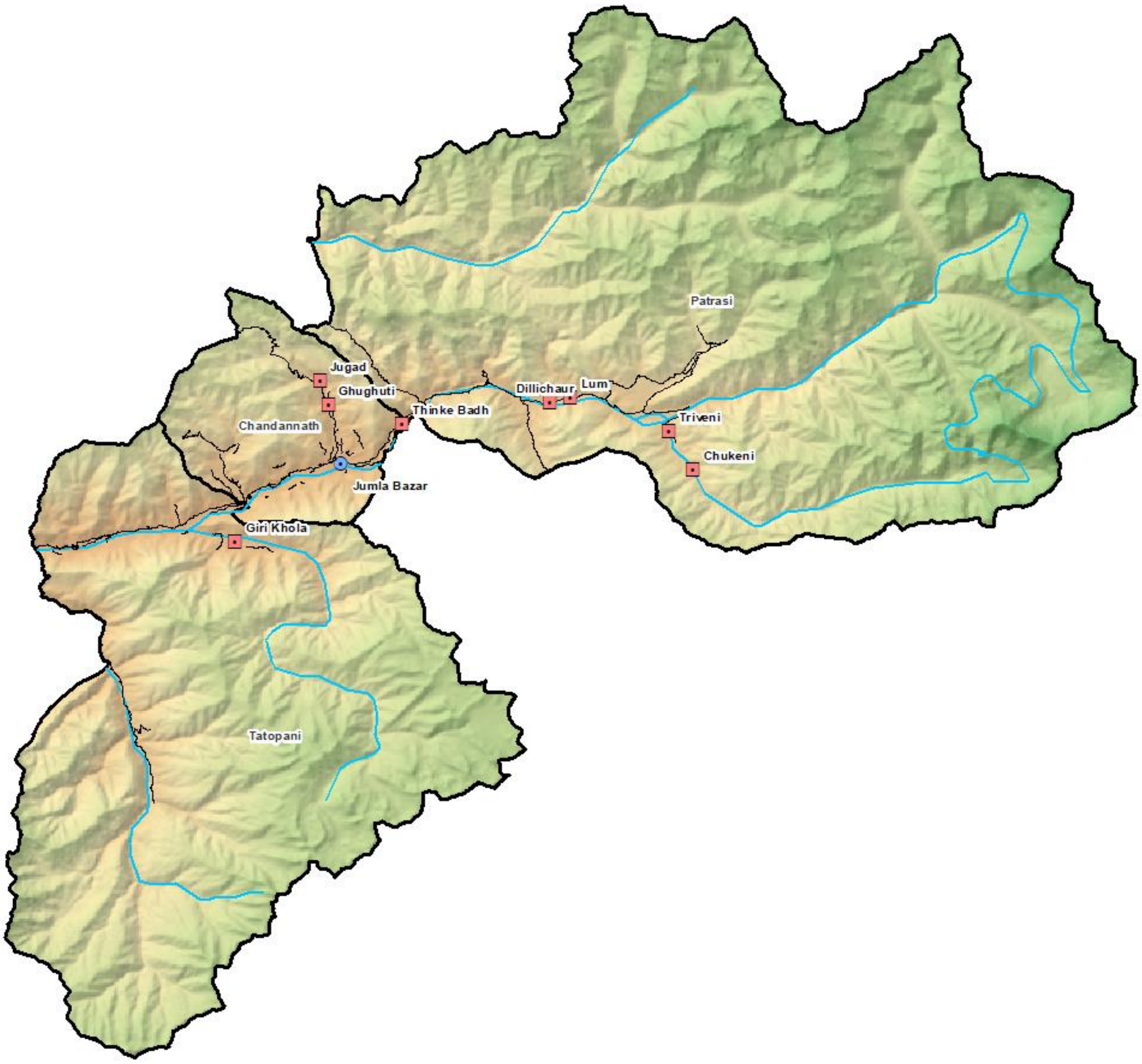
Detailed Feasibility Study of Mini/Micro Hydropower Interconnected Mini Grid in Jumla



Final Report

Submitted to:

Government of Nepal
Ministry of Energy, Water Resources and Irrigation
Alternative Energy Promotion Centre (AEPC)
Central Renewable Energy Fund (CREF)
Central Renewable Energy Fund,
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April 2021

FOREWORD AND EXECUTIVE SUMMARY

NEC extends plethora of thanks to AEPC for providing this opportunity to carry out detail feasibility study for Mini Grid Potential in Jumla. NEC would like to express deepest gratitude towards the Renewable Energy for Rural Livelihood (RERL), a joint project of AEPC and United Nations Development Programme (UNDP). RERL, which has been providing technical support to AEPC to implement the Asian Development Bank (ADB) funded South Asia Subregional Economic Cooperation (SASEC) Power System Expansion Project Off-grid Component, has provided with resources and consultations to support the project.

This study serves as a foundation for development of the Interconnection Master Plan of MHPs. NEC has worked its best to deliver the best possible outcome of the study as per the provided Terms of Reference and practical situation and requirement in the field. This report has been prepared after site visit to MHPs for data collection and series of discussions with the AEPC team and NEA. It serves as final report of the assignment.

The Mini grid concept faces number of challenges and we understand this document alone will not serve for successful completion of the project. We wish on successful implementation of the project and are open to further suggestions and comments from the Client and stakeholders of the assignment.

ABBREVIATIONS

Symbol	Abbreviations
A	Ampere
AEPC	Alternative Energy Promotion Centre
BoQ	Bill of Quantity
COL	Continuous Overload
CREF	Central Renewable Energy Fund
DC	Distribution Centre
DCSD	Distribution and Consumer Services Directorate
DG	Distributed Generation
ELC	Electronic Load Controller
ESMAP	Energy Sector Management Assistance Program
GoN	Government of Nepal
HT	High Tension, 11 kV
Hz	Hertz
IEC	International Electrotechnical Commission
INPS	Integrated Nepal Power System
kA	kiloampere
km	kilometer

kV	kilo volt
kVA	kilo voltampere
kW	Kilowatt
LT	Low Tension, 400 V
MHP	Mini/Micro Hydro Plant
m.s.	millisecond
MVA	Mega Voltampere
MW	Mega Watt
NEA	Nepal Electricity Authority
NEC	NEA Engineering Company Limited
NPC	National Planning Commission
NPR	Nepalese Rupee
PCC	Point of Common Coupling
PPA	Power Purchase Agreement
p.u.	per unit
RoR	Run of River
SLD	Single Line Diagram
ToD	Time of Day
ToR	Terms of Reference

USD	United States Dollar
WB	World Bank

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1 INTRODUCTION

Alternative Energy Promotion Centre has entrusted NEA Engineering Company to carry out Detailed Feasibility Study of Micro/Mini Hydropower Interconnected Mini grid in Jumla. AEPC is the national wing responsible for providing off grid electricity through mini/ micro hydro, solar, biomass and wind. AEPC has played a major role in providing electricity in remote areas of Nepal.

This project is focused on creating a mini grid by interconnecting several micro/mini hydropower in the vicinity of Jumla Bazar. Till date, Jumla Bazar is deprived of grid electricity. The expansion of electrical grid in Karnali Province is ongoing. National grid has been extended till Manma bazar. Karnali Provincial Office, Surkhet is extending the 33 kV lines under Dailekh Chilkha Jumla 33 kV Transmission Line and Substation Project. Jumla is expected to be connected to the central grid within next Fiscal Year. However, the mini grid would be a suitable solution for the present time. The mini grid should be able to connect to national gird in the future.

There are existing isolated micro/mini hydropower plants in operation in Jumla. The idea is to interconnect them forming a Mini grid such that it provides access to electricity as well as increase the reliability of electricity to end users at Jumla. Moreover, the Mini Grid will help to increase revenue of individual plants by increasing plant factor which ultimately help on sustainability of the MHPs. Mini grid[1] has been adopted as solution especially to off-grid issues in various parts of the world. This chapter presents the global context of the mini grid followed by the national scenario of Nepal and local scenario in Jumla.

[1] This report defines mini grid as: Mini/micro hydro system with both power generation and distribution facilities in a settlement/community through T&D line. The Mini grid in Jumla refers to the network of interconnected Micro Hydro Power plants feeding local loads.

1.1 Mini Grid - The Global Context

Mini grid is simply a cost-effective means to provide electricity to unelectrified areas. It includes an area to be served by collection of smaller scale power generating units isolated from the national grid. They can be deployed where needed and are site specific. Mini grids can be connected to the national grid, if available nearby. It reduces the loss incurred if power is supplied through the national grid.

Globally, World Bank (WB) and 19 partners have been involved in running Energy Sector Management Assistance Program (ESMAP) to help low- and middle-income countries reduce poverty and boost growth through sustainable energy solutions.[2] In May 2019, Energy Storage Partnership (ESP) was hosted by ESMAP in partnership with 34 other international organizations to seek to expand energy storage for renewable energy development in developing countries.[3]

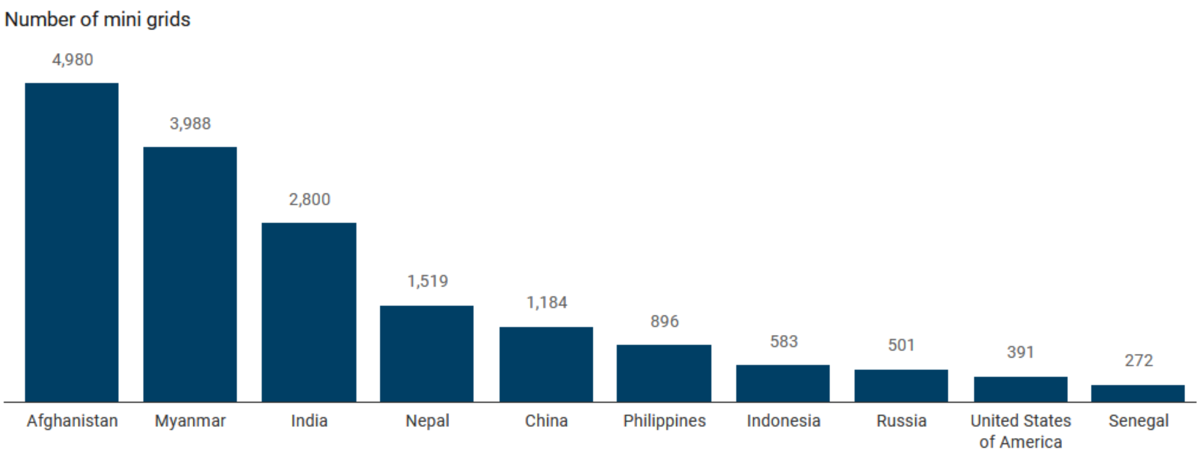


Figure 1-1: Top 10 countries with the highest number of Mini grids[4]

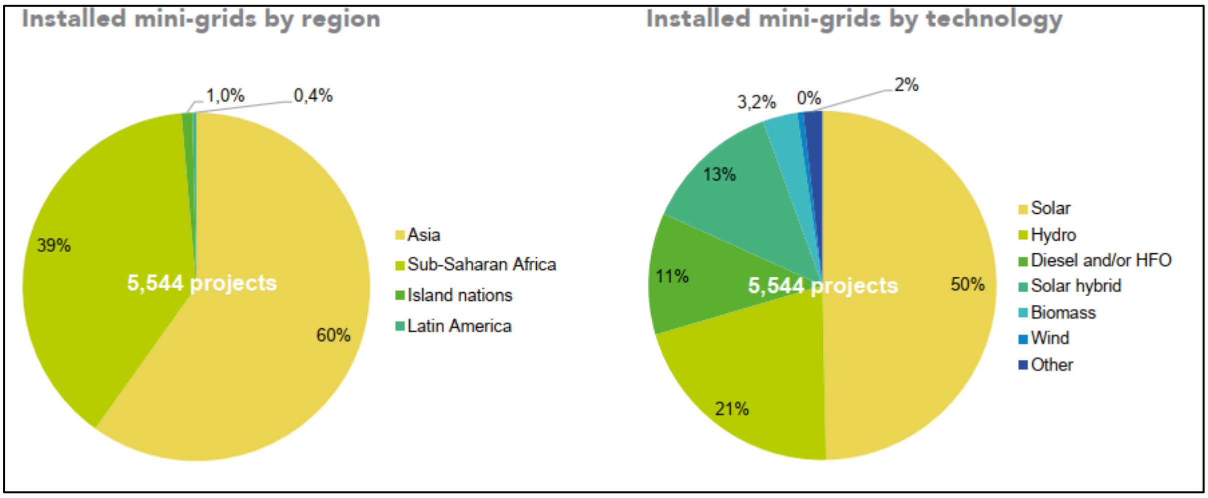
As per ESMAP report, as much as 89 percent of the 19,000 installed mini grids are in 10 countries. One can note that, China, Russia, and the USA are among the top 10 countries by number of operating mini-grids. On the other side, BloombergNEF, GIZ, Carbon Trust, CLUB-ER, surveyed

[2] ESMAP at a glance, Available In: https://esmap.org/node/70853
[3] ESMAP Annual Report 2020, Available In: https://www.esmap.org/energy-sector-management-assistance-program-%28esmap%29-annual-
[4] Mini Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers, Available In: https://openknowledge.worldbank.org/handle/10986/31926

developers have published the worldwide status of mini grids both by technology and region (See Figure 1-2). They have identified that the mini grid assets are rather smaller in quantity as it is more focused on third generation system[5].

Numerous organizations are working on to achieve the Energy Access target for Sustainable Development Goals by 2030. Energy 4 Impact and UBEBSYS have developed a website, hosted by African Development Bank to provide access to all the resources for mini grid development in Africa in one place. [6]

238 million households will need to gain electricity access in Sub-Saharan Africa, Asia, and island nations by 2030 to achieve universal electricity access. Mini-grids can serve almost half of this total – an estimated 111 million households. This will require capital investment of USD 128 billion, 78 percent higher than the estimated capital investment in a business-as-



usual scenario[7].ss

Figure 1-2: Operational Mini grid status worldwide, by region (left), by technology (right)[8]

1.2 Mini Grid - The National Context

Abundance of water in rugged hills of Nepal, allows suitable environment for construction of Micro Hydro Projects (MHPs)[9]. They are an

[5] See for Definitions of Three Generation of Mini Grids, https://atainsights.com/wp-content/uploads/2019/06/4.D.Tatia-Lemondzhava.World-Bank-notes.pdf
[6] Green Mini Grid Help Desk, Available In: https://greenmini grid.afdb.org/about-us
[7] Report on State of Global Mini-grids market Report: Trends of renewable energy hybrid mini grids in Sub-Saharan Africa, Asia, and island nations
[8] BloombergNEF, GIZ, Carbon Trust, CLUB-ER, surveyed developers, Available In: https://mini grids.org/market-report-2020/
[9] Alternative Energy Promotion Center (AEPC) identifies hydro power plant of 10 to 100 kW capacity, as a micro hydro plant.

environment friendly solution of energy causing minimum disturbance to flow of water.

Government of Nepal established Alternative Energy Promotion Center (AEPC) to facilitate development of MHPs along with other Renewable Energy Technologies (RETs) in 1996. AEPC emerged as complementary to Nepal Electricity Utility (NEA), stated-owned utility that maintains national electricity grid. The electrification percentage with national grid of Nepal has climbed to 86.44% of population in Fiscal Year 2019/20[10]. Similarly, around 9.75% population has access to electricity through MHPs and RETs. [11] . Numerous MHPs has been constructed in the country. They are often supported from national and international donor agencies. These supports conventionally include the initial investment cost along with operation and maintenance cost for certain duration of time. Generally, after the designated period, these plants are handed over to the local operating body.

Owing to the lower capacity and relatively higher operating and maintenance cost of MHPs, the income generated by the plant may not be enough to sustain the operation and maintenance cost of the plant. This has led to discontinuation of many such projects in different parts of the country after few years of operation. Another issue observed, is the availability of the national grid. With arrival of the grid supply, the MHPs are abandoned owing to the expenses to maintain it. This will snatch the opportunities from the locals to generate energy of their and own and gain financial benefits.

