	Birjung_Parwanipur_66(1)	132kV 1-Ckt	**12**	Wolf 66
17	Butwal-Kaligandaki_132	132kV 1-Ckt	**58**	Duck 132
18	Butwal-Kaligandaki_132(1)	132kV 1-Ckt	**58**	Duck 132
19	Butwal-Lumbini_132	132kV 1-Ckt	**22**	Bear 132
20	Butwal-Lumbini_132(1)	132kV 1-Ckt	**22**	Bear 132
21	Butwal-New Butwal_132	132kV 1-Ckt	**43**	Bear 132
22	Butwal-New Butwal_132(1)	132kV 1-Ckt	**43**	Bear 132
23	Chandranigapur-Nawalpur_132	132kV 1-Ckt	**25**	Bear 132
24	Chandranigapur-Nawalpur_132(1)	132kV 1-Ckt	**25**	Bear 132
25	Chandranigapur-Pathlaiya_132	132kV 1-Ckt	**32**	Bear 132
26	Chandranigapur-Pathlaiya_132(1)	132kV 1-Ckt	**32**	Bear 132
27	Chapali-Bhaktapur_132	132kV 1-Ckt	**12**	Bear 132
28	Chapali-Bhaktapur_132(1)	132kV 1-Ckt	**12**	Bear 132
29	Chapali-New Chabel_66	132kV 1-Ckt	**5**	AAAC Silvasa
30	Chapali-New Chabel_66(1)	132kV 1-Ckt	**5**	Dog 66
31	Chilime-Trishuli_66	132kV 1-Ckt	**39**	Wolf 66
32	Damak-Godak_132	132kV 1-Ckt	**34.55**	Bear 132
33	Devighat-Okhaltar_66	132kV 1-Ckt	**26.5**	Dog 66
34	Devighat-Okhaltar_66(1)	132kV 1-Ckt	**26.5**	Dog 66
35	Dhalke-Muzaffafpur 400kV	400kV 1-Ckt	**39**	Quad Moose
36	Dhalke-Muzaffapur 400kV	400kV 2-Ckt	**39**	Quad Moose
37	Dhalkebar-Mirchiya_132	132kV 1-Ckt	**32**	Bear 132
38	Dhalkebar-Mirchiya_132(1)	132kV 1-Ckt	**32**	Bear 132
39	Duhabi-Damak_132	132kV 1-Ckt	**43**	Bear 132

40	Gandak_Bardaghat_132	132kV 1-Ckt	**14**	Panther132
41	Hetauda-Kamane_132	132kV 1-Ckt	**8**	Bear 132
42	Hetauda-Kulekhani 1_66	132kV 1-Ckt	**16**	Wolf 66
43	Hetauda-Kulekhani 1_66(1)	132kV 1-Ckt	**16**	Wolf 66
44	Hetauda-Kulekhani 3_132	132kV 1-Ckt	**2**	Bear 132
45	Hetauda-Kulekhani-II_132	132kV 1-Ckt	**8**	Bear 132
46	Hetauda-Kulekhani-II_132(1)	132kV 1-Ckt	**8**	Bear 132
47	Hetauda-Parwanipur_66	132kV 1-Ckt	**52**	Wolf 66
48	Hetauda-Parwanipur_66(1)	132kV 1-Ckt	**52**	Wolf 66
49	Hetauda-Pathlaiya_132	132kV 1-Ckt	**37**	Bear 132
50	Hetauda-Simara_66	132kV 1-Ckt	**44**	Wolf 66
51	Hetauda-Simara_66(1)	132kV 1-Ckt	**44**	Wolf 66
52	Indrawati-Panchkhal_66	132kV 1-Ckt	**28**	Dog 66
53	Jhimruk-Lamahi_132	132kV 1-Ckt	**50**	Dog 132
54	Kaligandaki-Syangja_132	132kV 1-Ckt	**48**	Duck 132
55	Kamane-Pathlaiya_132	132kV 1-Ckt	**29**	Bear 132
56	Kamane-Pathlaiya_132(1)	132kV 1-Ckt	**29**	Bear 132
57	Kawasoti-Bharatpur_132	132kV 1-Ckt	**36**	Panther132
58	Kawasoti-NewBharatpur_132(1)	132kV 1-Ckt	**31**	Single Bison 132
59	Khimti-Likhu A_132	132kV 1-Ckt	**2.8**	Bear 132
60	Kohalpur-Bhurigaon_132	132kV 2-Ckt	**50**	Bear 132
61	Kohalpur-Bhurigaon_132(1)	132kV 1-Ckt	**50**	Bear 132
62	Kulekhani 1-Suichatar_66	132kV 1-Ckt	**29**	Wolf 66
63	Kulekhani 1-Suichatar_66(1)	132kV 1-Ckt	**29**	Wolf 66
64	Kulekhani 2-Matatirtha_132	132kV 1-Ckt	**36**	Bear 132
65	Kulekhani 2-Matatirtha_132(1)	132kV 1-Ckt	**36**	Bear 132
66	Kusaha-Duhabi_132	132kV 1-Ckt	**29**	Bear 132
67	Kusum-Hapure_132	132kV 1-Ckt	**20**	Bear 132
68	Kusum-Kohalpur_132	132kV 1-Ckt	**48**	Bear 132
69	Kusum-Kohalpur_132(1)	132kV 1-Ckt	**48**	Bear 132
70	Lahachowk-New Modi_132	132kV 1-Ckt	**40**	Bear 132
71	Lahachowk-New Modi_132(1)	132kV 1-Ckt	**40**	Bear 132
72	Lahan-Rupani_132	132kV 1-Ckt	**27**	Bear 132
73	Lahan-Rupani_132(1)	132kV 1-Ckt	**27**	Bear 132
74	Lainchour-New Chabel_132	XLPE 66	**7**	Dog 66
75	Lamahi-Ghorahi_132	132kV 1-Ckt	**13**	Bear 132
76	Lamahi-Ghorahi_132(1)	132kV 1-Ckt	**13**	Bear 132
77	Lamahi-Kusum_132	132kV 1-Ckt	**47**	Bear 132
78	Lamahi-Kusum_132(1)	132kV 1-Ckt	**47**	Bear 132
79	Lamahi-Shivapur_132	132kV 1-Ckt	**51**	Bear 132
80	Lamahi-Shivapur_132(1)	132kV 1-Ckt	**51**	Bear 132
81	Lamki-Bhurigaon_132	132kV 1-Ckt	**33**	Bear 132

82	Lamki-Bhurigaon_132(1)	132kV 1-Ckt	**33**	Bear 132
83	Lamosangu-Bhaktapur_132	132kV 1-Ckt	**48**	Bear 132
84	Lamosangu-Bhaktapur_132(1)	132kV 1-Ckt	**48**	Bear 132
85	Lamosangu-Khimti_132	132kV 1-Ckt	**46**	Bear 132
86	Lekhnath-Damauli_132	132kV 1-Ckt	**45**	Wolf 132
87	Lekhnath-Lahachowk_132	132kV 1-Ckt	**3**	Bear 132
88	Lekhnath-Lahachowk_132(1)	132kV 1-Ckt	**3**	Bear 132
89	Lekhnath-Pokhara_132	132kV 1-Ckt	**7**	Dog 132
90	Lekhnath-UMadi(132)	132kV 1-Ckt	**1**	Bear 132
91	LikhuIV-N Khimti_220(2)	Twin Moose220	**19**	Twin Bison 220
92	Mahendranagar-Attariya_132	132kV 1-Ckt	**37**	Bear 132
93	Mahendranagar-Attariya_132(1)	132kV 1-Ckt	**37**	Bear 132
94	Malekhu-Marsyangdi_132	132kV 1-Ckt	**36**	Bear 132
95	Marsyangdi-New Marsyangdhi_132	132kV 1-Ckt	**5**	Cardinal 132
96	Marsyangdi-New Marsyangdhi_132.	132kV 1-Ckt	**5**	Cardinal 132
97	Marsyangdi-Suichatar_132	132kV 1-Ckt	**84**	Duck 132
98	Matatirtha-Malekhu_132	132kV 1-Ckt	**36**	Bear 132
99	Matatirtha-Samundratar_132(2)	132kV 1-Ckt	**52**	Bear 132
100	Matatirtha-Suichatar_132	132kV 1-Ckt	**36**	Bear 132
101	Matatirtha-Suichatar_132(1)	132kV 1-Ckt	**36**	Bear 132
102	Middle Marsyangdi-Damauli_132(1)	132kV 1-Ckt	**18**	Bear 132
103	Mirchiya-Lahan_132	132kV 1-Ckt	**27**	Bear 132
104	Mirchiya-Lahan_132(1)	132kV 1-Ckt	**27**	Bear 132
105	Motipur-Butwal_132	132kV 1-Ckt	**38**	Bear 132
106	Motipur-Butwal_132(1)	132kV 1-Ckt	**38**	Bear 132
107	Motipur-Sandikharka_132	132kV 1-Ckt	**37**	Bear 132
108	Motipur-Sandikharka_132(1)	132kV 1-Ckt	**37**	Bear 132
109	N Khimti-Dhalkebar_220	220kV Tower 1-Ckt	**75**	Twin Bison 220
110	N Khimti-Dhalkebar_220(1)	220kV Tower 1-Ckt	**75**	Twin Bison 220
111	Nawalpur-Dhalkebar_132	132kV 1-Ckt	**45**	Bear 132
112	Nawalpur-Dhalkebar_132(1)	132kV 1-Ckt	**45**	Bear 132
113	New Bharatpur-Bharatpur_132	132kV 1-Ckt	**5**	Duck 132
114	New Bharatpur-Marsyangdi_132	132kV 1-Ckt	**20**	Duck 132
115	New Bharatpur-Marsyangdi_132(1)	132kV 1-Ckt	**20**	Duck 132
116	New Butwal-Bardghat_132	132kV 1-Ckt	**43**	Bear 132
117	New Butwal-Bardghat_132(1)	132kV 1-Ckt	**43**	Bear 132
118	New Marsyangdhi-Mid Marsyangdi_132	132kV 1-Ckt	**40**	Cardinal 132
119	New Marsyangdhi-Mid Marsyangdi_132(1)	132kV 1-Ckt	**40**	Cardinal 132
120	New Marsyangdi-Damauli_132	132kV 1-Ckt	**18**	Bear 132
121	Okhaltar-Chapali_132	132kV 1-Ckt	**2.8**	Dog 66

122	Okhaltar-Chapali_132(1)	132kV 1-Ckt	**2.8**	Dog 66
123	Pahalmanpur-Lamki_132	132kV 1-Ckt	**35**	Bear 132
124	Pahalmanpur-Lamki_132(1)	132kV 1-Ckt	**35**	Bear 132
125	Panchkhal-Banepa_66	132kV 1-Ckt	**8**	Wolf 66
126	Parwanipur-Pathlaiya_132	132kV 1-Ckt	**17**	Bear 132
127	Parwanipur-Pathlaiya_132(1)	132kV 1-Ckt	**17**	Bear 132
128	Patan-Baneshwor_66	132kV 1-Ckt	**2.7**	AAAC Silvasa
129	Pokhara-New Modi_132	132kV 1-Ckt	**37**	Bear 132
130	Purbi Chitwan-Hetauda_132	132kV 1-Ckt	**40**	Panther132
131	Rupani-Duhabi_132	132kV 1-Ckt	**58**	Bear 132
132	Rupani-Kusaha_132	132kV 1-Ckt	**29**	Bear 132
133	Samundratar-Trishuli_132	132kV 1-Ckt	**6**	AAAC Upas
134	Samundratar-Trishuli_132(1)	132kV 1-Ckt	**6**	AAAC Upas
135	Shivapur-Motipur_132	132kV 1-Ckt	**23**	Bear 132
136	Shivapur-Motipur_132(1)	132kV 1-Ckt	**23**	Bear 132
137	Simara-Parwanipur_66(2)	132kV 1-Ckt	**8**	Wolf 66
138	Simara-Parwanipur_66(3)	132kV 1-Ckt	**8**	Wolf 66
139	Suichatar-Balaju_132	132kV 1-Ckt	**4.9**	Bear 132
140	Suichatar-Balaju_66	132kV 1-Ckt	**7**	Wolf 66
141	Suichatar-Balaju_66(1)	132kV 1-Ckt	**7**	Wolf 66
142	Suichatar-Patan_66	132kV 1-Ckt	**7**	Wolf 66
143	Suichatar-Patan_66(1)	132kV 1-Ckt	**7**	Wolf 66
144	Suichatar-Teku_66(1)	132kV 1-Ckt	**4.1**	Bear 66
145	Sunkoshi-Panchkhal_66	132kV 1-Ckt	**29**	Wolf 66
146	Syangja-Lekhnath_132(1)	132kV 1-Ckt	**70**	Bear 132
147	Syaule-Attariya_132	132kV 1-Ckt	**131**	Bear 132
148	Tamakoshi-N Khimti_220	220kV Tower 1-Ckt	**47**	Twin Bison 220
149	Tamakoshi-N Khimti_220(1)	220kV Tower 1-Ckt	**47**	Twin Bison 220
150	Teku-K3_66	XLPE 66	**2.8**	Twin Moose 400
151	Teku-K3_66(1)	132kV 1-Ckt	**4.1**	Bear 66
152	Teku-K3_66(2)	XLPE 66	**2.8**	Bear 66
153	Tingla-Mirchiya_132	132kV 1-Ckt	**90**	Bear 132
154	Tingla-Mirchiya_132(1)	132kV 1-Ckt	**90**	Bear 132
155	Trishuli-Devighat_66	132kV 1-Ckt	**4.56**	Wolf 66
156	UMarsyangdhi-MMarsyangdi_132(2)	132kV 1-Ckt	**40**	Cardinal 132
157	UMarsyangdhi-Nyadi_132	132kV 1-Ckt	**6**	Bear 132

Table A-3 Load data connected INPS system

S.N.	Sub-Station	Load
1	Anarmani Load	31.8
2	Attariya Load	8.9
3	Bagmati Load	13.5
4	Balaju Load	24.5
5	Banepa Load	8.6
6	Baneshwor Load	4.7
7	Bardghat Load	2.4
8	Bhaktapur Load	10.5
9	Bharatpur Load	39.4
10	Bhurigaon Load	6.4
11	Birjung Load	17.1
12	Butwal Load	49.2
13	Chapel Load	34.5
14	Chandranigapur Load	17.8
15	Chapali Load	10.5
16	Damak Load	8.3
17	Damauli Load	3.4
18	Dhalkebar Load	30.2
19	Duhabi Load	112.2
20	Ghorahi Load	8.6
21	Hapure Load	4.4
22	Hetauda Load	42.3
23	Inaruwa load	13
24	K3 Load	25.8
25	Kamane Load	13
26	Kawasoti Load	12.5
27	Kohalpur Load	54.7
28	Kusum Load	0.4
29	Lahachowk Load	1.1
30	Lahan Load	13
31	Lainchour Load	23.1
32	Lamahi Substation	28.2
33	Lamki Load	5.9
34	Lamosangu Load	0
35	Lekhnath Load	29.6
36	Mahendranagar Load	10.5
37	Matatirtha Load	14.1
38	Mirchiya Load	15.3
39	Motipur Load	9.8
40	Muzaffarpur Export	300

41	Nawalpur(1)	14.8
42	New-Marsyangdi Load	18.6
43	Pahalmanpur Load	9.1
44	Panchkhal Load	14
45	Parwanipur Load	0
46	Patan Load	13.6
47	Pathlaiya Load	3
48	Pokhara Load	21.2
49	Purbi Chitwan Load	7.2
50	Rupani Load	9.4
51	Samundratar(1)	3.6
52	Sandhikharka Load	1.4
53	Shivpur Load	8.2
54	Simara Load	31.4
55	Suichatar Load	1.1
56	Syangja Load	2.4
57	Syaule Load	**3.7**
58	Teku Load	23
Total		**1244.9**