With plans from National Planning Commission (NPC) and Nepal Electricity Authority (NEA) to provide grid access to all citizens within next few years, it is evident that many more MHPs will face a similar fate unless the MHPs are grid connected where available. It is essential to

[10] Distribution and Consumer Services Directorate, Nepal Electricity Authority, A year in Review, Fiscal Year 2019/20.
[11] Progress at Glance: A year in Review FY 2075/76 (2018/19), Alternative Energy Promotion Center (AEPC)

understand that grid electricity is not a rival but a complement to the MHPs. MHPs can serve as a distributed generation (DG) source to the grid hence, contributing to the quality of the power served to the community.

Until few years back, NEA was reluctant buying energy from MHP of less than 100 kW due to technical and financial issues. With the help of GEF and UNDP, AEPC has prepared technical standard for grid interconnection and NEA has accepted it. NEA now has provisions to buy electricity from MHPs. The minimum criteria laid out by NEA is MHPs should use synchronous generators, meet the voltage and frequency deviations margin as per grid code and seek for approval before connecting it to the grid. NEA shall provide the same tariff as provided to hydropower up to 25 MW. The PPA rate is NPR 4.80/kWh (wet season) and NPR 8.40/kWh (dry season). The revenue generated from selling excess energy to NEA will still be profitable and help MHPs sustain themselves. Connecting MHPs having its own distribution networks to national grid needs technical modification in its operation. It requires synchronizing arrangement and complex protection system. Such arrangements are expensive investment but can easily payoff later.

Isolated MHPs and mini grid provide electricity access where the national grid is still unavailable. They can provide surplus energy during the off-peak hours but are overloaded in the peak load duration. The load curve varies as the day progress and mini grid cannot trace the load curve. The rural communities in Nepal do not have significantly high load and thus the energy generated is often wasted. With the extensive grid expansion plan of NEA, the grid is bound to reach every rural community of Nepal. The whole scenario changes as soon as the grid is available. The surplus energy can be sold during off peak period, the MHPs are no more overloaded in peak hours and thus the reliability, and continuity of supply is maintained. It will enhance the living standard of the local community, create employment opportunities, and reduce the dependency on the traditional sources of energy. The pilot project of mini grid was implemented in Baglung, which received wide appreciation for the development of Mini Grid in Nepal.[12]

However, connecting multiple MHPs to create a mini grid may not always be financially viable as the cost of connecting them to form a mini grid is significantly high. Factors like access to transportation facility, distance between the MHPs and finally the power market to consume the generated power dominates the viability of mini grid. At least one study has recommended not to continue mini grid development in Nepal.[13]

1.3 Mini Grid - The Local Context

As per the report issued by Distribution and Consumer Service Directorate of Nepal Electricity Authority, Jumla has electrification percentage of merely 5.64% in Fiscal year 2019/20[14]. Jumla is yet to be connected to national grid but NEA has planned to construct 132 kV Transmission line connecting Jumla to Surkhet/Dailekh. Electricity is being provided by isolated micro hydropowers in Jumla. Ghughuti Mini Hydro Project (200 kW) is the only plant owned by NEA while six other community owned micro/mini hydropower projects and one under construction mini hydro project promoted by AEPC are located in the vicinity of Jumla Bazaar. A distribution center (DC), under office of DCSD, NEA, has been newly established in Jumla by NEA.

According to a report developed by, Karnali Development Commission, entitled "Ten years plan for the development of Karnali region (2016/17-

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[12] Few of related publications
Techno-Socio-Economic Study of Baglung Mini Grid, Alternative Energy Promotion Center, Available In: https://www.aepc.gov.np/uploads/docs/2018-07-09_report_on_techno_Socio_economic_Study_on_Baglung_Mini_Grid.pdf
Bhupendra Shakya, Mini Grid Development in Nepal: An Experience from RERL, Available in: https://www.researchgate.net/publication/286580026_Mini_Grid_Development_in_Nepal_An_Experience_from_RERL
Smriti Malapatty, Micro-hydro electrifies remote villages in Nepal, Available in: https://www.thethirdpole.net/ne/2012/09/14/micro-hydro-electrifies-remote-villages-in-nepal/
Ashish Shrestha, Yaju Rajbhandari1, Nasib Khadka, Aayush Bista, Anup Marahatta, Rojesh Dahal, Jiwan Kumar Mallik, Anup Thapa, Barry P. Hayes, Petr Korba, And Francisco M. Gonzalez Longatt, Status of Micro/Mini-Grid Systems in a Himalayan Nation: A Comprehensive Review, Available in: https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9133062
Amy, Yee, Micro hydro Drives Change in Rural Nepal, Available in: https://www.nytimes.com/2012/06/21/business/global/microhydro-drives-change-in-rural-nepal.html
Ranju Pandey, Technical and Socio-Economic assessment of a community based mini grid in Baglung District of Nepal, page 73, Energy and Sustainable Development, Mini-grid and Hybrid Systems, Available in: https://www.uni-flensburg.de/fileadmin/content/abteilungen/developing-countries/dokumente/downloads/alumni/yb-2014-eem-ppre.pdf
[13] Nepal: Scaling Up Electricity Access through Mini and Micro Hydropower Applications, A strategic stock-taking and developing a future roadmap, Available In: https://www.esmap.org/node/70729
[14] Distribution and Consumer Services Directorate, Nepal Electricity Authority, A year in Review, Fiscal Year 2019/20

2026/27)", micro hydropower projects running in, the erstwhile, 18 village development committees of Jumla are generating a total of 526 kilowatts of electricity.[15] According to the Commission's report, 44 percent households in the district use solar energy to light their houses while 29 percent use hydropower for the purpose. Likewise, 99 percent households use firewood for cooking. Forty-two percent households own radio sets, 11 percent own television sets and 46 percent own cell phones. Altogether 621 households in the district have landline telephone, but only 68 households have internet[16]. Karnali Province Government has unveiled plan to install solar plant of one megawatt capacity in Jumla district headquarters Khalanga. The plant will supply electricity to Khalanga and surrounding areas till Jumla is connected to national electricity grid[17].

AEPC has formulated a project to interconnect the isolated mini/micro hydropower forming a Mini grid. The location and details of the MHPs intended for Interconnection are presented in Figure 1-3 , and Table 1-1. This scheme will increase the availability of electricity in the project area.

Table 1-1: List of MHPs intended for Interconnection as MHPs.

SN	Project Name	kW	Location
1	Giri Khola Mini Hydro Project	200	Tatopani Rural Municipality, Jumla
2	Ghughuti Mini Hydro Project	200	Chandannath Municipality, Jumla
3	Thinke Badh Micro Hydro Project	100	
4	Triveni Micro Hydro Project	45	Patarashi Rural Municipality, Jumla
5	Lum Micro Hydro Project	31	
6	Dillichaur Micro Hydro Project	50	
7	Chukeni Khola Mini hydropower	998	

15 In: http://southasiacheck.org/fact-check/entire-jumla-getting-less-1-mw-electricity/
16 http://southasiacheck.org/fact-check/entire-jumla-getting-less-1-mw-electricity/
17 https://myrepublica.nagariknetwork.com/news/1-mw-solar-plant-to-be-built-in-jumla/

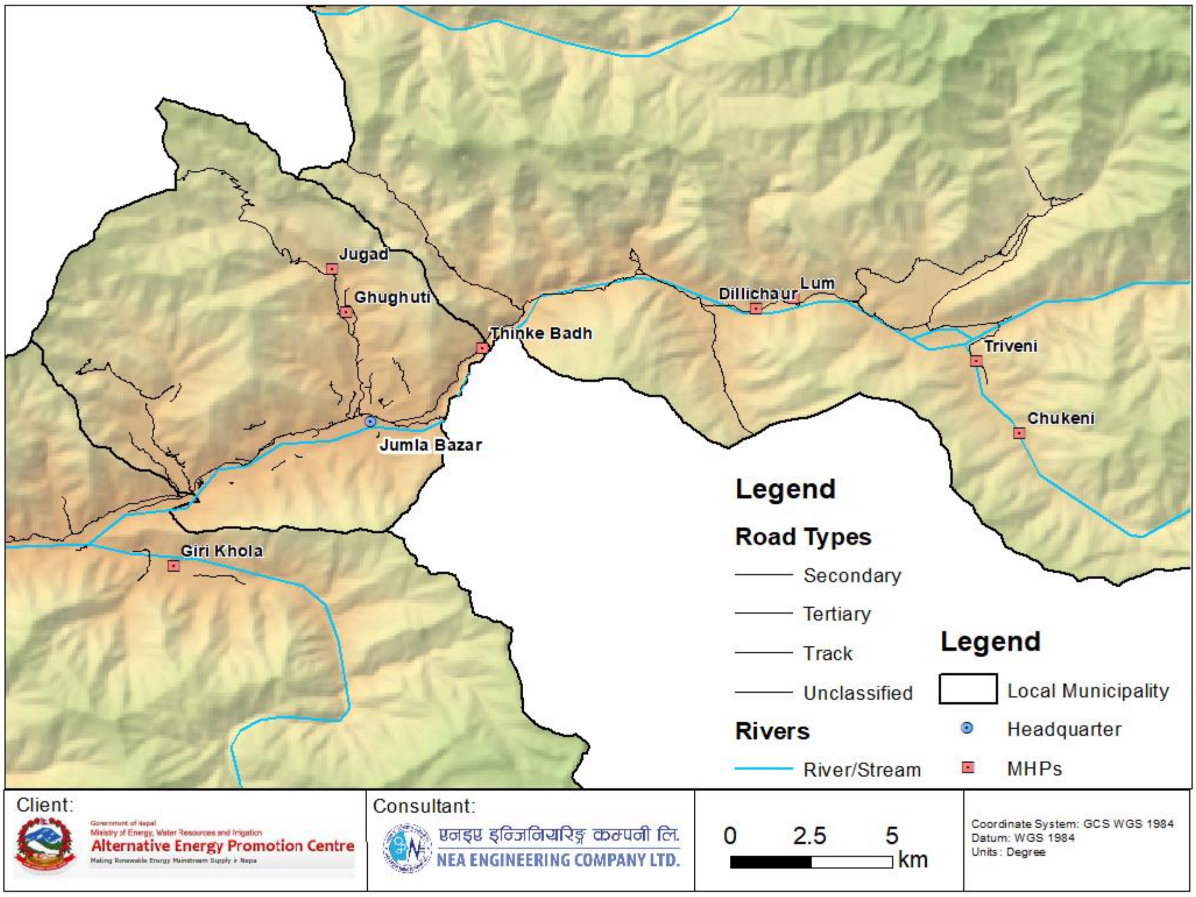


Figure 1-3: Locations of micro hydro power plants, Jugad was identified during site visit

1.4 Identification of the Challenges

The major challenge forming the mini grid is its viability. Previous Studies suggest that, as NEA has removed the barrier of grid connectivity of the isolated micro/mini hydropower plants, forming a mini grid might not be financially viable. [18] However, for places like Jumla which is yet to be connected to national grid, a mini grid comprising micro/mini hydro could be an effective means of providing reliable electricity.

AEPC has identified the average load factor of isolated MHPs to be around 30% with power deficit during evening and power surplus during daytime.[19] Considering the rural nature of Jumla district, the same scenario can be expected in the region of study. Even after implementation of mini

[18] Nepal: Scaling Up Electricity Access through Mini and Micro Hydropower Applications, A strategic stock-taking and developing a future roadmap, Available In: https://www.esmap.org/node/70729
[19] Terms of Reference of this assignment

grid there could be surplus power at certain times. This could impact the financial viability of the grid. On the other hand, the mini grid will be supplying the peak load of Khalanga Bazaar in District Headquarter of Jumla. A scenario could be such that, there shall exist capacity deficit during the evening peak.

Technically, MHP uses an Electronic Load Controller (ELC) as a load balancing component in place of Governor, used in Larger Hydropower Plants. It dumps unused energy generated by the plant to maintain the power supply frequency. With no trade opportunity, ELC dumps excess power. The ELC must be assigned to supply power to grid or interconnected local network.

As the national grid will reach the Jumla eventually, the mini grid must be grid compatible to improve the sustainability of the micro/mini hydropower plants which adds cost for the mini grid. The cost of infrastructure for forming a mini grid specially the transmission lines will be on the higher side further decreasing attractiveness of mini grid. Furthermore, several stake holders will get involved in forming a mini grid and may induce the issues of ownership and identity. Thus, all these issues will impose a challenge in forming a mini grid in Jumla. To summarize, NEC has identified following challenges,

- Excess energy in the system even after implementation of Mini Grid.
- Capacity Deficit in Mini Grid during peak hours.
- Compatibility of Mini Grid and National Grid Interconnection.
- Social Issues in formation of Mini Grid.

2 EXISTING STATUS AND INTERCONNECTION APPROACH

The study has been carried out based upon the Terms of Reference provided by the Client and discussions with the Client regarding the documents. The technical standards developed for grid interconnection has been studied thoroughly. The technical propositions in this document, although slightly varied than the approved technical standard, are based on the technical standards developed for grid interconnection of MHPs by AEPC and NEA.

The Consultant was assigned to develop annual energy generated from individual MHP plant and provide draft monthly energy table to be proposed for PPA with NEA. The Consultant carried out the site visit of the locality and all listed projects in the Terms of Reference. The scenario in the site was quite different with many MHPs operating in unmanned mode while one under construction and two still in testing, commissioning, or preliminary output phase. No logbooks were maintained and no data of outage, annual energy, etc. were available. The operational approach of MHPs was found to depend upon the capability of the User Communities of that MHP. Few plants were operating without physical presence of the Operator. The details gathered during the site visit of each MHP is presented in following sub-section.

Ghughuti (200 kW) and Giri Khola (200 kW) mini hydro had hydro governors while the remaining micro hydro were ELC based. Triveni (45 kW), Lum (31 kW) and Dillichaur (50 kW) had generation and distribution at 0.4 kV while Jugad Khola, Giri Khola, Thinke Badh and Ghughuti generated at 0.4 kV and transmitted at 11 kV. Chukeni MHP construction is still ongoing, and its SLD suggests it will be generating electricity at 0.4 kV and transmit at 11 kV. Chukeni will be hydro governor-based power plant. Considering the present status of micro/mini hydro and uncertainty of Chukeni Khola and its transmission line till Jumla Bazar being online, there can be two options for forming the Mini grid. First option would be

Mini grid considering all the plants while the second one would be mini grid comprising of Ghughuti, Jugad, Thinke Badh and Giri Khola.

The technical and economic analysis has been caried out for these options. Technical analysis has been divided into Load Flow Analysis, Short Circuit Analysis and Transient Analysis.

Within the two options there exists two different scenarios. The first scenario is of isolated mini grid while the second scenario is mini grid connected to the national grid. Consultant has considered the time frame of 2022 A.D to carry out the power system analysis. Consultant has included all the existing generations, transmission line, loads and those that are likely to online by the year 2022. The analysis has been further divided into peak and off-peak periods of Dry and Wet season.

In case of Economic Analysis, the income requires information on energy generated by MHPs, which was not readily available in site. Furthermore, current scenario of revenue collection may not be suitable in Mini grid. Hence, the economic analysis is carried out with certain assumptions, presented in the economic analysis section.

2.1 Existing Scenario of MHPs in site

Upon the visit, it was observed that, two major mini hydros namely Chukeni (998 kW) and Giri Khola (200 kW) were still under construction. The construction of Giri Khola will soon be completed with most of the components already being installed, whereas it should take at least a year or two for completion of Chukeni MHP. The mini hydro of Nepal Electricity Authority (200 kW) was not in operation due to some technical issues of the generator. Jumla Bazar was supplied by operating Diesel Generator and partially by Thinke Badh micro hydro (100 kW). There is one more Micro Hydro named Jugad Khola (68 kW) near the Ghughuti MHP which can be integrated in the Mini grid.

The MHPs in site were observed from electrical point of view. Chukeni Khola MHP (998 kW) is still under construction. The road is tough to reach there, with the Consultant team needing to walk from midway due to ice on top of the road.

Giri Khola MHP (200 kW) was under construction, with testing and commissioning ongoing. The power has yet not been evacuated for public use.

Ghughuti MHP (200 kW) is being operated by the utility, Nepal Electricity Authority. During the site inspection, the generators of this MHP were out of operation, disassembled and taken to Nepalgunj for maintenance. The NEA team kept regular records of current voltage and other electrical parameters of the MHP.

Thinke Badh MHP (100 kW) was recently completed, starting to supply load to Khalanga Bazaar as well as its local load. The powerhouse was spacious and there were operators present at site.

Triveni (45 kW), Lum (31 kW) and Dillichaur (50 kW), all these MHPs were observed. They were found to be operating in absence of operator. No records of electrical parameters were maintained.

In addition to these, the Consultant also visited Jugad MHP (68 kW). It was maintained and operated with electrical parameters recorded once a day.

Figure 2-1: Building on place of Powerhouse of Chukeni MHP (Probably Control Panel Building)

Figure 2-2: Powerhouse of Triveni MHP

Figure 2-3: Turbine Generator Set of 200 kW Giri Khola MHP

Figure 2-4: Existing Metering Panel of Thinke Badh

Figure 2-5: Powerhouse of 200 kW Ghughuti MHP

No electrical measurement sheets were maintained by operating micro hydros indicated in Terms of Reference, other than Ghughuti MHP, thus concrete data were not available at site. Lack of information kept by the plants made it difficult to obtain the energy data for each MHPs. As concrete data is unavailable, the analysis must be based on the assumptions made by the consultant.

2.2 Electrical Load in Jumla and Utility's Approach

The electrical load in Jumla district is primarily concentrated in Khalanga Bazaar, the center of Headquarter of Jumla. Nepal Electricity Authority, the government owned Electrical Utility, is taking care of electrical supply in Khalagna. Jumla is still devoid with interconnection of National Power Grid of Nepal. However, there has been substantial development of MHPs in Jumla, with initiation from Alternative Energy Promotion Centre. The Distribution Centre (DC) of Jumla has collected a list of MHPs operating in Jumla, with an aim of interconnecting them. NEA DC Jumla appear to be supportive for Interconnection of MHPs in Jumla with the national grid for sustainable operation of Electrical Grid as well as MHPs in the future.

The current network of NEA Jumla DC constitutes of total 16 transformers with a combined capacity of 700 kVA. The capacity of transformer supplying to the airport is 100 kVA which is the largest among them. 25 kVA transformers are used by telecom networks – NTC, Ncell, by organizations like Karnali Technical School, Agricultural Research Centre and in sparse villages. 50 kVA transformers are prevalent in urban residential region in Khalanga Bazaar.

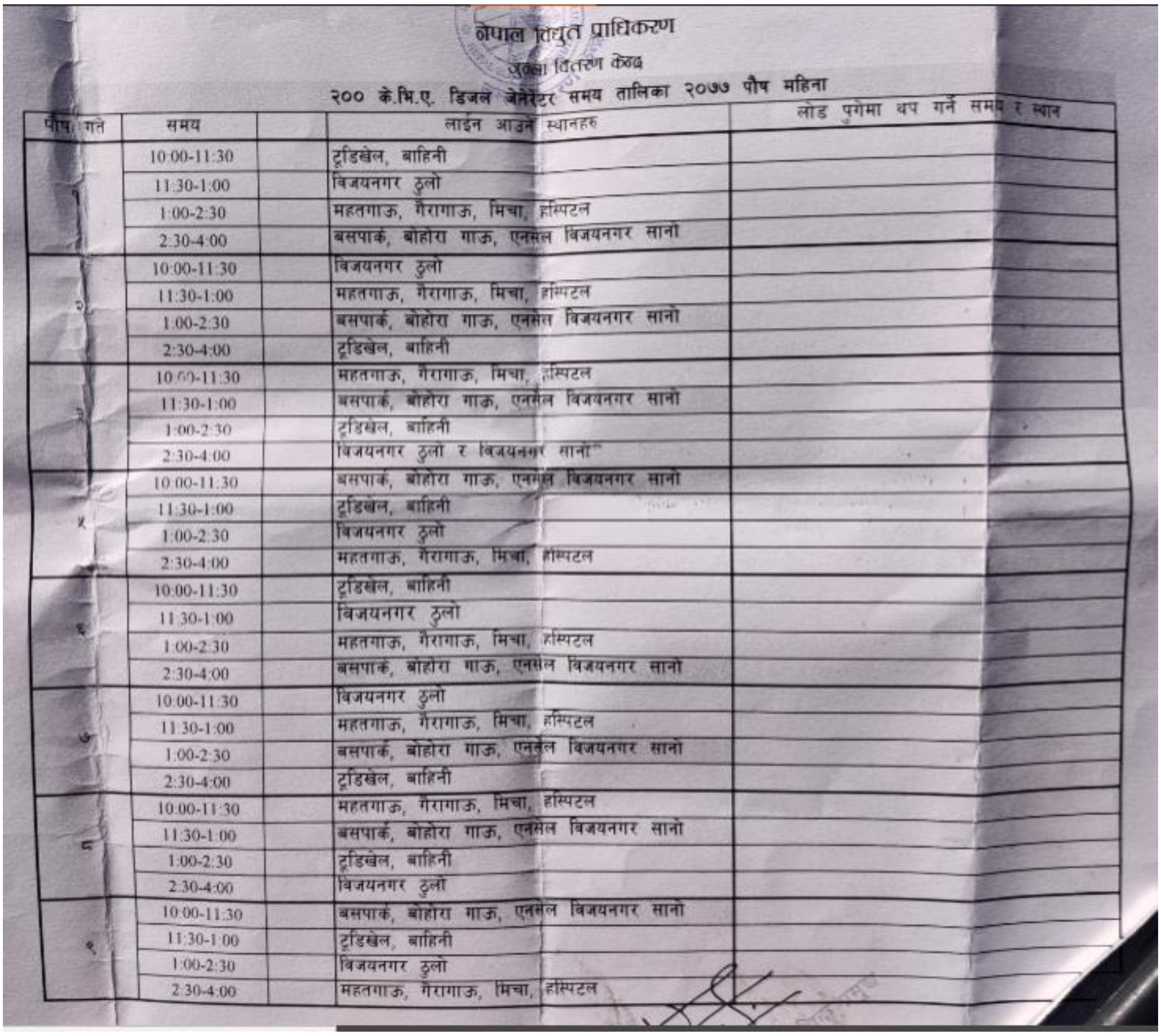
A 200 kVA Diesel and Thinke Badh MHP (recently commissioned) were supplying the load to the Khalanga Bazaar at the time of the site visit. It was insufficient to carter all the loads in the network leading to scheduled power outage in the region. The installed transformer capacity is insufficient in some locations, like Bus Park area and they need to be upgraded. The locals primarily use electricity for mobile phone charging, lighting, and commercial activities. One important demand of the public was to provide electricity during daytime for operation of offices and mobile charging purpose, rather than during evening for lighting applications.

Table 2-1: Existing Distribution Network Capacity of NEA in Jumla, 11/0.4 kV Transformers

S.N,	**Transformer Capacity, kVA**	**No. of Transformers**	**Remarks**
1	25	6	Telecom Networks Included
2	50	9	Larger share in market area
3	100	1	Airport
Total	**700**	**16**	

The Consultant deduces the load of the Khalanga Bazaar to be approximately 1000 kW should the power be available to the consumers. The simulations carried out in this report is based on this assumption. It must be noted that, even after implementation of mini grid from existing MHPs, the power supply will still face scheduled outage due to limited power availability.

Giri Khola MHP, under construction is also carrying out rural electrification works. It was appreciable to find that the user communities are maintaining standards for household electrification for safety purposes.

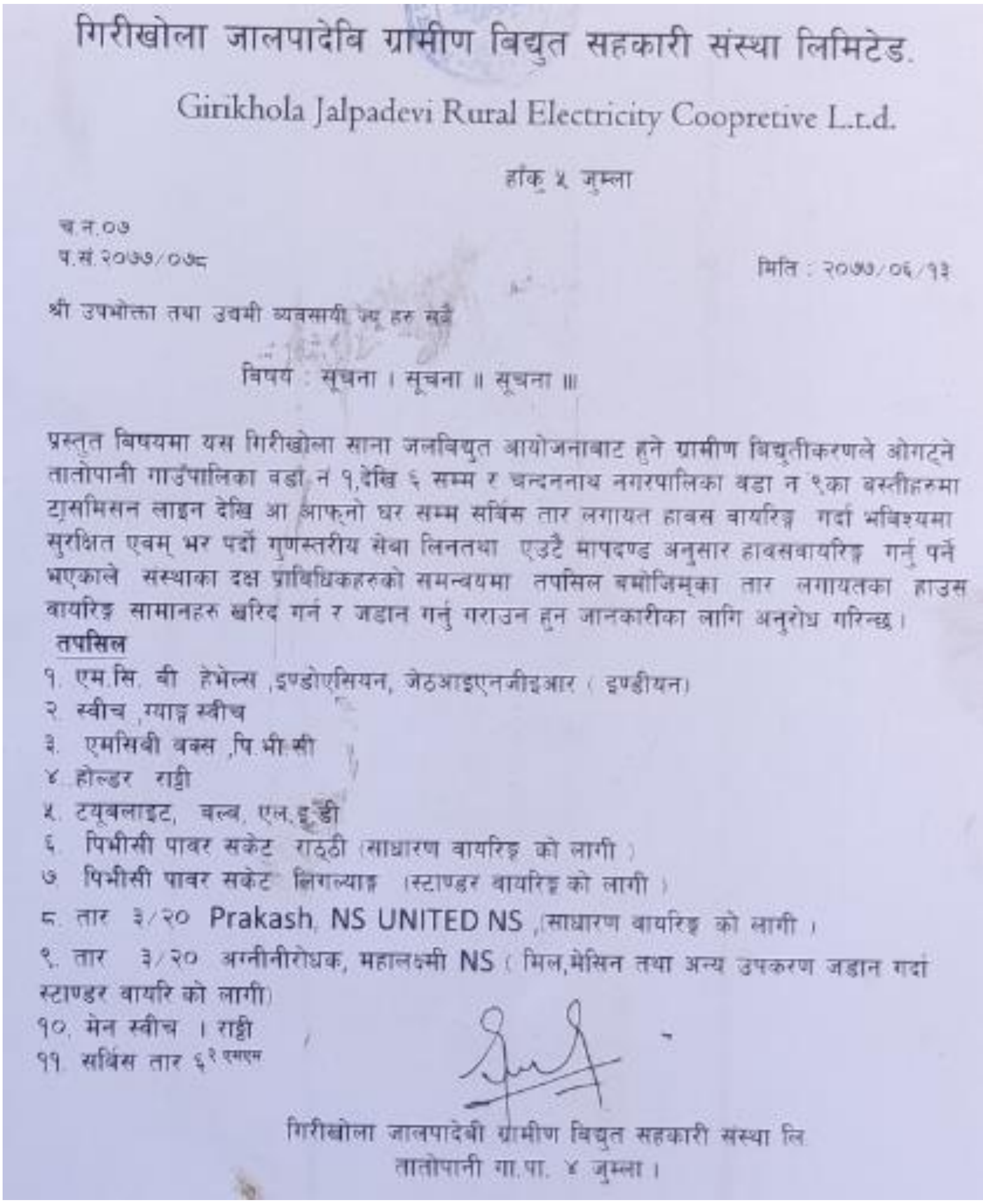


नेपाल विद्युत प्राधिकरण
जुम्ला वितरण केन्द्र
२०० के.भि.ए. डिजल जेनेरेटर समय तालिका २०७७ पौष महिना

पौष गते	समय		लाईन आउने स्थानहरु	लोड पुगेमा थप गर्ने समय र स्थान
१	10:00-11:30		टूडिखेल, बाहिनी	
	11:30-1:00		विजयनगर ठूलो	
	1:00-2:30		महतगाऊ, गैरागाऊ, मिचा, हस्पिटल	
	2:30-4:00		बसपार्क, बोहोरा गाऊ, एनसेल विजयनगर सानो	
२	10:00-11:30		विजयनगर ठूलो	
	11:30-1:00		महतगाऊ, गैरागाऊ, मिचा, हस्पिटल	
	1:00-2:30		बसपार्क, बोहोरा गाऊ, एनसेल विजयनगर सानो	
	2:30-4:00		टूडिखेल, बाहिनी	
३	10:00-11:30		महतगाऊ, गैरागाऊ, मिचा, हस्पिटल	
	11:30-1:00		बसपार्क, बोहोरा गाऊ, एनसेल विजयनगर सानो	
	1:00-2:30		टूडिखेल, बाहिनी	
	2:30-4:00		विजयनगर ठूलो र विजयनगर सानो	
४	10:00-11:30		बसपार्क, बोहोरा गाऊ, एनसेल विजयनगर सानो	
	11:30-1:00		टूडिखेल, बाहिनी	
	1:00-2:30		विजयनगर ठूलो	
	2:30-4:00		महतगाऊ, गैरागाऊ, मिचा, हस्पिटल	
६	10:00-11:30		टूडिखेल, बाहिनी	
	11:30-1:00		विजयनगर ठूलो	
	1:00-2:30		महतगाऊ, गैरागाऊ, मिचा, हस्पिटल	
	2:30-4:00		बसपार्क, बोहोरा गाऊ, एनसेल विजयनगर सानो	
७	10:00-11:30		विजयनगर ठूलो	
	11:30-1:00		महतगाऊ, गैरागाऊ, मिचा, हस्पिटल	
	1:00-2:30		बसपार्क, बोहोरा गाऊ, एनसेल विजयनगर सानो	
	2:30-4:00		टूडिखेल, बाहिनी	
८	10:00-11:30		महतगाऊ, गैरागाऊ, मिचा, हस्पिटल	
	11:30-1:00		बसपार्क, बोहोरा गाऊ, एनसेल विजयनगर सानो	
	1:00-2:30		टूडिखेल, बाहिनी	
	2:30-4:00		विजयनगर ठूलो	
९	10:00-11:30		बसपार्क, बोहोरा गाऊ, एनसेल विजयनगर सानो	
	11:30-1:00		टूडिखेल, बाहिनी	
	1:00-2:30		विजयनगर ठूलो	
	2:30-4:00		महतगाऊ, गैरागाऊ, मिचा, हस्पिटल	

Figure 2-6: Jumla is facing forced power outage due to limited electrical generation resources.

In addition to operating and maintaining the existing infrastructures, high tension lines and transformers for full electrification of Jumla has been envisioned by the Jumla DC. It can be deduced that, NEA has plans to extend 11 kV lines from 33/11 kV substation near Ghughuti to all over the district.



गिरीखोला जालपादेवि ग्रामीण बियुत सहकारी संस्था लिमिटेड.

Girikhola Jalpadevi Rural Electricity Coopretive L.t.d.

हाँकु ५ जुम्ला

च.न.०७
प.सं.२०७७/०७८

मिति : २०७७/०६/१३

श्री उपभोक्ता तथा उद्यमी व्यवसायी ज्यू हरु सबै

विषय : सूचना । सूचना ॥ सूचना ॥।

प्रस्तुत बिषयमा यस गिरीखोला साना जलबियुत आयोजनाबाट हुने ग्रामीण बिद्युतीकरणले ओगट्ने तातोपानी गाउँपालिका वडा न १,देखि ६ सम्म र चन्दननाथ नगरपालिका वडा न ९का बस्तीहरुमा ट्रासमिसन लाइन देखि आ आफ्नो घर सम्म सर्बिस तार लगायत हाबस वायरिङ्ग गर्दा भबिश्यमा सुरक्षित एवम् भर पर्दो गुणस्तरीय सेबा लिनतथा एउटै मापदण्ड अनुसार हाबसवायरिङ्ग गर्नु पर्ने भएकाले संस्थाका दक्ष प्राबिधिकहरुको समन्वयमा तपसिल बमोजिम्का तार लगायतका हाउस वायरिङ्ग सामानहरु खरिद गर्न र जडान गर्नु गराउन हुन जानकारीका लागि अनुरोध गरिन्छ।

तपसिल

१. एम.सि. बी हेभेल्स ,इण्डोएसियन, जेठआइएनजीइआर (इण्डीयन)
२. स्वीच ,ग्याङ्ग स्वीच
३. एमसिबी बक्स ,पि.भी.सी
४. होल्डर राड्डी
५. टयूबलाइट, बल्ब, एल.इ.डी
६. पिभीसी पावर सकेट राठ्ठी (साधारण वायरिङ्ग को लागी)
७. पिभीसी पावर सकेट लिगल्याङ्ग (स्टाण्डर वायरिङ्ग को लागी)
८. तार ३/२० Prakash, NS UNITED NS ,(साधारण वायरिङ्ग को लागी ।
९. तार ३/२० अग्नीनीरोधक, महालक्ष्मी NS (मिल,मेसिन तथा अन्य उपकरण जडान गर्दा स्टाण्डर वायरि को लागी)
१०. मेन स्वीच । राड्डी
११. सर्बिस तार ६^२ एमएम

गिरीखोला जालपादेवी ग्रामीण बियुत सहकारी संस्था लि.
तातोपानी गा.पा. ४ जुम्ला ।

Figure 2-7: Authorities in Jumla, including User Committee and AEPC have been setting up standards for Household Electrification.