APPENDIX B: Impact On Voltage Profile With/Without HDI 400kv Transmission Line

S.N.	Buses	With 400 kV Line	Without 400kV line	Difference
1	Anarmani_132	124.6473	112.9942	11.6531
2	Attariya_132	129.6284	129.628	0.0004
3	Balaju_132	127.0701	126.8737	0.1964
4	Balaju_66	62.79284	62.7687	0.02414
5	Banepa_66	63.00483	63.00861	-0.00378
6	Baneshwor_66	62.40999	62.38553	0.02446
7	Bardghat_132	130.9838	130.9669	0.0169
8	Bhaktapur_132	127.3623	127.0758	0.2865
9	Bhaktapur_66	63.12901	63.13456	-0.00555
10	Bharatpur_132	130.8778	130.7645	0.1133
11	Bhurigaon_132	123.2999	123.2984	0.0015
12	Birgunj_66	63.13748	62.15253	0.98495
13	Butwal_132	128.005	127.9989	0.0061
14	Chandranigapur_132	130.8611	125.8542	5.0069
15	Chapali_132	127.014	126.7718	0.2422
16	Chapali_66	63.02619	62.99731	0.02888
17	Damak_132	127.4639	116.1159	11.348

18	Damauli_132	131.6716	131.6484	0.0232
19	Devighat_66	66	66	0
20	Dhalkebar_132	133.0127	123.4126	9.6001
21	Dhalkebar_220	224.9088	213.8181	11.0907
22	Dhalkebar_400	416.6179	391.3323	25.2856
23	Duhabi_132	127.2165	102.4464	24.7701
24	Gandak	132	132	0
25	Ghorahi_132	124.965	124.9624	0.0026
26	Godak_132	132	132	0
27	Hapure_132	123.1764	123.1742	0.0022
28	Hetauda_132	132.4427	131.4146	1.0281
29	Hetauda_66	65.65986	65.20329	0.45657
30	Inaruwa	136.285	104.067	32.218
31	Indrawati_66	66	66	0
32	K3_66	61.77882	61.7452	0.03362
33	Kaligandaki_132	132	132	0
34	Kamane_132	131.7508	130.1017	1.6491
35	Kawasoti_132	130.7247	130.6574	0.0673
36	Khimti_132	132	132	0
37	Kohalpur_132	121.7547	121.7529	0.0018
38	Kulekhani 1_66	66	66	0
39	Kulekhani 2_132	132	132	0
40	Kulekhani 3_132	132	132	0
41	Kusaha_132	135.1401	104.2216	30.9185
42	Kusum_132	123.4441	123.4419	0.0022
43	Lahachowk_132	132.1886	132.1897	-0.0011
44	Lahan_132	131.9446	111.7568	20.1878
45	Lainchour_66	62.43203	62.40993	0.0221
46	Lamahi_132	125.1381	125.1355	0.0026
47	Lamki_132	125.0229	125.0217	0.0012
48	Lamosangu_132	130.1431	129.8601	0.283
49	Lekhnath_132	132.0183	132.0186	-0.0003
50	Likhu-A_132	132	132	0
51	LikhuIV	220	220	0
52	Lumbini_132	128.0403	128.0341	0.0062
53	Mahendranagar_132	132	132	0
54	Malekhu_132	131.0912	131.0562	0.035
55	Marsyangdi_132	132	132	0
56	Matatirtha_132	130.0548	129.9836	0.0712
57	Mid Marsyangdi_132	132	132	0
58	Mirchiya_132	132.3332	116.6509	15.6823
59	Motipur_132	126.5311	126.526	0.0051
60	Muzaffarpur_400	418.914	391.8136	27.1004
61	Nawalpur_132	131.3335	124.6323	6.7012
62	New Bharatpur_132	131.2052	131.1297	0.0755

63	New Butwal_132	129.6303	129.6188	0.0115
64	New Chabel_66	62.24466	62.20253	0.04213
65	New Khimti_220	221.2405	218.6516	2.5889
66	New Marsyangdhi_132	131.8598	131.8581	0.0017
67	New Modi_132	134.4057	134.4167	-0.011
68	Nyadi	132	132	0
69	Okhaltar_66	63.31249	63.28649	0.026
70	Pahalmanpur_132	127.0415	127.0407	0.0008
71	Panchkhal_66	63.45999	63.46245	-0.00246
72	Parwanipur_132	130.3178	127.6824	2.6354
73	Parwanipur_66	63.94845	62.97657	0.97188
74	Patan_66	62.34335	62.31217	0.03118
75	Pathlaiya_132	131.0223	128.251	2.7713
76	Pokhara_132	132.0355	132.0375	-0.002
77	Purbi Chitwan_132	131.2091	130.6508	0.5583
78	Rupani_132	132.0076	107.8663	24.1413
79	Samundratar_132	131.8827	131.8789	0.0038
80	Sandikharka_132	126.545	126.5399	0.0051
81	Shivapur_132	125.9184	125.9141	0.0043
82	Simara_66	63.38203	62.47711	0.90492
83	Suichatar_132	127.6173	127.4627	0.1546
84	Suichatar_66	62.64738	62.61424	0.03314
85	Syangja_132	132.0631	132.0629	0.0002
86	Syaule_132	132	132	0
87	Teku_66	61.99008	61.95657	0.03351
88	Tingla_132	132.9462	117.1912	15.755
89	Trishuli 3A_132	132	132	0
90	Trishuli_66	66	66	0
91	UTK_220	220	220	0
92	Upper Marsyangdi_50.5	132	132	0
93	UpperMadi_132	132	132	0

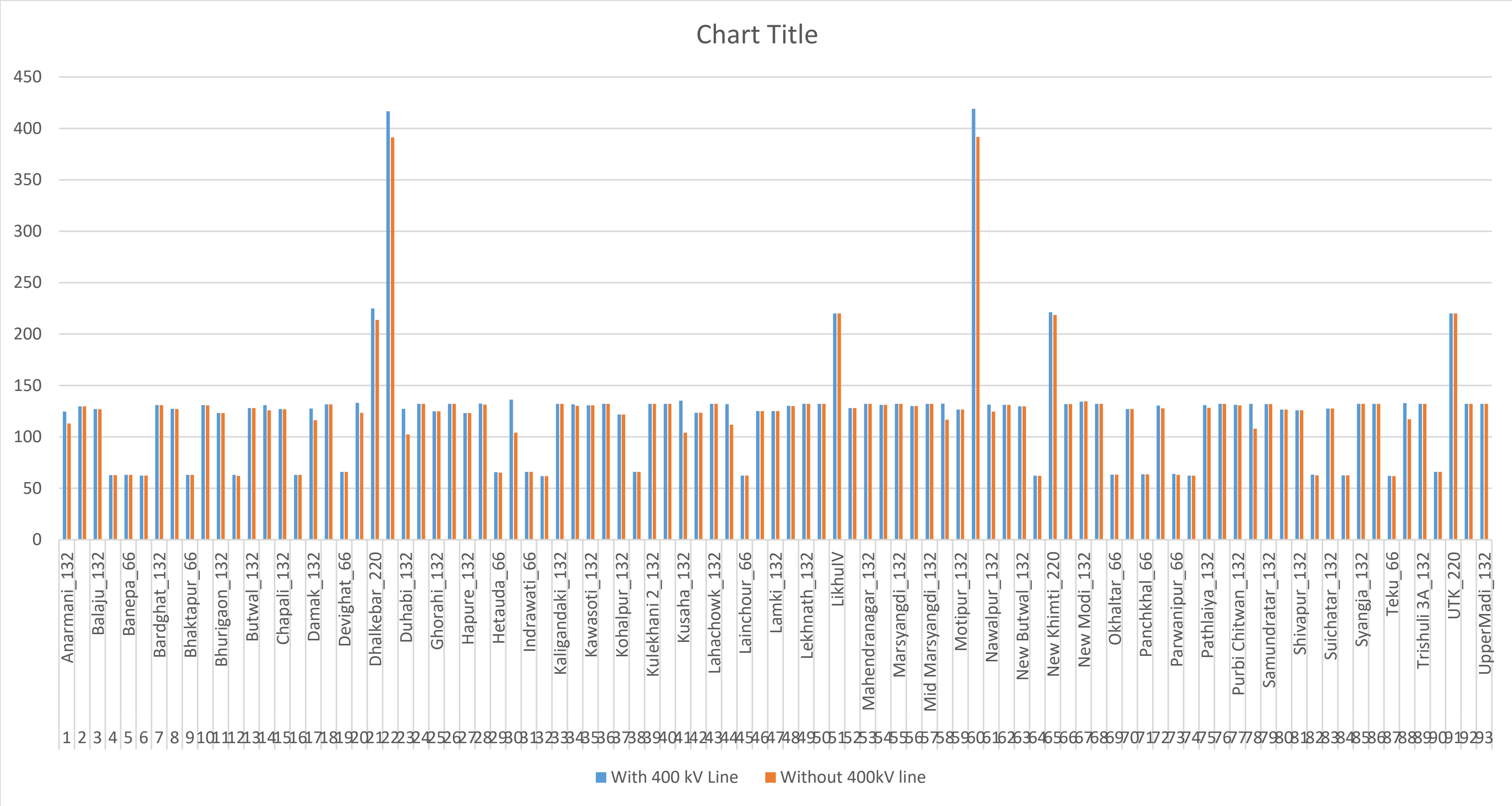


Figure: Voltage profile with/without HDL 400kV Transmission Line

APPENDIX C: LOSSES WITHOUT 400KV HDL LINE

S.N.	Line (From-To)	Length in KM	Without HDI 400KV line Losses (KW)
1	Anarmani-Damak_132	27	369.5848
2	Attariya-Pahalmanpur_132	38	202.5594
3	Attariya-Pahalmanpur_132(1)	38	202.5594
4	Balaju-Chapali_132	11	54.71104
5	Balaju-Chapali_132(1)	11	54.71104
6	Balaju-Lainchour_66	2	50.41452
7	Balaju-Trishuli_66	29	498.5684
8	Balaju-Trishuli_66(1)	29	498.5684
9	Baneshwor-Bhaktapur_66	11	97.85829
10	Bardghat-Kawasoti_132	34	64.70312
11	Bhaktapur-Banepa_132	11	44.95485
12	Bharatpur-Damauli_132(1)	39	160.5152
13	Bharatpur-Purbi Chitwan_132	35	369.7764
14	Bhotekoshi HP-Lamosangu_132	31	93.6306
15	Birjung_Parwanipur_66	12	65.16795
16	Birjung_Parwanipur_66(1)	12	65.16795
17	Butwal-Kaligandaki_132	58	1219.342
18	Butwal-Kaligandaki_132(1)	58	1219.342
19	Butwal-Lumbini_132	22	0.03928294
20	Butwal-Lumbini_132(1)	22	0.03928294
21	Butwal-New Butwal_132	43	40.98238
22	Butwal-New Butwal_132(1)	43	40.98238
23	Chandranigapur-Nawalpur_132	25	166.3907
24	Chandranigapur-Nawalpur_132(1)	25	166.3907
25	Chandranigapur-Pathlaiya_132	32	203.4982
26	Chandranigapur-Pathlaiya_132(1)	32	203.4982
27	Chapali-Bhaktapur_132	12	149.1294
28	Chapali-Bhaktapur_132(1)	12	149.1294
29	Chapali-New Chabel_66	5	180.8767
30	Chapali-New Chabel_66(1)	5	187.1615
31	Chilime-Trishuli_66	39	625.4012
32	Damak-Godak_132	34.55	4719.415
33	Devighat-Okhaltar_66	26.5	308.9049
34	Devighat-Okhaltar_66(1)	26.5	308.9049

35	Dhalke-Inaruwa 400kV line	145	0
36	Dhalke-Muzaffafpur 400kV	39	0.5229681
37	Dhalke-Muzaffafpur 400kV(1)_a	19.5	0
38	Dhalke-Muzaffafpur 400kV(2)_a	19.5	0
39	Dhalke-Muzaffapur 400kV	39	0.5229681
40	Dhalkebar-Mirchiya_132	32	2517.547
41	Dhalkebar-Mirchiya_132(1)	32	2517.547
42	Duhabi-Damak_132	43	3210.955
43	Gandak_Bardaghat_132	14	61.93033
44	Hetauda-Kamane_132	8	142.0584
45	Hetauda-Kulekhani 1_66	16	62.53662
46	Hetauda-Kulekhani 1_66(1)	16	62.53662
47	Hetauda-Kulekhani 3_132	2	120.1707
48	Hetauda-Kulekhani-II_132	8	62.05649
49	Hetauda-Kulekhani-II_132(1)	8	62.05649
50	Hetauda-Parwanipur_66	52	84.43442
51	Hetauda-Parwanipur_66(1)	52	84.43442
52	Hetauda-Pathlaiya_132	37	178.9064
53	Hetauda-Simara_66	44	158.0851
54	Hetauda-Simara_66(1)	44	158.0851
55	Hetauda-dhalkewar line	143	0
56	Indrawati-Panchkhal_66	28	245.8065
57	Jhimruk-Lamahi_132	50	320.4118
58	Kaligandaki-Syangja_132	48	6.899607
59	Kamane-Pathlaiya_132	29	80.10007
60	Kamane-Pathlaiya_132(1)	29	80.10007
61	Kawasoti-Bharatpur_132	36	20.16219
62	Kawasoti-NewBharatpur_132(1)	31	44.73634
63	Khimti-Likhu A_132	2.8	2.797851
64	Kohalpur-Bhurigaon_132	50	102.4667
65	Kohalpur-Bhurigaon_132(1)	50	41.28881
66	Kulekhani 1-Suichatar_66	29	525.968
67	Kulekhani 1-Suichatar_66(1)	29	525.968
68	Kulekhani 2-Matatirtha_132	36	402.9334
69	Kulekhani 2-Matatirtha_132(1)	36	402.9334
70	Kusaha-Duhabi_132	29	1026.767
71	Kusum-Hapure_132	20	4.081715
72	Kusum-Kohalpur_132	48	95.95465
73	Kusum-Kohalpur_132(1)	48	95.95465
74	Lahachowk-New Modi_132	40	104.9388
75	Lahachowk-New Modi_132(1)	40	104.9388
76	Lahan-Rupani_132	27	1513.004
77	Lahan-Rupani_132(1)	27	1513.004