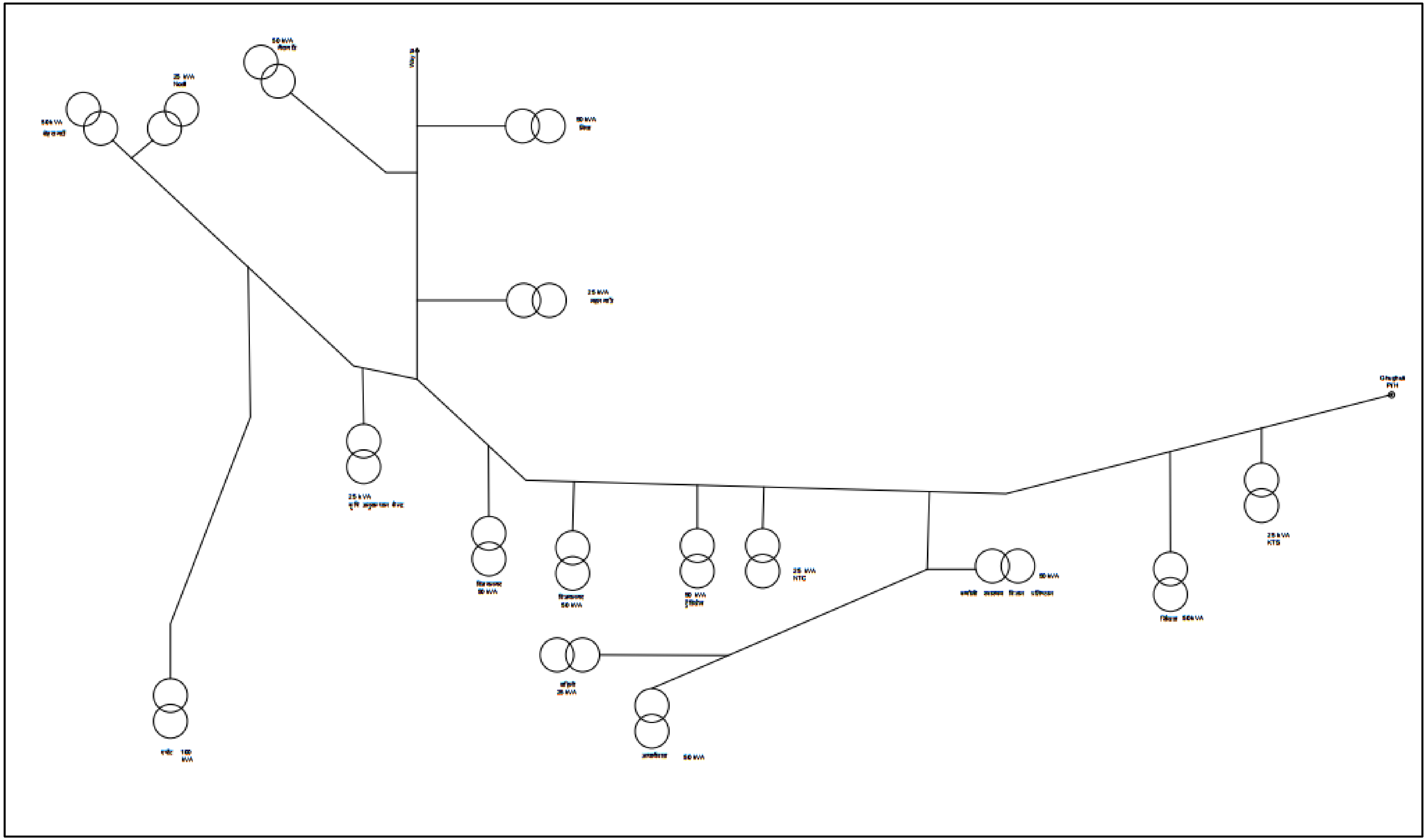


Figure 2-8: Existing Distribution Network of NEA in Jumla

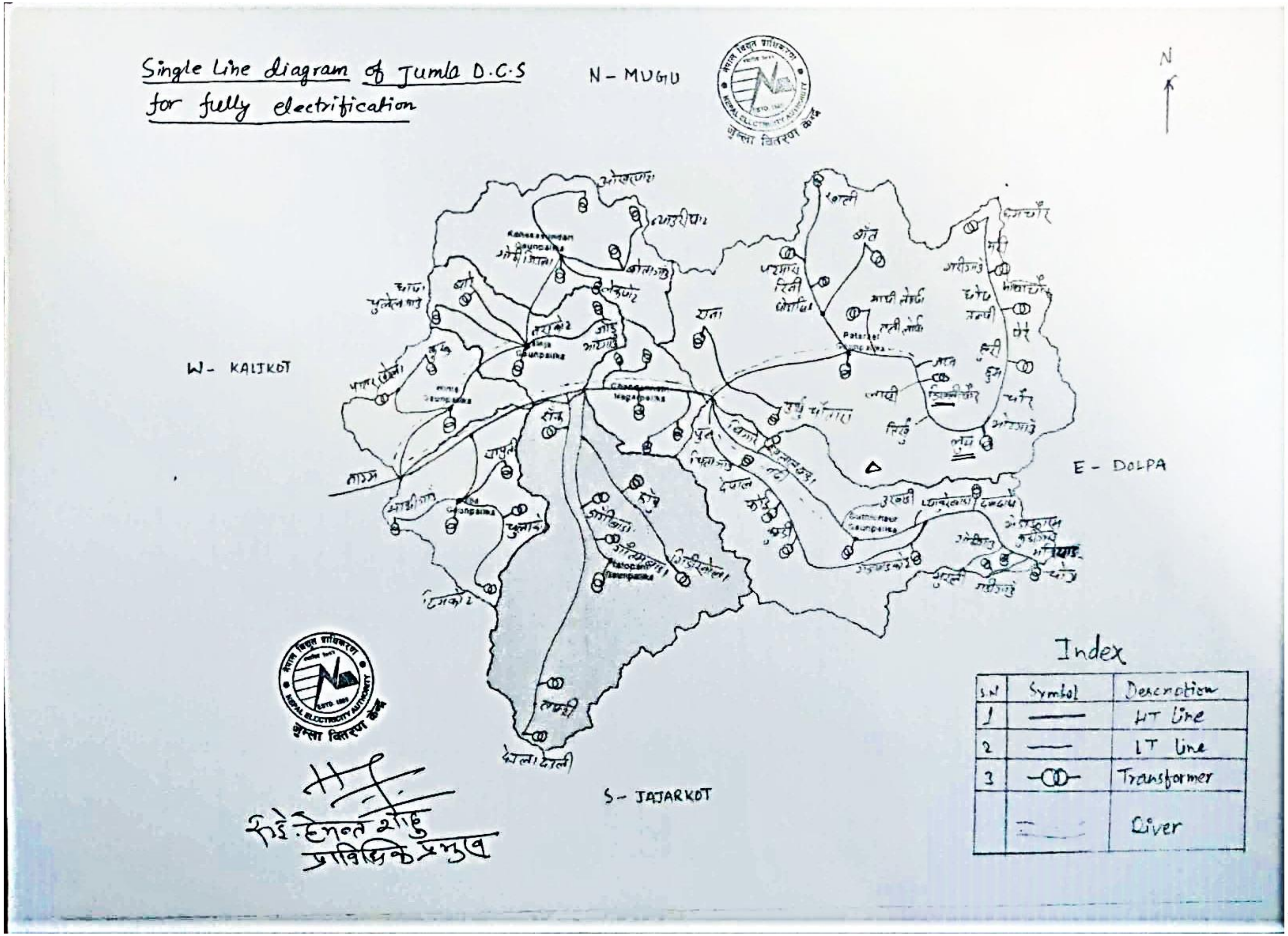


Figure 2-9: Schematics for Complete Electrification of Jumla District

2.3 Identification of PCC and Optimal Voltage for Interconnection

The interconnection between two generating units is possible when the frequency, voltage phases and voltage sequence between them are in synchronism. The process of syncing two or more generating stations with one another is known as synchronization. Mini and Micro Hydropower Applications published by World Bank Group has discussed the Technical aspects of the Interconnection of MHPs to grid. The proposed single line diagram for the Interconnection of MHP to the grid has been presented later in this document. It has been developed with reference to the document discussed earlier, and available literatures. The detail list of Bill of Quantity required for each MHP and respective cost has also been stated later in this document. In case of earthing requirement, it is highly recommended to carry out the earthing resistance measurement before proceeding with Mini grid interconnection. The current practice in Nepal is to adopt earthing resistance of 1 W for small power plants and 0.5 W for larger power plant. For MHP in kW range, earthing resistance of less than 10 W is observed.

The point of common coupling was identified for each MHPs. The MHPs will be connected at their own terminal via a 11/0.4 kV transformers of relevant size. The distance between two terminals decided in this study are as follows:

Table 2-2: Distance between MHPs in Mini Grid

S.N.	MHP 1	MHP 2	Distance, km
1	Ghughuti	Thinke Badh	4.5
2	Thinke Badh	Dillichaur	10.0
3	Dillichaur	Lum	1.5

S.N.	MHP 1	MHP 2	Distance, km
4	Lum	Triveni	6.0
5	Triveni	Chukeni	3.0
Total			**25**
6	Ghughuti	Giri Khola	15.8
Total			**40.8**

The Interconnection Scheme will be such that, all MHPs will be connected to Ghughuti MHP and then the power shall be distributed.

The tentative length of the transmission line from Chukeni MHP to Jumla Bazar is 25 km. For such length, there could be two options for transmission voltage in Nepalese power system, 11 kV and 33 kV. The Client plans to interconnect other MHPs of capacity less than 100 kW as well in the same line. Doing so, in a 33 kV line requires additional cost for 33 kV switchgear, 33/0.4 kV transformers, which are not quite popular in the country. Eventually a separate set of Inventory must be maintained.

A 33/11 kV substation is proposed in the vicinity of the Ghughuti MHP. Further, NEA DC Jumla has plans to extend 11 kV lines from this substation all over Jumla. Hence, the Consultant proposes to make use of 11 kV for interconnection of MHPs in the region. The simulation results of the approach justify this decision as presented in following chapters.

2.4 Proposed Methodology of Interconnection

The Consultant has identified two different options of interconnection. First option is to interconnect all the MHPs stated in the Terms of Reference by AEPC. Load Flow Analysis for Isolated and Grid Connected Mini Grid has been carried out for this approach in PSS/E simulation software and the results are presented in the following chapter. The load flow analysis has been carried out for both isolated and grid connected mode. Short Circuit Analysis as well as Transient Analysis has been carried out for the system.

It is essential to understand the daily load demand of the system. The load characteristics of Jumla region must be analyzed. Figure 2-10 represents the typical load curve of a household in Kathmandu Valley of Nepal. The typical residential load curve in Jumla after continuous power supply is available will have almost no difference. Morning peak with lighting and some heating load will be observed and the same for the evening peak.

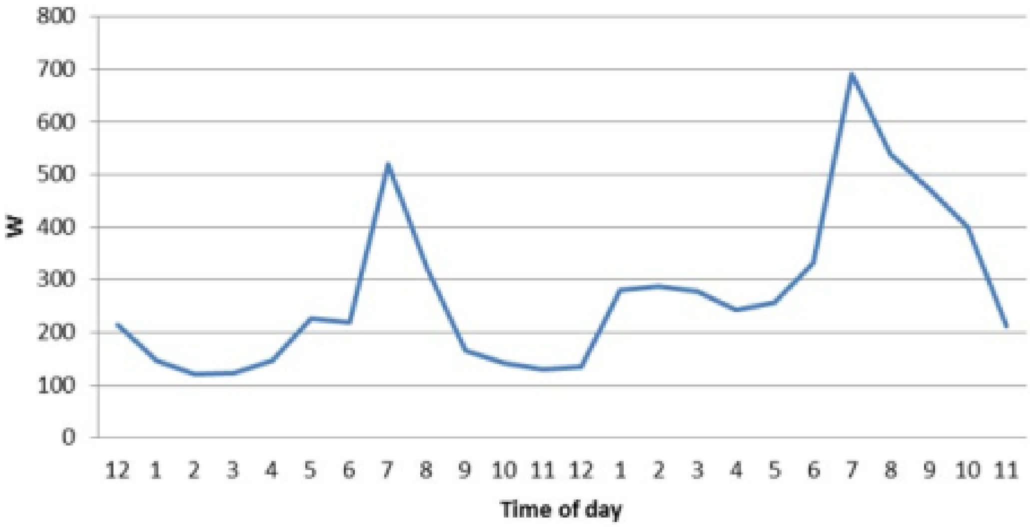


Figure 2-10: Typical Demand Curve of a Household in Nepal[20]

[20] Utsav Shree Rajbhandari 1, Laxman Poudel, Nawraj Bhattarai, Demand Characteristics of Electricity in Residential Sector of Kathmandu Valle