78	Lainchour-New Chabel_132	7	4.755679
79	Lamahi-Ghorahi_132	13	2.532944
80	Lamahi-Ghorahi_132(1)	13	2.532944
81	Lamahi-Kusum_132	47	117.99
82	Lamahi-Kusum_132(1)	47	117.99
83	Lamahi-Shivapur_132	51	338.433
84	Lamahi-Shivapur_132(1)	51	338.433
85	Lamki-Bhurigaon_132	33	92.46275
86	Lamki-Bhurigaon_132(1)	33	92.46275
87	Lamosangu-Bhaktapur_132	48	1116.318
88	Lamosangu-Bhaktapur_132(1)	48	1116.318
89	Lamosangu-Khimti_132	46	2784.205
90	Lekhnath-Damauli_132	45	20.44609
91	Lekhnath-Lahachowk_132	3	7.941406
92	Lekhnath-Lahachowk_132(1)	3	7.941406
93	Lekhnath-Pokhara_132	7	0.3754689
94	Lekhnath-UMadi(132)	1	2.37984
95	LikhuIV-N Khimti_220(2)	19	22.54546
96	Mahendranagar-Attariya_132	37	214.5649
97	Mahendranagar-Attariya_132(1)	37	214.5649
98	Malekhu-Marsyangdi_132	36	168.8597
99	Marsyangdi-New Marsyangdhi_132	5	23.59138
100	Marsyangdi-New Marsyangdhi_132.	5	23.59138
101	Marsyangdi-Suichatar_132	84	327.7865
102	Matatirtha-Malekhu_132	36	170.2838
103	Matatirtha-Samundratar_132(2)	52	1065.853
104	Matatirtha-Suichatar_132	36	118.5412
105	Matatirtha-Suichatar_132(1)	36	118.5412
106	Middle Marsyangdi-Damauli_132(1)	18	274.081
107	Mirchiya-Lahan_132	27	1807.188
108	Mirchiya-Lahan_132(1)	27	1807.188
109	Motipur-Butwal_132	38	433.8563
110	Motipur-Butwal_132(1)	38	433.8563
111	Motipur-Sandikharka_132	37	0.1526092
112	Motipur-Sandikharka_132(1)	37	0.1526092
113	N Khimti-Dhalkebar_220	75	1259.645
114	N Khimti-Dhalkebar_220(1)	75	1259.645
115	Nawalpur-Dhalkebar_132	45	372.2739
116	Nawalpur-Dhalkebar_132(1)	45	372.2739
117	New Bharatpur-Bharatpur_132	5	62.01096
118	New Bharatpur-Marsyangdi_132	20	115.7621
119	New Bharatpur-Marsyangdi_132(1)	20	115.7621
120	New Butwal-Bardghat_132	43	29.69136

121	New Butwal-Bardghat_132(1)	43	29.69136
122	New Marsyangdhi-Mid Marsyangdi_132	40	155.4716
123	New Marsyangdhi-Mid Marsyangdi_132(1)	40	155.4716
124	New Marsyangdi-Damauli_132	18	55.71289
125	Okhaltar-Chapali_132	2.8	33.16529
126	Okhaltar-Chapali_132(1)	2.8	33.16529
127	Pahalmanpur-Lamki_132	35	127.9769
128	Pahalmanpur-Lamki_132(1)	35	127.9769
129	Panchkhal-Banepa_66	8	28.21628
130	Parwanipur-Pathlaiya_132	17	33.4451
131	Parwanipur-Pathlaiya_132(1)	17	33.4451
132	Patan-Baneshwor_66	2.7	7.842655
133	Pokhara-New Modi_132	37	133.7016
134	Purbi Chitwan-Hetauda_132	40	309.1718
135	Rupani-Duhabi_132	58	2553.933
136	Rupani-Duhabi_132(1)	3	8.188344
137	Rupani-Kusaha_132	29	1564.139
138	Samundratar-Trishuli_132	6	28.67272
139	Samundratar-Trishuli_132(1)	6	28.67272
140	Shivapur-Motipur_132	23	194.9314
141	Shivapur-Motipur_132(1)	23	194.9314
142	Simara-Parwanipur_66(2)	8	47.83665
143	Simara-Parwanipur_66(3)	8	47.83665
144	Suichatar-Balaju_132	4.9	64.71687
145	Suichatar-Balaju_66	7	57.01817
146	Suichatar-Balaju_66(1)	7	57.01817
147	Suichatar-Patan_66	7	11.70619
148	Suichatar-Patan_66(1)	7	11.70619
149	Suichatar-Teku_66(1)	4.1	112.1229
150	Sunkoshi-Panchkhal_66	29	195.2426
151	Syangja-Lekhnath_132(1)	70	2.879171
152	Syaule-Attariya_132	131	30.53269
153	Tamakoshi-N Khimti_220	47	809.6049
154	Tamakoshi-N Khimti_220(1)	47	809.6049
155	Teku-K3_66	2.8	5.539736
156	Teku-K3_66(1)	4.1	112.1229
157	Teku-K3_66(2)	2.8	5.539736
158	Tingla-Mirchiya_132	90	2.250704
159	Tingla-Mirchiya_132(1)	90	2.250704
160	Trishuli-Devighat_66	4.56	7.66667
161	UMarsyangdhi-MMarsyangdi_132(2)	40	565.4472
162	UMarsyangdhi-Nyadi_132	6	7.142706

	Total Line losses in MW	55.30797206

Table 2 Line Losses without HDI Transmission Line

APPENDIX D: Loss details on particular line with HDI line On INPS

S.N.	Line (From-To)	Length in KM	With HDI 400KV line Losses (KW)
1	Anarmani-Damak_132	27	302.6087
2	Attariya-Pahalmanpur_132	38	202.5319
3	Attariya-Pahalmanpur_132(1)	38	202.5319
4	Balaju-Chapali_132	11	6.183568
5	Balaju-Chapali_132(1)	11	6.183568
6	Balaju-Lainchour_66	2	54.01618
7	Balaju-Trishuli_66	29	481.5124
8	Balaju-Trishuli_66(1)	29	481.5124
9	Baneshwor-Bhaktapur_66	11	64.1065
10	Bardghat-Kawasoti_132	34	64.03739
11	Bhaktapur-Banepa_132	11	44.9782
12	Bharatpur-Damauli_132(1)	39	149.1946
13	Bharatpur-Purbi Chitwan_132	35	271.8857
14	Bhotekoshi HP-Lamosangu_132	31	80.35694
15	Birjung_Parwanipur_66	12	63.11296
16	Birjung_Parwanipur_66(1)	12	63.11296
17	Butwal-Kaligandaki_132	58	1216.348
18	Butwal-Kaligandaki_132(1)	58	1216.348
19	Butwal-Lumbini_132	22	0.03928673
20	Butwal-Lumbini_132(1)	22	0.03928673
21	Butwal-New Butwal_132	43	41.32737
22	Butwal-New Butwal_132(1)	43	41.32737
23	Chandranigapur-Nawalpur_132	25	13.90409
24	Chandranigapur-Nawalpur_132(1)	25	13.90409
25	Chandranigapur-Pathlaiya_132	32	0.5246155
26	Chandranigapur-Pathlaiya_132(1)	32	0.5246155
27	Chapali-Bhaktapur_132	12	47.53136
28	Chapali-Bhaktapur_132(1)	12	47.53136
29	Chapali-New Chabel_66	5	166.3087
30	Chapali-New Chabel_66(1)	5	172.0873
31	Chilime-Trishuli_66	39	625.4012
32	Damak-Godak_132	34.55	574.7908
33	Devighat-Okhaltar_66	26.5	308.3619

34	Devighat-Okhaltar_66(1)	26.5	308.3619
35	Dhalke-Inaruwa 400kV line	145	84.74632
36	Dhalke-Muzaffafpur 400kV	39	40.44603
37	Dhalke-Muzaffafpur 400kV(1)_a	19.5	0.07241894
38	Dhalke-Muzaffafpur 400kV(2)_a	19.5	0.07480372
39	Dhalke-Muzaffapur 400kV	39	40.44603
40	Dhalkebar-Mirchiya_132	32	126.0821
41	Dhalkebar-Mirchiya_132(1)	32	126.0821
42	Duhabi-Damak_132	43	2.843536
43	Gandak_Bardaghat_132	14	59.93205
44	Hetauda-Kamane_132	8	76.69164
45	Hetauda-Kulekhani 1_66	16	51.95291
46	Hetauda-Kulekhani 1_66(1)	16	51.95291
47	Hetauda-Kulekhani 3_132	2	68.03314
48	Hetauda-Kulekhani-II_132	8	44.80709
49	Hetauda-Kulekhani-II_132(1)	8	44.80709
50	Hetauda-Parwanipur_66	52	53.1865
51	Hetauda-Parwanipur_66(1)	52	53.1865
52	Hetauda-Pathlaiya_132	37	72.56716
53	Hetauda-Simara_66	44	118.7293
54	Hetauda-Simara_66(1)	44	118.7293
55	Hetauda-dhalkewar line	143	82.27115
56	Indrawati-Panchkhal_66	28	245.9357
57	Jhimruk-Lamahi_132	50	320.1759
58	Kaligandaki-Syangja_132	48	7.309881
59	Kamane-Pathlaiya_132	29	25.23684
60	Kamane-Pathlaiya_132(1)	29	25.23684
61	Kawasoti-Bharatpur_132	36	21.87333
62	Kawasoti-NewBharatpur_132(1)	31	43.4123
63	Khimti-Likhu A_132	2.8	2.797851
64	Kohalpur-Bhurigaon_132	50	102.4402
65	Kohalpur-Bhurigaon_132(1)	50	41.27812
66	Kulekhani 1-Suichatar_66	29	416.9036
67	Kulekhani 1-Suichatar_66(1)	29	416.9036
68	Kulekhani 2-Matatirtha_132	36	200.3786
69	Kulekhani 2-Matatirtha_132(1)	36	200.3786
70	Kusaha-Duhabi_132	29	2151.482
71	Kusum-Hapure_132	20	4.081554
72	Kusum-Kohalpur_132	48	95.96401
73	Kusum-Kohalpur_132(1)	48	95.96401
74	Lahachowk-New Modi_132	40	104.0729
75	Lahachowk-New Modi_132(1)	40	104.0729
76	Lahan-Rupani_132	27	21.88998

77	Lahan-Rupani_132(1)	27	21.88998
78	Lainchour-New Chabel_132	7	2.642244
79	Lamahi-Ghorahi_132	13	2.532831
80	Lamahi-Ghorahi_132(1)	13	2.532831
81	Lamahi-Kusum_132	47	117.9964
82	Lamahi-Kusum_132(1)	47	117.9964
83	Lamahi-Shivapur_132	51	338.3806
84	Lamahi-Shivapur_132(1)	51	338.3806
85	Lamki-Bhurigaon_132	33	92.44379
86	Lamki-Bhurigaon_132(1)	33	92.44379
87	Lamosangu-Bhaktapur_132	48	494.1877
88	Lamosangu-Bhaktapur_132(1)	48	494.1877
89	Lamosangu-Khimti_132	46	857.4648
90	Lekhnath-Damauli_132	45	20.87757
91	Lekhnath-Lahachowk_132	3	7.87346
92	Lekhnath-Lahachowk_132(1)	3	7.87346
93	Lekhnath-Pokhara_132	7	0.3681781
94	Lekhnath-UMadi(132)	1	2.353872
95	LikhuIV-N Khimti_220(2)	19	21.61082
96	Mahendranagar-Attariya_132	37	214.5448
97	Mahendranagar-Attariya_132(1)	37	214.5448
98	Malekhu-Marsyangdi_132	36	170.8123
99	Marsyangdi-New Marsyangdhi_132	5	24.4339
100	Marsyangdi-New Marsyangdhi_132.	5	24.4339
101	Marsyangdi-Suichatar_132	84	455.3481
102	Matatirtha-Malekhu_132	36	171.8697
103	Matatirtha-Samundratar_132(2)	52	1066.455
104	Matatirtha-Suichatar_132	36	131.9513
105	Matatirtha-Suichatar_132(1)	36	131.9513
106	Middle Marsyangdi-Damauli_132(1)	18	269.3085
107	Mirchiya-Lahan_132	27	50.85208
108	Mirchiya-Lahan_132(1)	27	50.85208
109	Motipur-Butwal_132	38	433.8164
110	Motipur-Butwal_132(1)	38	433.8164
111	Motipur-Sandikharka_132	37	0.1526079
112	Motipur-Sandikharka_132(1)	37	0.1526079
113	N Khimti-Dhalkebar_220	75	1443.665
114	N Khimti-Dhalkebar_220(1)	75	1443.665
115	Nawalpur-Dhalkebar_132	45	90.44502
116	Nawalpur-Dhalkebar_132(1)	45	90.44502
117	New Bharatpur-Bharatpur_132	5	50.17779
118	New Bharatpur-Marsyangdi_132	20	98.61346
119	New Bharatpur-Marsyangdi_132(1)	20	98.61346

120	New Butwal-Bardghat_132	43	30.01149
121	New Butwal-Bardghat_132(1)	43	30.01149
122	New Marsyangdhi-Mid Marsyangdi_132	40	157.7131
123	New Marsyangdhi-Mid Marsyangdi_132(1)	40	157.7131
124	New Marsyangdi-Damauli_132	18	59.92324
125	Okhaltar-Chapali_132	2.8	33.08413
126	Okhaltar-Chapali_132(1)	2.8	33.08413
127	Pahalmanpur-Lamki_132	35	127.9551
128	Pahalmanpur-Lamki_132(1)	35	127.9551
129	Panchkhal-Banepa_66	8	28.26836
130	Parwanipur-Pathlaiya_132	17	37.24279
131	Parwanipur-Pathlaiya_132(1)	17	37.24279
132	Patan-Baneshwor_66	2.7	2.816441
133	Pokhara-New Modi_132	37	132.8206
134	Purbi Chitwan-Hetauda_132	40	230.6533
135	Rupani-Duhabi_132	58	508.4592
136	Rupani-Duhabi_132(1)	3	384.0494
137	Rupani-Kusaha_132	29	241.1833
138	Samundratar-Trishuli_132	6	28.67754
139	Samundratar-Trishuli_132(1)	6	28.67754
140	Shivapur-Motipur_132	23	194.9095
141	Shivapur-Motipur_132(1)	23	194.9095
142	Simara-Parwanipur_66(2)	8	52.39606
143	Simara-Parwanipur_66(3)	8	52.39606
144	Suichatar-Balaju_132	4.9	43.85907
145	Suichatar-Balaju_66	7	40.29576
146	Suichatar-Balaju_66(1)	7	40.29576
147	Suichatar-Patan_66	7	13.93706
148	Suichatar-Patan_66(1)	7	13.93706
149	Suichatar-Teku_66(1)	4.1	111.9652
150	Sunkoshi-Panchkhal_66	29	195.3581
151	Syangja-Lekhnath_132(1)	70	3.232678
152	Syaule-Attariya_132	131	30.52534
153	Tamakoshi-N Khimti_220	47	710.7724
154	Tamakoshi-N Khimti_220(1)	47	710.7724
155	Teku-K3_66	2.8	5.531924
156	Teku-K3_66(1)	4.1	111.9652
157	Teku-K3_66(2)	2.8	5.531924
158	Tingla-Mirchiya_132	90	2.899769
159	Tingla-Mirchiya_132(1)	90	2.899769
160	Trishuli-Devighat_66	4.56	9.625468
161	UMarsyangdhi-MMarsyangdi_132(2)	40	565.4472