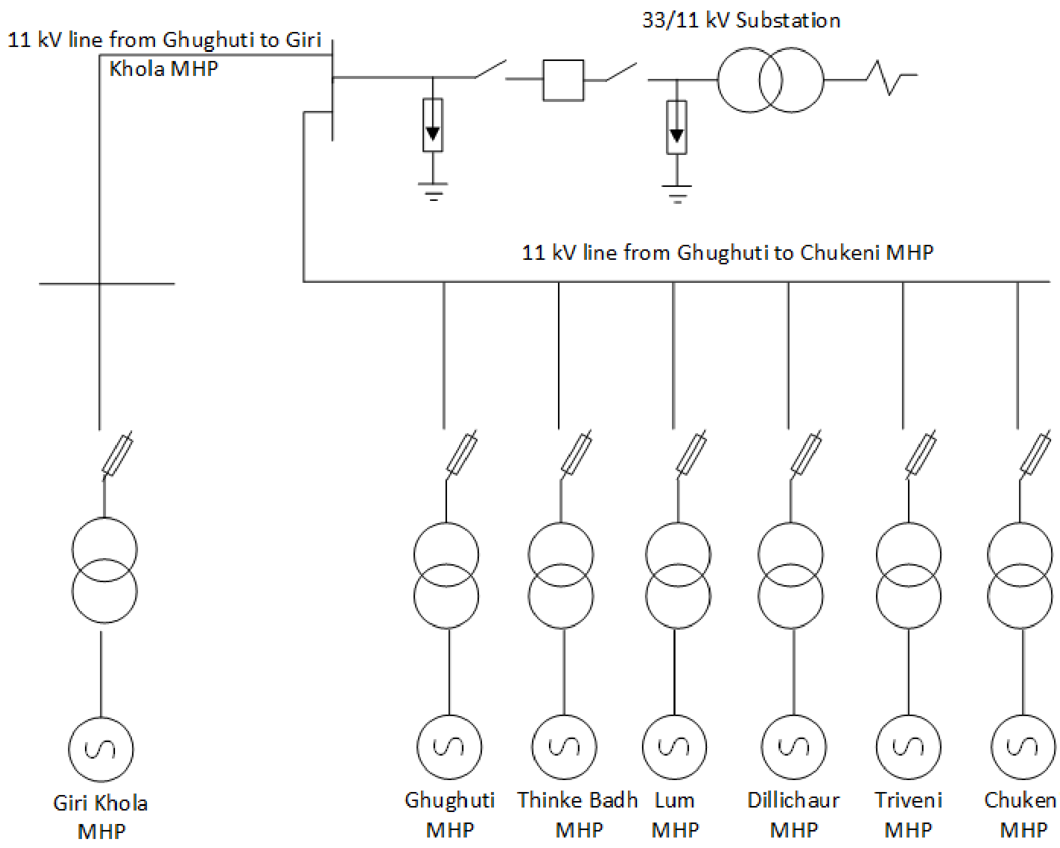


Figure 2-11: Grid Interconnection Schematics for Mini Grid/Grid Connected Mode

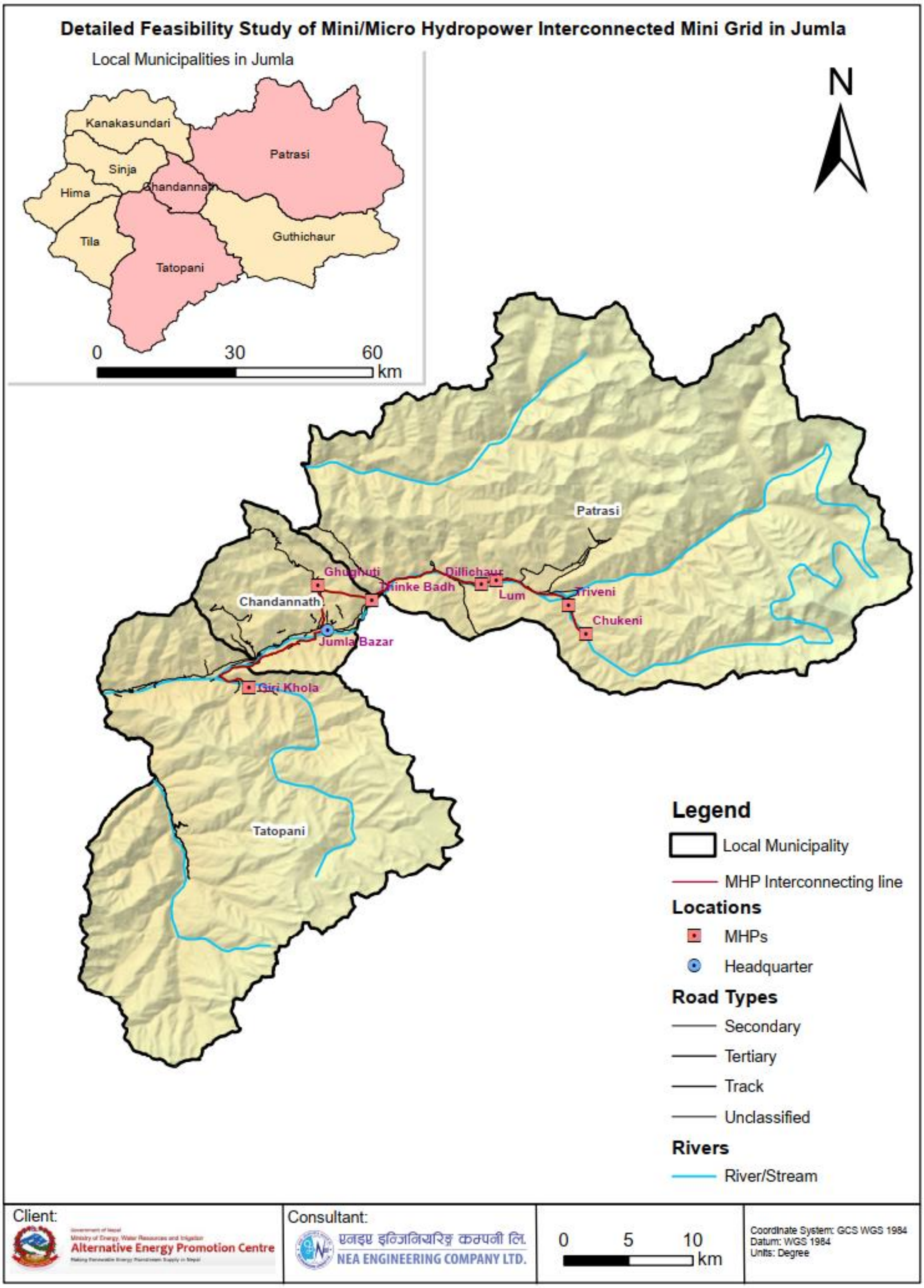


Figure 2-12: Map of Project Area Local Municipalities showing locations of 7 MHPs indicated in the Terms of Reference of the study

Other loads in the region are commercial loads of offices like banks as well as government bodies. One can assume that, the situation will be such that the demand will be high during peak hours, precisely morning and evening peak, and less during the night. The morning peak may not have many issues; but the supply is sure not to be enough to carter the load during evening peak. The direct effect of the load characteristics will have on revenue with energy being spilled during off peak hours, especially during nighttime and capacity limited during peak hours.

Figure 2-11 and Figure 2-12 represent the interconnection schematics and map for Mini Grid as well as Grid Connected Mode after the national grid reaches Jumla. However, it will take considerable time for Chukeni (998 kW) to come online. The 11 kV lines are yet to be constructed. The 11 kV line from Ghughuti to Chukeni MHP is under design phase and will be constructed by AEPC. Other 11 kV line from Ghughuti to Giri Khola MHP needs to be constructed too. There exists a 11 kV line in certain sections of the intended route. AEPC has carried out study to effectively evacuate power generated in Giri Khola to Khalanga Bazaar. The study has proposed role of NEA, AEPC/SASEC and ADB in completing this project. The Consultant understands that this can be done in short time should there be poles, conductors and other 11 kV line infrastructure available with NEA.

For immediate implementation, the Consultant has identified a slightly different interconnection approach. Figure 2-13 presents the model proposed by the Consultant for immediate implementation.

The Consultant visited the site and observed that, the Jugad MHP (68 kW), although not in AEPC's Terms of Reference is working fine and there exists a 11 kV line from Jugad MHP to Ghughuti MHP. On the other hand, the Thinke Badh MHP, although recently commissioned, has been supplying power to parts of the Khalanga Bazaar. There exists a 11 kV line from Thinke Badh to Jumla Bazaar for this purpose. Giri Khola is about to complete construction, and as discussed earlier, it will be relatively quick to evacuate its power to Khalanga Bazaar.

The former has been represented as Option I while presenting the simulation results whereas the latter has been denoted as Option II and its results follows the results of Option I in subsequent chapters.

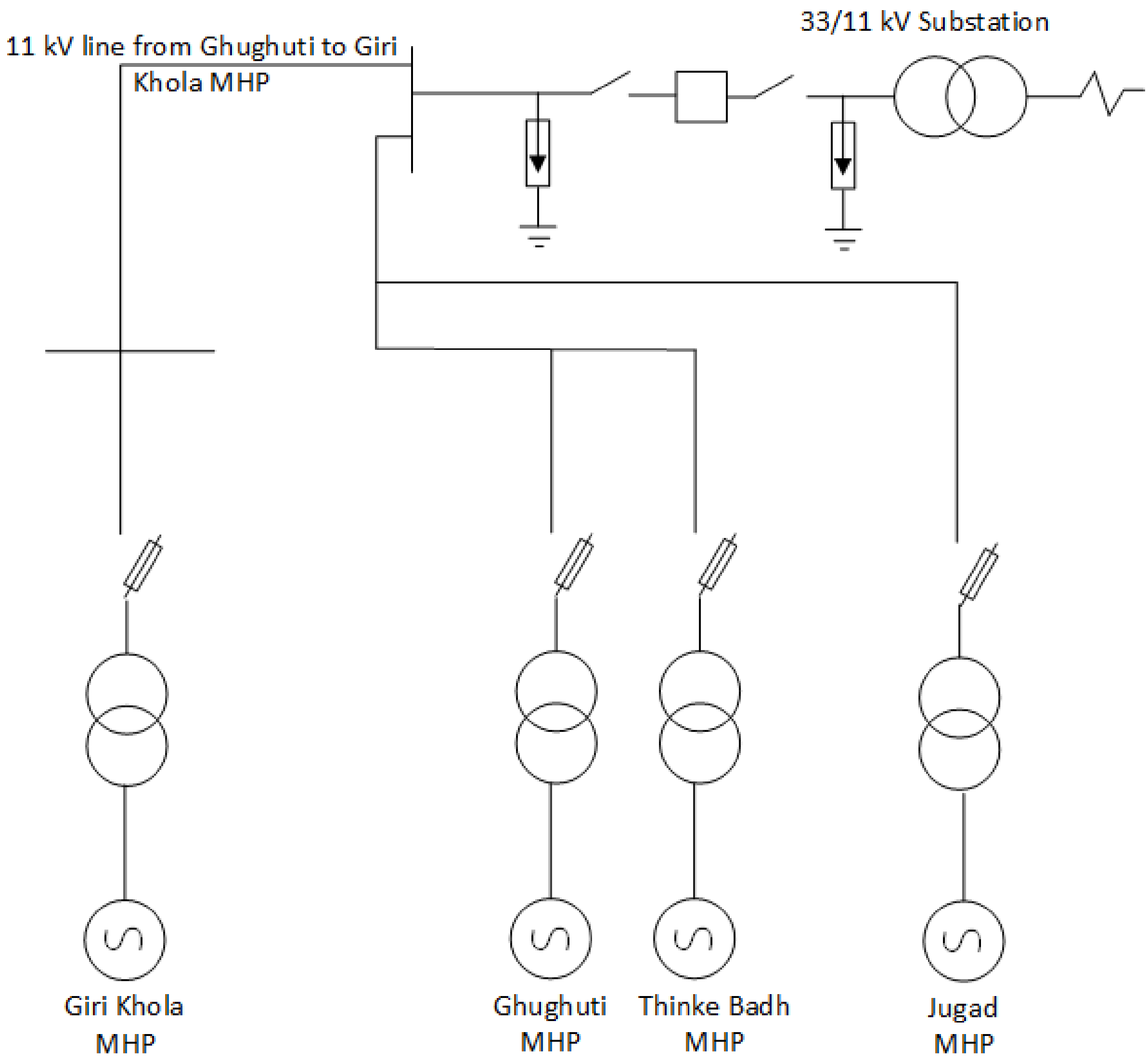


Figure 2-13: Proposed Interconnection scheme for Immediate Implementation of Mini Grid in Jumla,

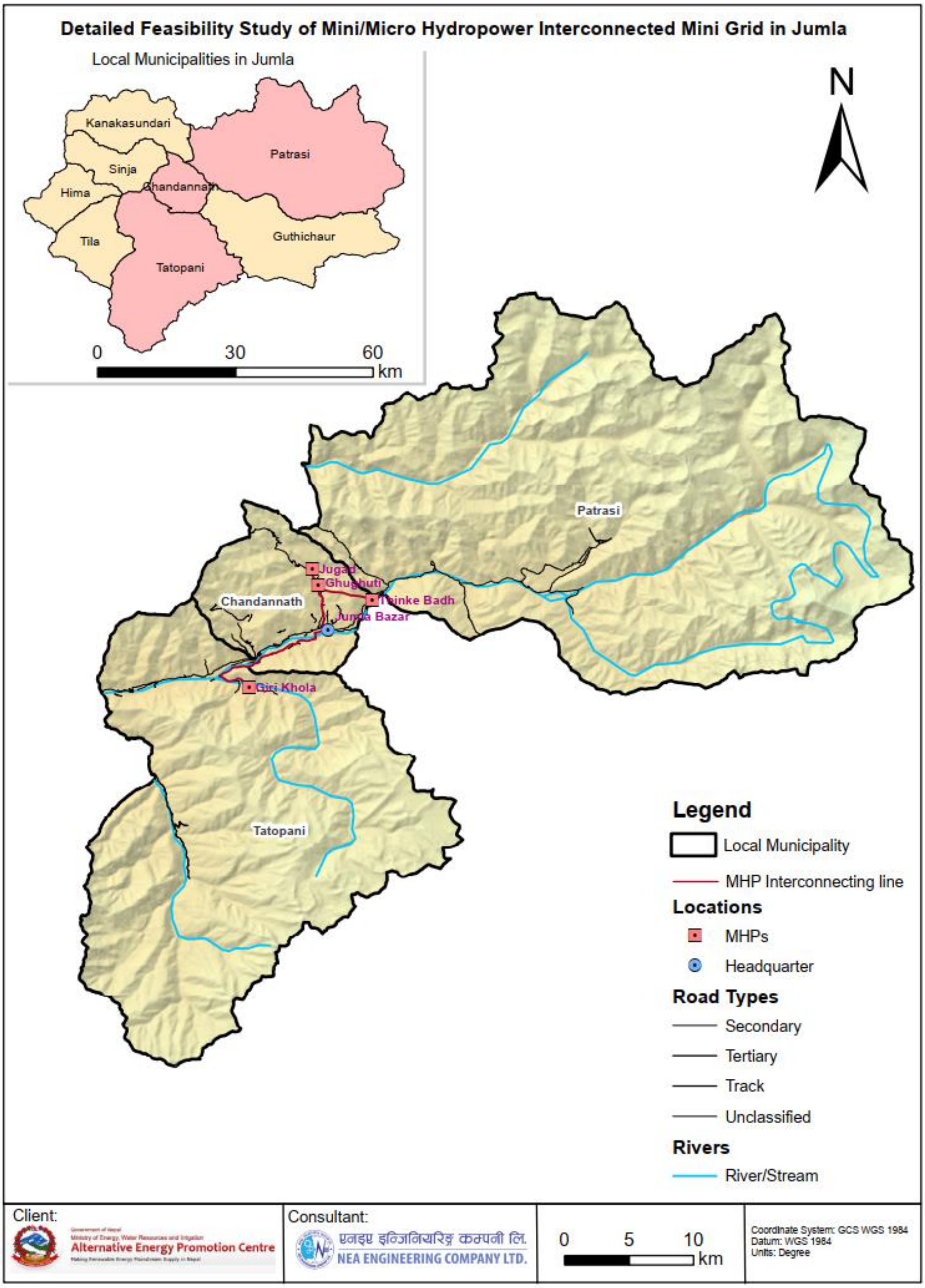


Figure 2-14: Map of Project Area Local Municipalities showing locations of 4 MHPs identified in site visit deemed suitable for immediate interconnection in the region

Eventually, all 8 MHPs can be interconnected in the proposed Mini grid. The map indicating locations of all 8 MHPs is presented in Figure 2-15.

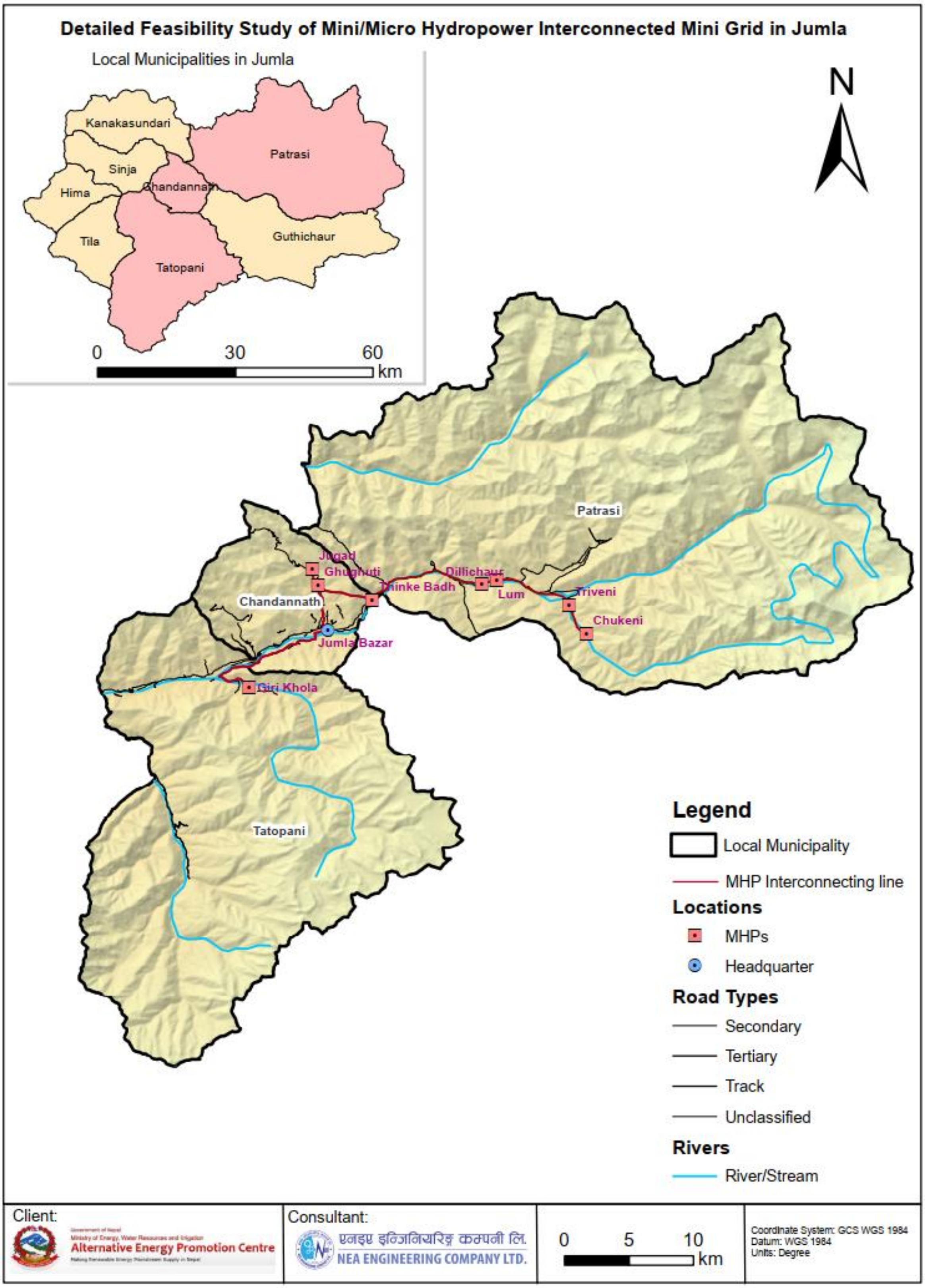


Figure 2-15: Map of Project Area Local Municipalities showing locations of 8 MHPs that will be interconnected after commissioning of Chukeni Mini Hydro Power Plant

3 Simulation Analysis of the Mini Grid System for Option 1

3.1 Load Flow Analysis

3.1.1 Scenario I – Isolated Mini Grid

The isolated Mini grid scheme will be revolving around the backbone 11 kV transmission line from Chukeni Mini hydro to Jumla substation. Chukeni Mini hydro is the farthest plant from Jumla Bazar towards the north. Triveni, Lum and Dillichaur are located enroute to Chukeni Mini hydropower. These three micro hydros will be tapped to the same transmission line from Chukeni to Jumla Substation.