162	UMarsyangdhi-Nyadi_132	6	7.142706
Total Line losses in MW			**29.0310615**

APPENDIX E: Impact on Line Loading in Terms of Percentage

S.N.	Transmission line	% of Line loading with HDI line	% of Line loading without HDI line
1	Dhalkebar-Mirchiya_132	19.50885	81.41986
2	Dhalkebar-Mirchiya_132(1)	19.50885	81.41986
3	Mirchiya-Lahan_132	13.71165	75.52539
4	Mirchiya-Lahan_132(1)	13.71165	75.52539
5	Lahan-Rupani_132	10.98761	69.04596
6	Lahan-Rupani_132(1)	10.98761	69.04596
7	Damak-Godak_132	32.3697	87.99176
8	Duhabi-Damak_132	17.79865	56.7076
9	Rupani-Duhabi_132	30.11851	61.01472
10	Rupani-Kusaha_132	38.36932	67.89333
11	Lamosangu-Khimti_132	41.77302	64.66889
12	Lamosangu-Bhaktapur_132	31.71035	42.13869
13	Lamosangu-Bhaktapur_132(1)	31.71035	42.13869
14	Chapali-Bhaktapur_132	19.33894	29.39026
15	Chapali-Bhaktapur_132(1)	19.33894	29.39026
16	Balaju-Chapali_132	6.944507	16.787
17	Balaju-Chapali_132(1)	6.944507	16.787
18	Kulekhani 2-Matatirtha_132	23.88582	30.30672
19	Kulekhani 2-Matatirtha_132(1)	23.88582	30.30672
20	Nawalpur-Dhalkebar_132	19.99844	25.14223
21	Nawalpur-Dhalkebar_132(1)	19.99844	25.14223
22	Chandranigapur-Nawalpur_132	13.66241	18.33274
23	Chandranigapur-Nawalpur_132(1)	13.66241	18.33274
24	LikhuIV-N Khimti_220(2)	15.5447	20.19985
25	Chandranigapur-Pathlaiya_132	7.199018	10.31475
26	Chandranigapur-Pathlaiya_132(1)	7.199018	10.31475
27	Dhalkewar -Inaruwa line 400KV line	5.591934	8.697087
28	Suichatar-Balaju_66	23.40117	26.3021
29	Suichatar-Balaju_66(1)	23.40117	26.3021
30	Anarmani-Damak_132	33.27609	36.12078
31	Kulekhani 1-Suichatar_66	37.49623	40.18246
32	Kulekhani 1-Suichatar_66(1)	37.49623	40.18246
33	New Bharatpur-Bharatpur_132	26.49941	28.79492
34	N Khimti-Dhalkebar_220	34.27217	36.45126

35	N Khimti-Dhalkebar_220(1)	34.27217	36.45126
36	Patan-Baneshwor_66	4.870818	6.965695
37	Bharatpur-Purbi Chitwan_132	27.09975	29.09511
38	Chapali-New Chabel_66(1)	62.93288	64.68085
39	Bhotekoshi HP-Lamosangu_132	38.51553	40.25972
40	Baneshwor-Bhaktapur_66	11.7764	13.51602
41	Tamakoshi-N Khimti_220	27.59435	29.12009
42	Tamakoshi-N Khimti_220(1)	27.59435	29.12009
43	New Bharatpur-Marsyangdi_132	18.70961	19.87592
44	New Bharatpur-Marsyangdi_132(1)	18.70961	19.87592
45	Hetauda-Kulekhani 1_66	16.08566	17.11787
46	Hetauda-Kulekhani 1_66(1)	16.08566	17.11787
47	Hetauda-Parwanipur_66	9.212467	10.24319
48	Hetauda-Parwanipur_66(1)	9.212467	10.24319
49	Lainchour-New Chabel_132	4.449034	5.44667
50	Purbi Chitwan-Hetauda_132	24.02753	25.02068
51	Hetauda-Simara_66	15.363	16.35605
52	Hetauda-Simara_66(1)	15.363	16.35605
53	Bharatpur-Damauli_132(1)	36.5241	37.4584
54	Chapali-New Chabel_66	28.32147	29.10816
55	Suichatar-Balaju_132	30.51788	31.18113
56	Balaju-Trishuli_66	43.96707	44.43171
57	Balaju-Trishuli_66(1)	43.96707	44.43171
58	Gandak_Bardaghat_132	19.65388	20.08308
59	Birjung_Parwanipur_66	22.56965	22.78846
60	Birjung_Parwanipur_66(1)	22.56965	22.78846
61	Middle Marsyangdi-Damauli_132(1)	38.96506	39.15661
62	Bardghat-Kawasoti_132	13.19396	13.36958
63	Kawasoti-NewBharatpur_132(1)	11.01567	11.12957
64	Dhalke-Inaruwa 400kV(2)_a	0.6302682	0.6830137
65	Dhalke-Muzaffafpur 400kV	1.245357	1.295124
66	Dhalke-Muzaffapur 400kV	1.245357	1.295124
67	Butwal-Kaligandaki_132	38.8453	38.88371
68	Butwal-Kaligandaki_132(1)	38.8453	38.88371
69	Lekhnath-Lahachowk_132	16.33961	16.36975
70	Lekhnath-Lahachowk_132(1)	16.33961	16.36975
71	Lahachowk-New Modi_132	16.79725	16.82709
72	Lahachowk-New Modi_132(1)	16.79725	16.82709
73	Jhimruk-Lamahi_132	61.27782	61.30655
74	Pokhara-New Modi_132	19.56933	19.59721
75	Lekhnath-Pokhara_132	5.499603	5.524508
76	Suichatar-Teku_66(1)	52.50522	52.52498
77	Teku-K3_66(1)	52.50522	52.52498

78	Teku-K3_66	10.3928	10.39673
79	Teku-K3_66(2)	10.3928	10.39673
80	Lamahi-Shivapur_132	26.01823	26.02126
81	Lamahi-Shivapur_132(1)	26.01823	26.02126
82	Lamki-Bhurigaon_132	17.2029	17.20523
83	Lamki-Bhurigaon_132(1)	17.2029	17.20523
84	Shivapur-Motipur_132	29.29022	29.29254
85	Shivapur-Motipur_132(1)	29.29022	29.29254
86	Pahalmanpur-Lamki_132	19.60442	19.60663
87	Pahalmanpur-Lamki_132(1)	19.60442	19.60663
88	Attariya-Pahalmanpur_132	23.61407	23.6162
89	Attariya-Pahalmanpur_132(1)	23.61407	23.6162
90	Kohalpur-Bhurigaon_132	10.90131	10.90313
91	Motipur-Butwal_132	33.98967	33.99146
92	Motipur-Butwal_132(1)	33.98967	33.99146
93	Kohalpur-Bhurigaon_132(1)	9.795971	9.797605
94	Mahendranagar-Attariya_132	24.54558	24.54714
95	Mahendranagar-Attariya_132(1)	24.54558	24.54714
96	Syaule-Attariya_132	7.130425	7.131265
97	Lamahi-Ghorahi_132	4.581686	4.581811
98	Lamahi-Ghorahi_132(1)	4.581686	4.581811
99	Kusum-Hapure_132	4.756321	4.756433
100	Chilime-Trishuli_66	39.71532	39.71532
101	Khimti-Likhu A_132	10.06794	10.06794
102	UMarsyangdhi-MMarsyangdi_132(2)	27.88009	27.88009
103	UMarsyangdhi-Nyadi_132	11.00524	11.00524
104	Butwal-Lumbini_132	0.8498603	0.8498069
105	Butwal-Lumbini_132(1)	0.8498603	0.8498069
106	Motipur-Sandikharka_132	1.135363	1.135296
107	Motipur-Sandikharka_132(1)	1.135363	1.135296
108	Lamahi-Kusum_132	16.24259	16.24187
109	Lamahi-Kusum_132(1)	16.24259	16.24187
110	Samundratar-Trishuli_132	13.12405	13.12299
111	Samundratar-Trishuli_132(1)	13.12405	13.12299
112	Kusum-Kohalpur_132	14.58859	14.58751
113	Kusum-Kohalpur_132(1)	14.58859	14.58751
114	Matatirtha-Samundratar_132(2)	45.59648	45.58363
115	Lekhnath-UMadi(132)	15.48001	15.46104
116	Bhaktapur-Banepa_132	20.00376	19.97966
117	Okhaltar-Chapali_132	36.99031	36.95747
118	Okhaltar-Chapali_132(1)	36.99031	36.95747
119	Devighat-Okhaltar_66	36.93677	36.9024
120	Devighat-Okhaltar_66(1)	36.93677	36.9024