Consultant assumes that by 2022 all the mini and micro hydro under the scope of the project will be in operation and mini grid will comprise all these plants.

3.1.1.1 Wet Peak Period

For power system analysis of isolated mini grid, Chukeni Mini hydro is considered as the swing bus. For peak load period, it is assumed that the peak local loads of micro hydro will be 70% of the total generation made by the micro hydro while for the mini hydro Giri Khola and Chukeni it will be 40% of the rated capacity.

Table 3-1 Load Generation Scenario for Wet Peak Period

	P gen (kW)	Load (kW)
CHUKENI 0.4000	998.00	399.20
DILLICHAUR 0.4000	50.00	35.00
GHUGHUTI 0.4000	200.00	1000.00
GIRIKHOLA 0.4000	200.00	80.00
LUM 0.4000	31.00	21.70
TINKEBADH 0.4000	100.00	70.00
TRIVENI 0.4000	45.00	31.50
Total	1624.00	1637.40

As per the Consultation with NEA officials, the suppressed peak of Jumla Bazar is around 1 MW, thus Consultant considers the same figure for the load flow analysis. The mini/micro hydro will be operating in its rated capacity except for the swing machine. There is a slight imbalance in load-generation scenario which can be covered by slight overloading of the mini hydro or shedding some loads. It is evident from the load flow report that as Chukeni is acting as the swing bus it will be generating above its rated capacity. Generator of Chukeni is designed to be operated at 10% COL, thus it as to operate at COL rating.

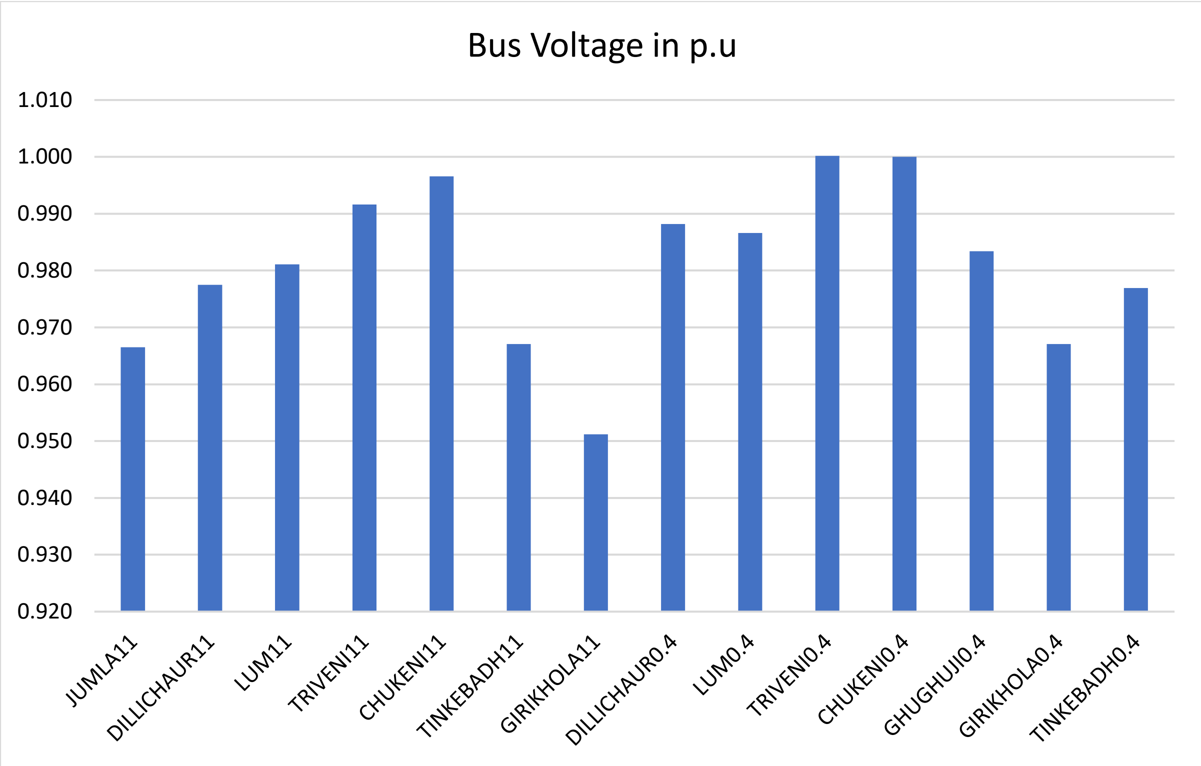


Figure 3-1 Bus voltages of different bus during wet peak period

Figure 3-1 depicts that during Wet Peak period all the bus voltages will be within the limits of ± 5% of the rated voltage. Total loss during the peak period will be around 32.27 kW. The load flow report for this scenario has been attached in the Annex.

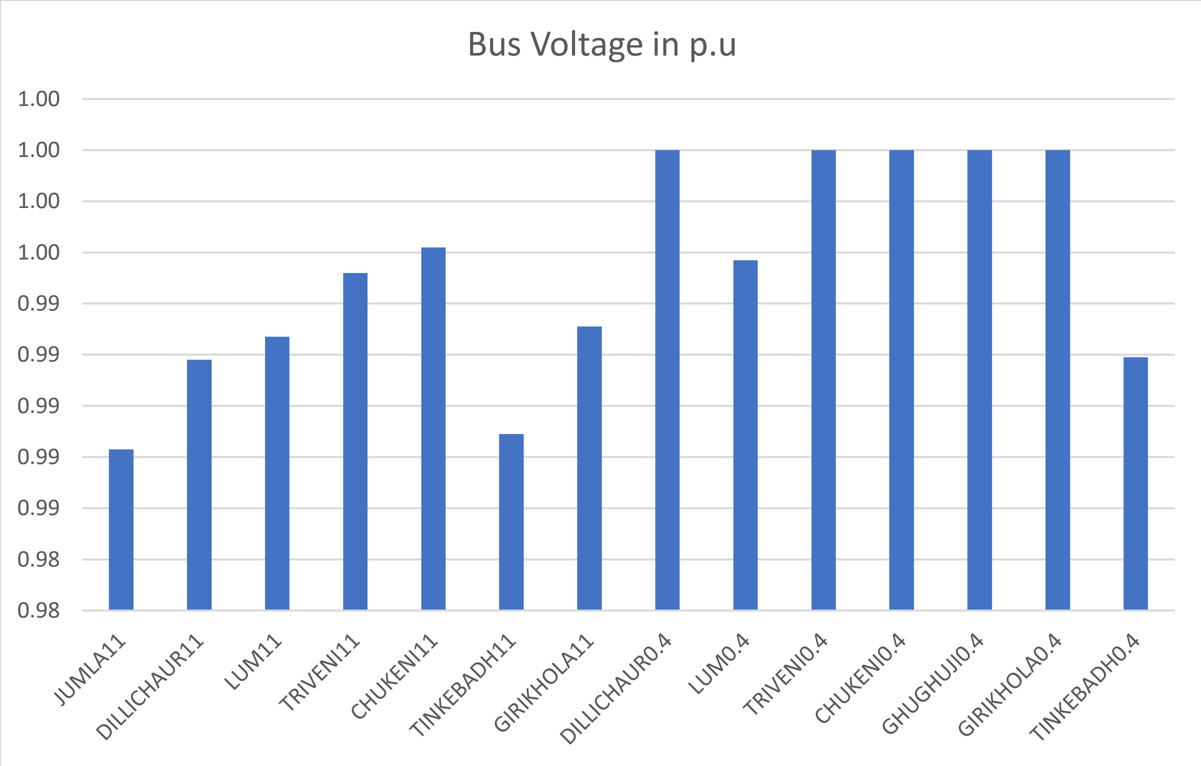


Figure 3-2 Bus voltages of different bus during wet off-peak period

3.1.1.2 Wet Off Peak Period

For off peak period, it is assumed that the off-peak local loads reduce to 50 % of the peak load while the load of Jumla Bazar will drop down to 500 kW.

Figure 3-2 depicts that during Wet Off-Peak period all the bus voltages will be within the limits of ± 5% of the rated voltage. Total loss during the peak period will be around 1.31 kW. As the generation exceeds the loads, significant amount of power needs to be dumped to ballast load. It must be understood that the difference of rated power of Chukeni and the power generated by it during this scenario is the amount of power that needs to be dumped or managed by governor action of Chukeni. The assumptions made by the Consultant is such that all other micro hydros operate at its rated capacity while the Chukeni will operate at reduced capacity. Chukeni being the farthest plant from the load center, reducing its capacity will reduces the overall loss of the system. Loads will be fed by the generators near the load center. The load flow report for this scenario has been attached in the Annex.

3.1.1.3 Dry Peak Period

As the mini/micro hydro are RoR type power plant, during dry season, Consultant assumes that the power generation reduces to 60% of the rated capacity while the loads remain the same.

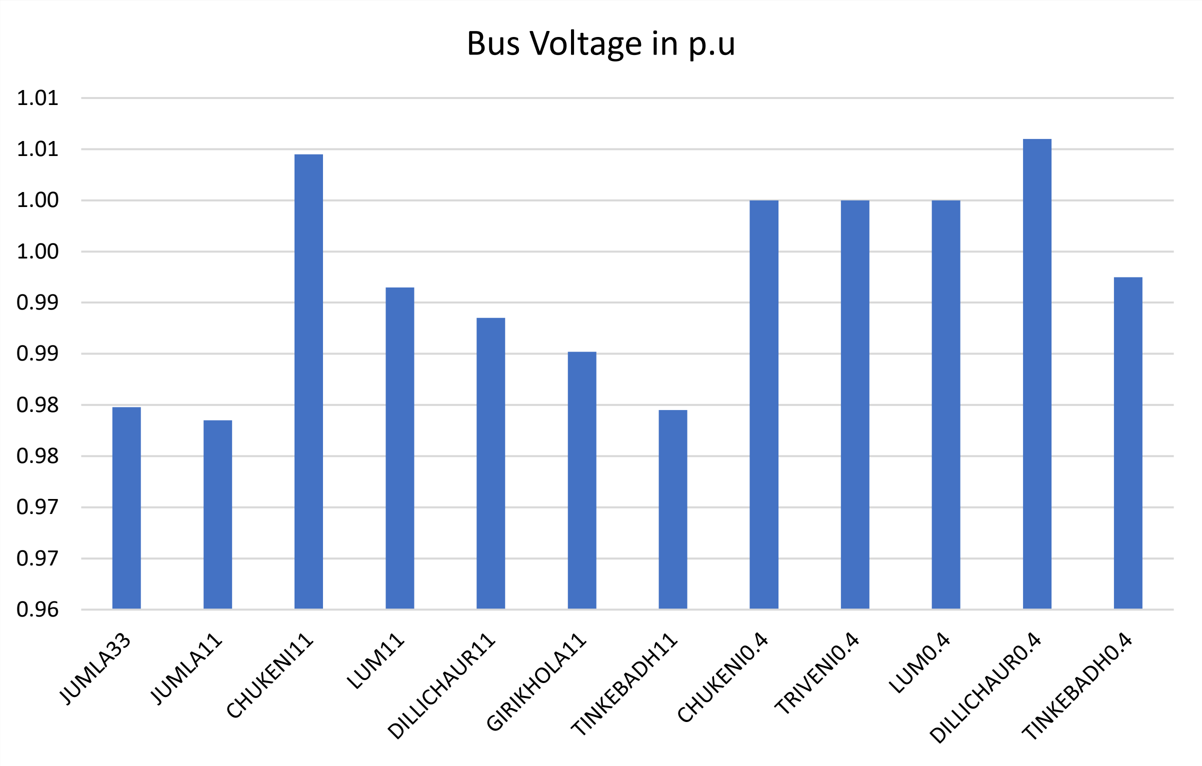


Figure 3-3 Bus voltages of different bus during dry peak period

Figure 3-1 depicts that during Wet Peak period all the bus voltages will be within the limits of ± 5% of the rated voltage. Total loss during the peak period will be around 26.04 kW. Chukeni mini hydro will be loaded to 130% of rated capacity, thus load must be shed during this period. The load flow report for this scenario has been attached in the Annex.

3.1.1.4 Dry Off Peak Period

As the mini/micro hydro are RoR type power plant, during dry season, Consultant assumes that the power generation reduces to 60% of the rated capacity while the loads reduce to 50% of that of peak period.

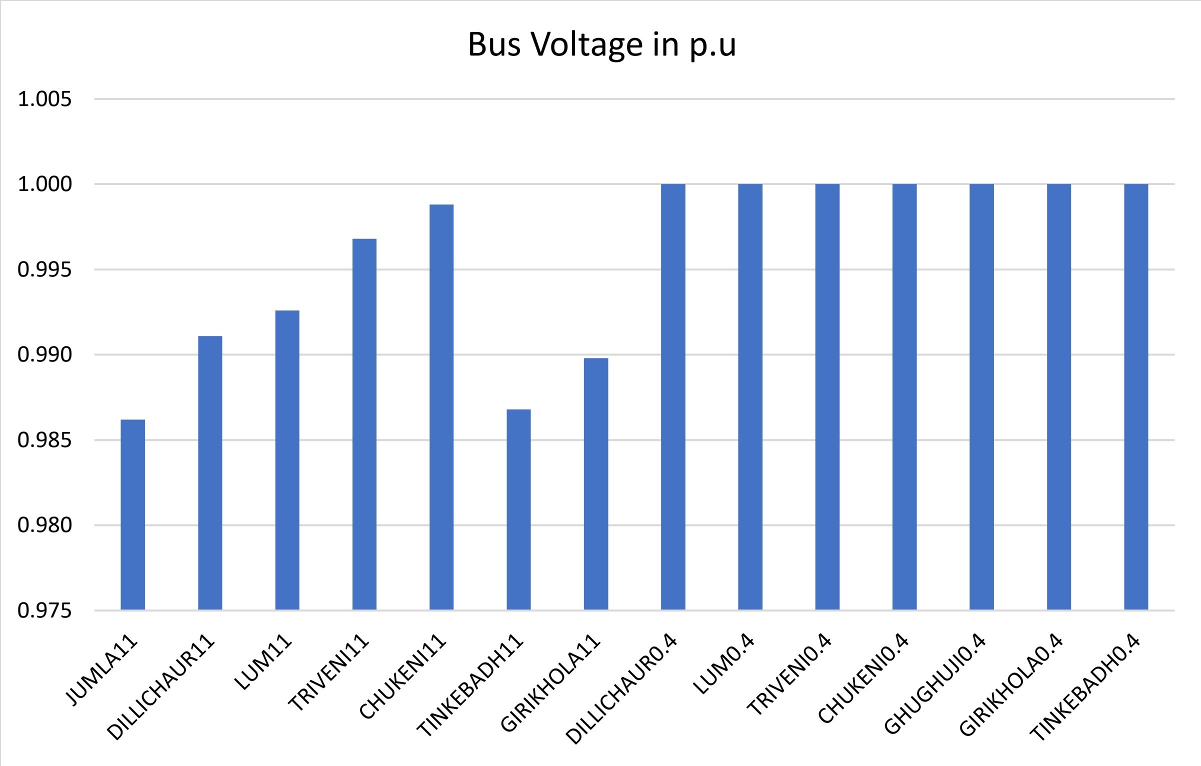


Figure 3-4 Bus voltages of different bus during dry off-peak period

Figure 3-4 depicts that during Dry Off-Peak period all the bus voltages will be within the limits of ± 5% of the rated voltage. Total loss during the peak period will be around 2.96 kW. There will still be excess generation which must be managed by governor action of Chukeni mini hydro. The load flow report for this scenario has been attached in the Annex.

3.1.2 Scenario II - National Grid Extension

NEA has several major projects under pipeline in Jumla. As per annual Report of NEA for Fiscal Year 2077, the projects are listed below:

- 132 kV double circuit transmission line from Dailekh-Kalikot-Jumla approximately 80 km and associated substation at Jumla, Kalikot and bay extension at Dailekh
- Dailekh-Chilkhaya-Jumla 33 kV Transmission Line and Substation Project at Dailekh.
- Sanfe-Manma-Jumla 33 kV Transmission Line & Substation Project

Consultant has considered the 33 kV Transmission line from Kohalpur-Surkhet-Dailekh-Dullu-Manma-Jumla to simulate grid connected scenario for Jumla Mini grid. Despite Jumla is still out of the national grid, 33 kV transmission line will reach Jumla by next two year as it has already connected Manma substation. The analysis has been performed for four different scenario and discussed below:

3.1.2.1 Wet Peak Period

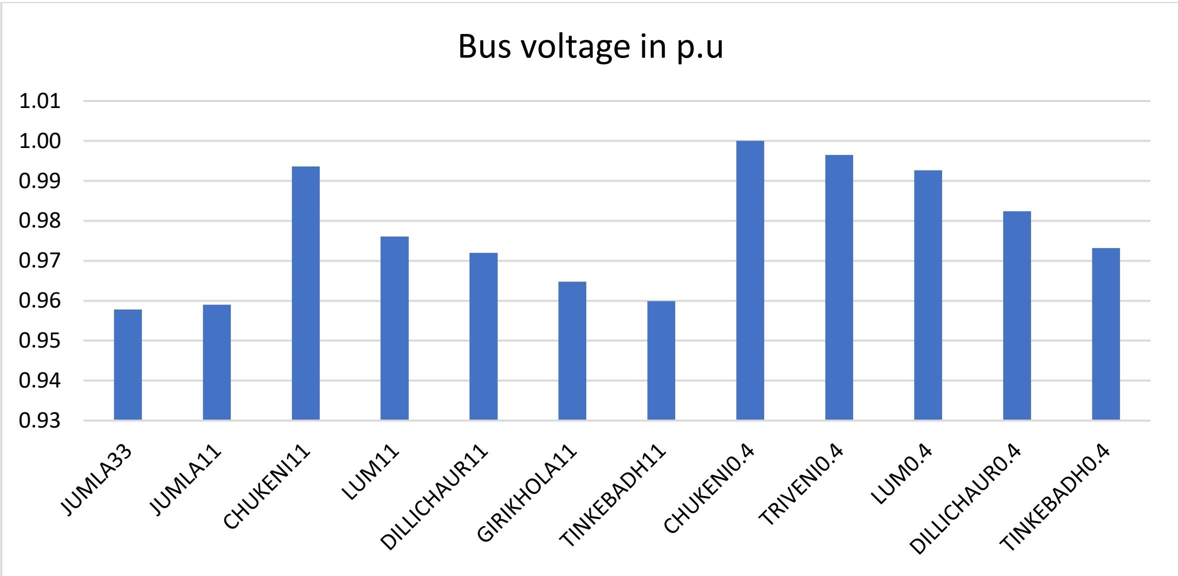


Figure 3-5 Bus voltages of different bus during grid connected wet off-peak period.

Figure 3-5 depicts that during Wet Peak period all the bus voltages will be within the limits of ± 5% of the rated voltage. Total loss during the peak period will be around 16.02 kW. As the local generation is insufficient to meet the peak demand, national grid supplies the deficit power and maintains the reliability of the power supply. During this scenario, national grid supplies 31 kW to Jumla Mini grid. This import will result in all the generators of mini grid operating at its rated capacity without any one being overloaded. The load flow report for this scenario has been attached in the Annex.

3.1.2.2 Wet Off Peak Period

Figure 3-6 depicts that during Wet Off-Peak period all the bus voltages will be within the limits of ± 5% of the rated voltage. Total loss during the peak period will be around 36.06 kW. Mini grid can sell excess power of 807 kW to national grid. The load flow report for this scenario has been attached in the Annex.

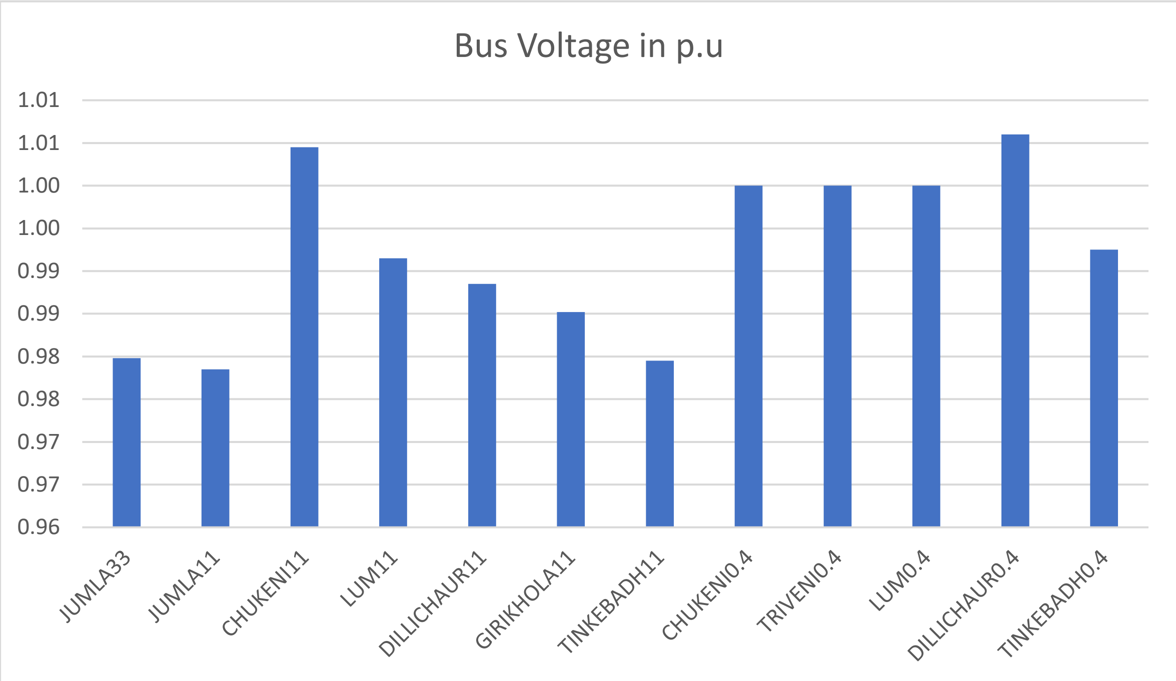


Figure 3-6 Bus voltages of different bus during grid connected wet off-peak period.

3.1.2.3 Dry Peak Period

Figure 3-7 depicts that during Dry Off-Peak period all the bus voltages will

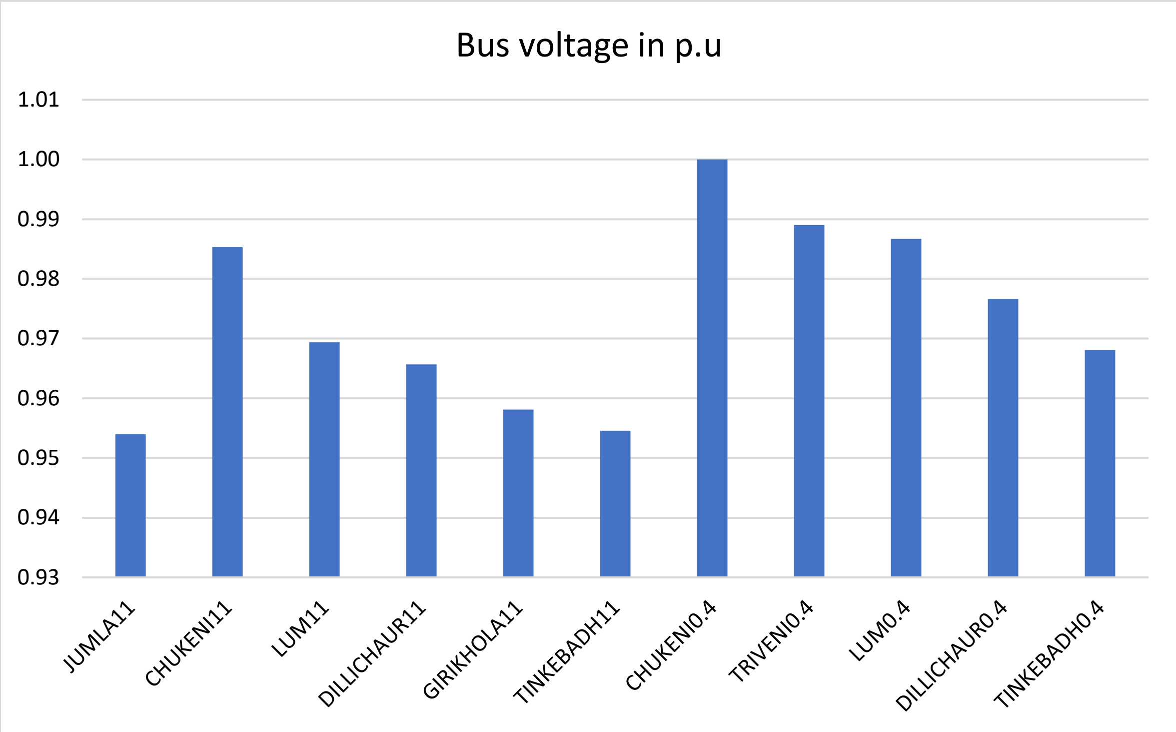


Figure 3-7 Bus voltages of different bus during grid connected dry peak period.

be within the limits of ± 5% of the rated voltage. Total loss during the peak period will be around 15.5 kW. As the local generation is insufficient to meet the peak demand, national grid supplies the deficit power and maintains the reliability of the power supply. During this scenario, national grid supplies 569 kW to Jumla Mini grid. The load flow report for this scenario has been attached in the Annex.

3.1.2.4 Dry Off Peak Period

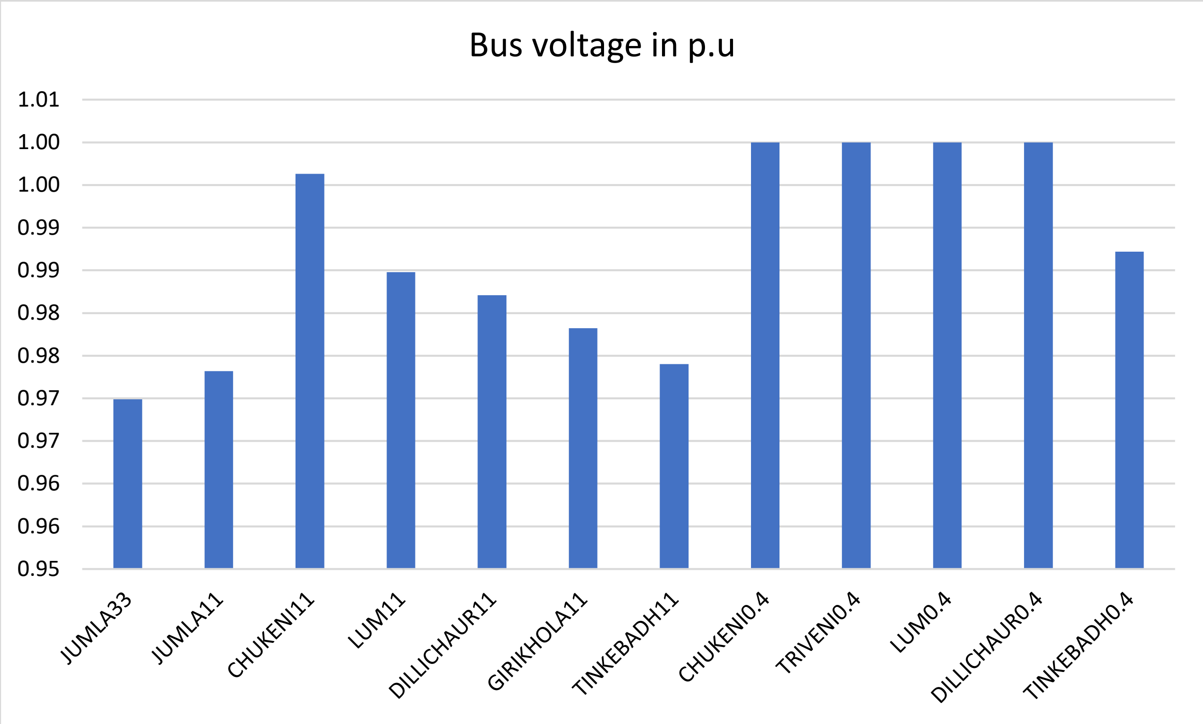


Figure 3-8 Bus voltages of different bus during grid connected dry off-peak period

Figure 3-8 depicts that during Dry Off-Peak period all the bus voltages will be within the limits of ± 5% of the rated voltage. Total loss during the peak period will be around 8.93 kW. Peak demand of the Mini grid reduces significantly during off peak period. Mini grid can sell excess power of 189 kW to national grid. The load flow report for this scenario has been attached in the Annex.

3.2 Short Circuit Analysis

Owing to lack of actual data, certain assumptions were made for the development of Model in PSSE. Short Circuit Analysis is based on IEC 60909 standard. The assumptions are enlisted here for understanding the modeling criteria of the System Analysis.

Table 3-2 Impedances Parameters for System Modeling, in absence of actual data

Line Parameters				
Description		Pu. per km 100 MVA Base		
Voltage, kV	Conductor (ACSR)	R	X	B
11	Dog	0.226694	0.304871	4.24E-06
33		0.02518	0.03712	0.00004
Transformer Parameters				
3 MVA Transformer: 4.5% on its own base				
Generator Parameters				
Xd" = 0.13 p. u				

Table 3-3 Short Circuit Current Levels of different MHP

MHP	**Faulted Bus**	**Short Circuit Current**	
		Isolated	**Grid Connected**
Chukeni	Fault at 11 kV side	0.49 kA	0.816 kA
	Fault at 0.4 kV Side	14.5 kA	23.17 kA
Triveni	Fault at 11 kV side	0.48 kA	0.833 kA
	Fault at 0.4 kV Side	2.1 kA	2.5 kA
Lum	Fault at 11 kV side	0.46 kA	0.886 kA
	Fault at 0.4 kV Side	1.5 kA	1.72 kA
Dillichaur	Fault at 11 kV side	0.45 kA	0.911 kA
	Fault at 0.4 kV Side	2.2 kA	2.53 kA
Tinke Badh	Fault at 11 kV side	0.401 kA	0.844 kA
	Fault at 0.4 kV Side	0.404 kA	5.12 kA
Ghughuti	Fault at 11 kV side	0.431 kA	10.17 kA

	Fault at 0.4 kV Side	6.5 kA	8.3 kA
Giri Kola	Fault at 11 kV side	0.36 kA	0.633 kA
	Fault at 0.4 kV Side	6.1 kA	8.4 kA

3.3 Transient Analysis

3.3.1 Isolated Mini grid

Transient Simulation for Mini grid Interconnection in Jumla has been performed on the software PSSE 34.1.6. The major purpose of the study is to determine three different stability criteria for the project namely Voltage Stability, Rotor Angle Stability, and the Frequency stability.