121	Sunkoshi-Panchkhal_66	25.93287	25.89817
122	Indrawati-Panchkhal_66	32.16921	32.1307
123	Butwal-New Butwal_132	10.61956	10.57218
124	Butwal-New Butwal_132(1)	10.61956	10.57218
125	New Butwal-Bardghat_132	9.137728	9.088613
126	New Butwal-Bardghat_132(1)	9.137728	9.088613
127	Matatirtha-Malekhu_132	22.02621	21.96253
128	New Marsyangdhi-Mid Marsyangdi_132	14.74937	14.68077
129	New Marsyangdhi-Mid Marsyangdi_132(1)	14.74937	14.68077
130	Kaligandaki-Syangja_132	3.610064	3.540831
131	Lekhnath-Damauli_132	12.86024	12.78877
132	Malekhu-Marsyangdi_132	21.92963	21.85235
133	Panchkhal-Banepa_66	18.67578	18.59765
134	Syangja-Lekhnath_132(1)	2.801322	2.718134
135	Kawasoti-Bharatpur_132	7.502174	7.36561
136	Marsyangdi-New Marsyangdhi_132	16.37435	16.20611
137	Marsyangdi-New Marsyangdhi_132.	16.37435	16.20611
138	Tingla-Mirchiya_132	3.73616	3.483751
139	Tingla-Mirchiya_132(1)	3.73616	3.483751
140	Parwanipur-Pathlaiya_132	15.65226	15.35024
141	Parwanipur-Pathlaiya_132(1)	15.65226	15.35024
142	New Marsyangdi-Damauli_132	18.45995	18.10862
143	Simara-Parwanipur_66(2)	26.0829	25.70371
144	Simara-Parwanipur_66(3)	26.0829	25.70371
145	Dhalke-Muzaffafpur 400kV(1)_a	0.5979684	0
146	Suichatar-Patan_66	14.07444	13.17378
147	Suichatar-Patan_66(1)	14.07444	13.17378
148	Trishuli-Devighat_66	14.46118	13.45404
149	Balaju-Lainchour_66	49.21737	48.05239
150	Matatirtha-Suichatar_132	19.95623	18.36188
151	Matatirtha-Suichatar_132(1)	19.95623	18.36188
152	Marsyangdi-Suichatar_132	20.24078	18.27665
153	Kamane-Pathlaiya_132	7.745122	4.156047
154	Kamane-Pathlaiya_132(1)	7.745122	4.156047
155	Hetauda-Pathlaiya_132	11.86732	7.526587
156	Hetauda-dhalkewar line	4.87812	
157	Hetauda-dhalkewar line_a	7.031999	0
158	Hetauda-Kamane_132	26.79998	19.39126
159	Hetauda-Kulekhani-II_132	38.63543	22.16635
160	Hetauda-Kulekhani-II_132(1)	38.63543	22.16635
161	Kusaha-Duhabi_132	94.10435	54.02264
162	Hetauda-Kulekhani 3_132	127.3627	46.87525

163	Inaruwa-Kusaha 132KV	129.1981	15.18208

APPENDIX F: Interest rate of top 20 commercial Bank in Nepal

S. No.	Name of Bank	General Saving Max. Interest (% p.a.)	Interest Rate Fixed Deposit (% p.a.)	
			Individual	Institutional
1	Machhapuchchhre Bank Limited	7.85	9	7
2	Citizens Bank International Limited	7.4	9.99	7.99
3	Laxmi Sunrise Bank Limited	7.4	9.99	7.99
4	Prime Commercial Bank Limited	7.93	10.93	8.93
5	Kumari Bank Limited	7.4	10.01	7.51
6	Nepal SBI Bank Limited	6.4	9.99	7.99
7	Himalayan Bank Limited	7.4	9.99	7.99
8	Prabhu Bank Limited	7.5	9.5	7.5
9	Sanima Bank Limited	7.2	9.52	7.52
10	Siddhartha Bank Limited	7	9.5	7.5
11	Global IME Bank Limited	7	9.99	7.99
12	NMB Bank Limited	7.98	10.98*	7.99

13	Agricultural Development Bank Limited	7	9.51	7.51
14	Nepal Investment Mega Bank Limited	7.4	9.99	7.99
15	Everest Bank Limited	6.75	9.5	7.5
16	Nabil Bank Limited	7.9	10.49	8.49
17	Nepal Bank Limited	6.66	8.99	6.99
18	Standard Chartered Bank Nepal Limited	6.45	8.95	6.95
19	Rastriya Banijjya Bank	6.66	8.99	6.99
20	Nepal Bank Limited	7.95	9.29	7.29
Average Interest Rate(%)		**7.2615**	**9.6906842**	**7.6805**

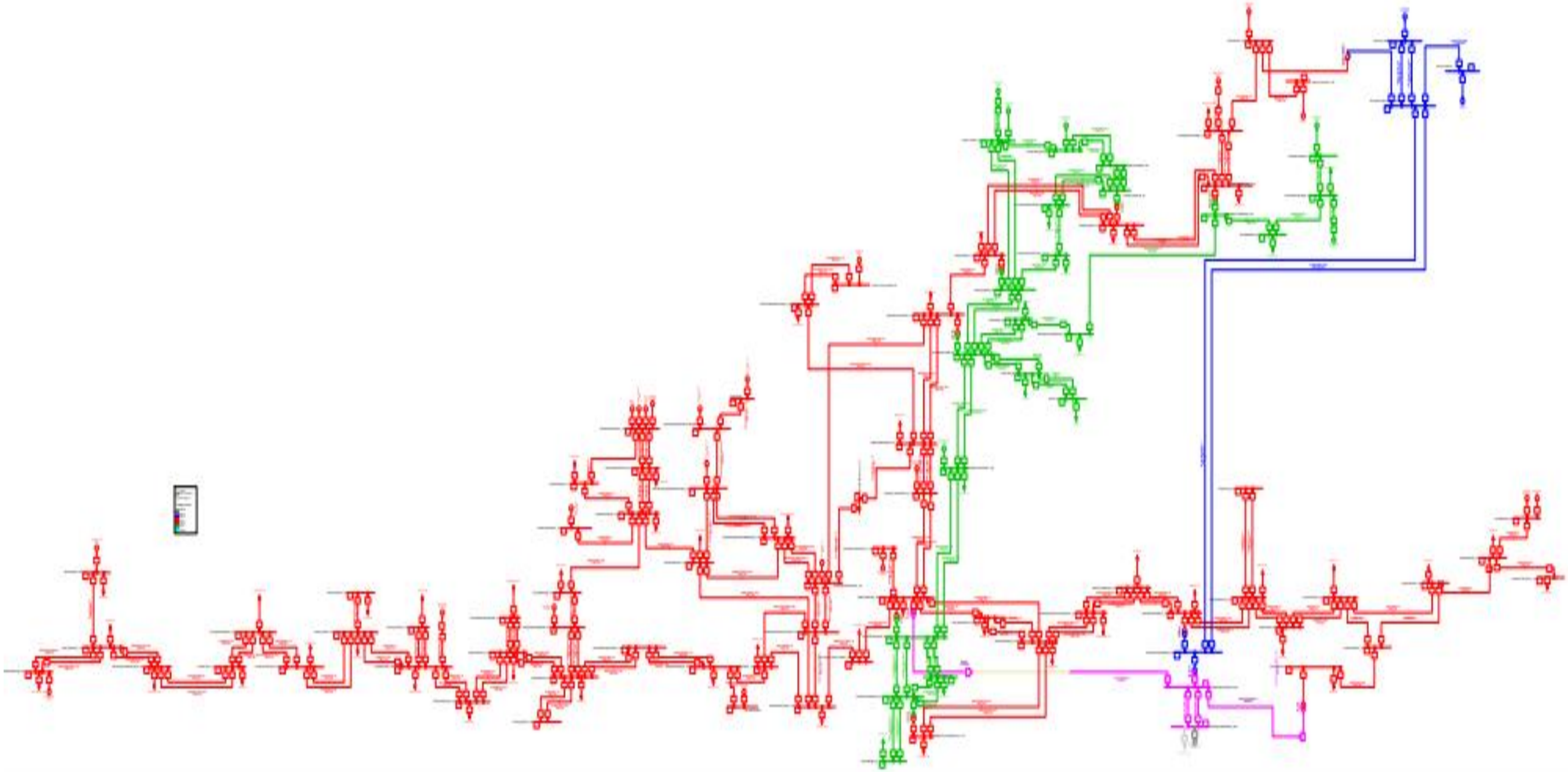


Figure 14 Overall INPS network simulation model drawn in Dig-silent software