Consultant has performed the analysis for the time frame of 2021 in an isolated mode and grid connected mode considering all the generation and the transmission lines that the Consultant assumes are likely to be online by the time frame. Four different scenarios have been simulated during the stability study. They are as follows:

Case 1: Three Phase fault on the line from Chukeni to Triveni

Case 2: Three Phase Fault on 0.4 kV bus of Chukeni

Case 3: Tripping of Chukeni HEP without reclose

Case 4: Three Phase Fault on 11kV bus of Jumla

Case 5: Tripping of Ghughuti without reclose

Consultant has assumed several standard and generic models for the generator, excitation system, governor, and the stabilizer due to unavailability of the data for the existing system. The fault clearing time of 11 kV system is assumed to be 7.5 cycles or 0.15 sec as per Nepalese grid code. Consultant assumes following criteria to evaluate the stability the system:

- Transient undervoltage after the fault clearance should remain above 0.7 p. u and the voltage should recover above 0.9 p. u within

2 seconds from the fault occurrence.

- Transient overvoltage should remain below 1.3 p. u for first 200 m.s. from the fault occurrence and the voltage should recover below 1.1 p. u after that.
- The frequency deviation must be within the ± 2.5% of the nominal frequency.

The standard models used for different items are as follows:

Generator: GENSAL as most of the generators are hydro based.

Excitation System: SEXS

Turbine Governor: HYGOV

As the ELC are semiconductor-based devices, ELC could not be modelled in PSSE. The limitation of this study is that the ELC based plants are supposed to have constant power output despite of the faults in the power system.

For each of the scenarios, the parameters like bus voltage, frequency deviation, rotor angle has been observed for different critical bus and generators.

This study is based on the standard values of models and assumptions made by the Consultant and thus may not represent the actual behavior of the system and is prone some margin of error.

3.3.2 Case 1: Three Phase Fault on the line from Chukeni to Triveni

For the system to be stable, it must be able to survive a permanent three phase to ground fault on a 11 kV line close to the bus and cleared in 150 m.s. For this case, three-phase fault has been applied to transmission line circuit from Chukeni to Triveni.

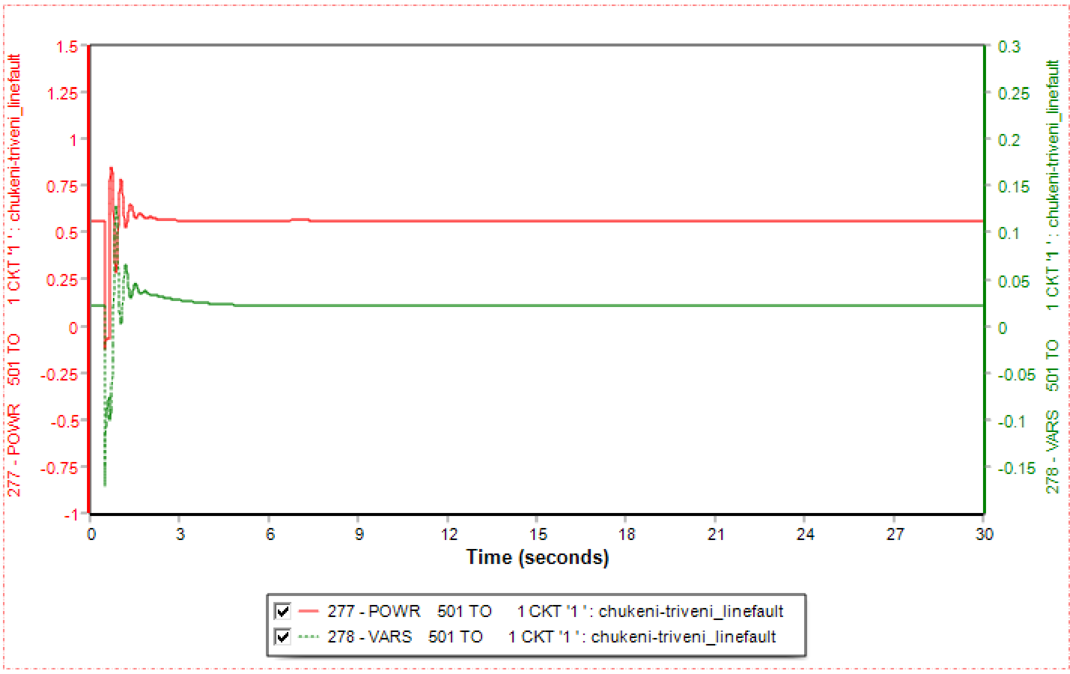


Figure 3-9 Power flow through Tinke Badh to Jumla Case 1

During the normal flow condition each circuit carries 560 which drops down to 6 kW in reverse direction after the application of the three-phase fault. The flow resumes to original condition after the removal of fault followed by some transient oscillations as shown in

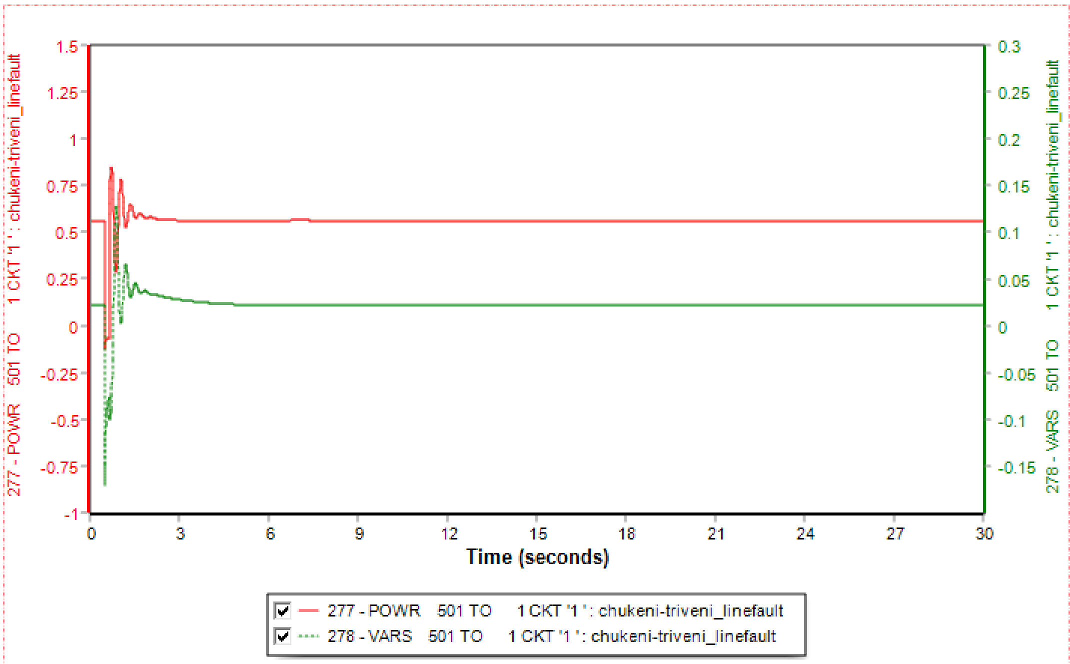


Figure 3-9.

Figure 3-10 depicts the frequency deviation of the 11 kV Jumla bus during the event. It is evident that the system frequency will be overshoot beyond the tolerable limit for fraction of a second but will later settle to nominal value if the fault is cleared within the specified time. The overshoot is due to the lower values of Inertia constant of generators.

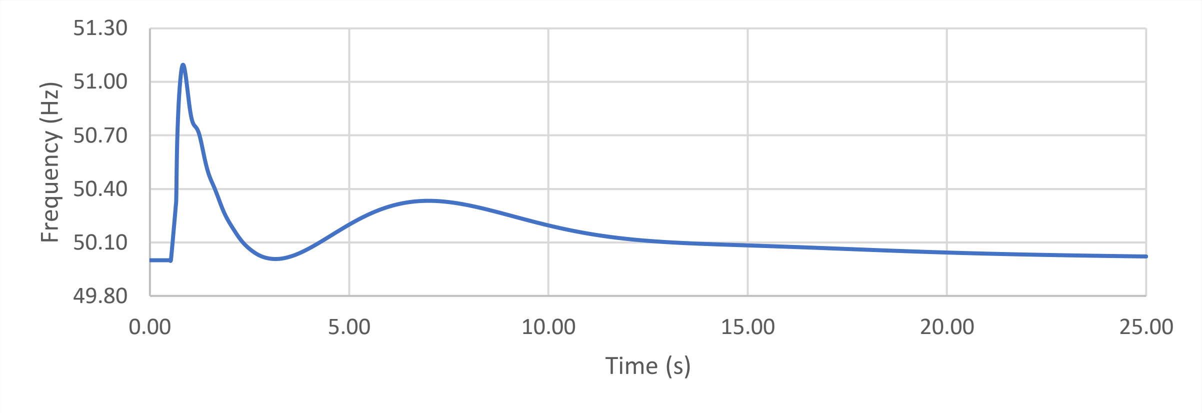


Figure 3-10 Frequency deviation of Jumla in Hz for case 1

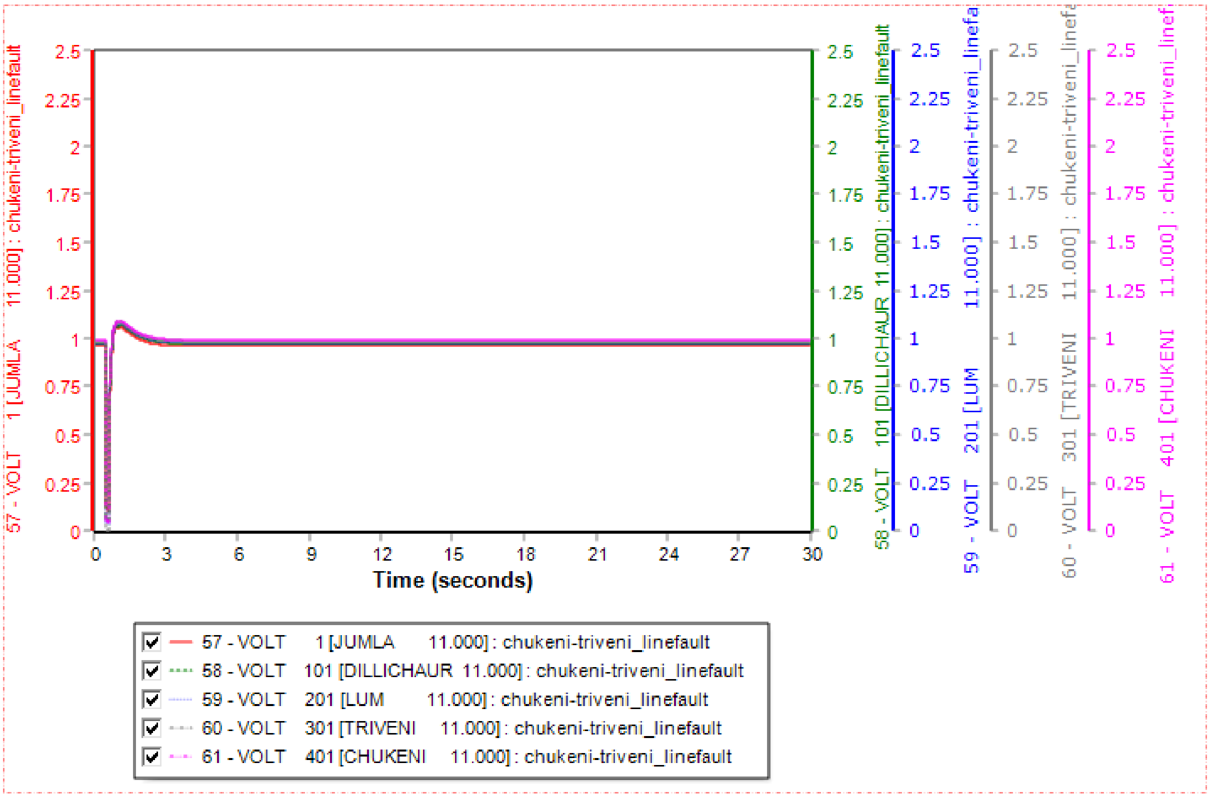


Figure 3-11 Bus Voltage of different 11 kV bus in p.u for Case 1

Figure 3-11 shows that during the three-phase line fault, the bus voltages will be within the tolerable limit of 1.1 p.u.

Figure 3-12 shows that the rotor angle deviation relative to Chukeni MHP of the different MHPs stabilizes after certain time after the fault has been cleared. This implies the generator will be stable during the three-phase line fault.

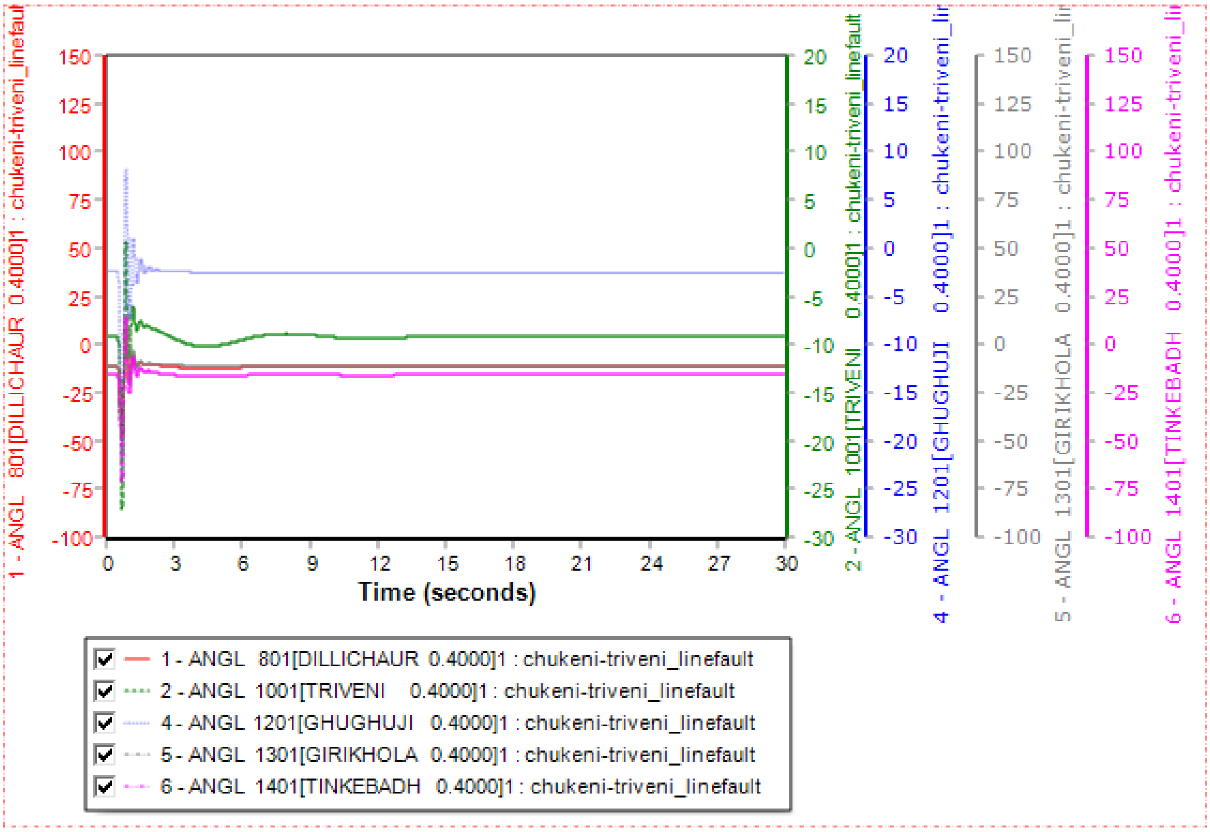


Figure 3-12 Rotor angle of different MHPS for Case 1

3.3.3 Case 2 Three Phase fault on 0.4 kV Chukeni Bus

Three-phase fault has been applied at generation bs of Chukeni MHP and cleared at 150 m.s. During the normal flow condition, Chukeni generates 980kW which drops down to 0 kW after the application of the three-phase fault. The flow resumes to original condition after the removal of fault followed by some transient oscillations as shown in Figure 3-13.

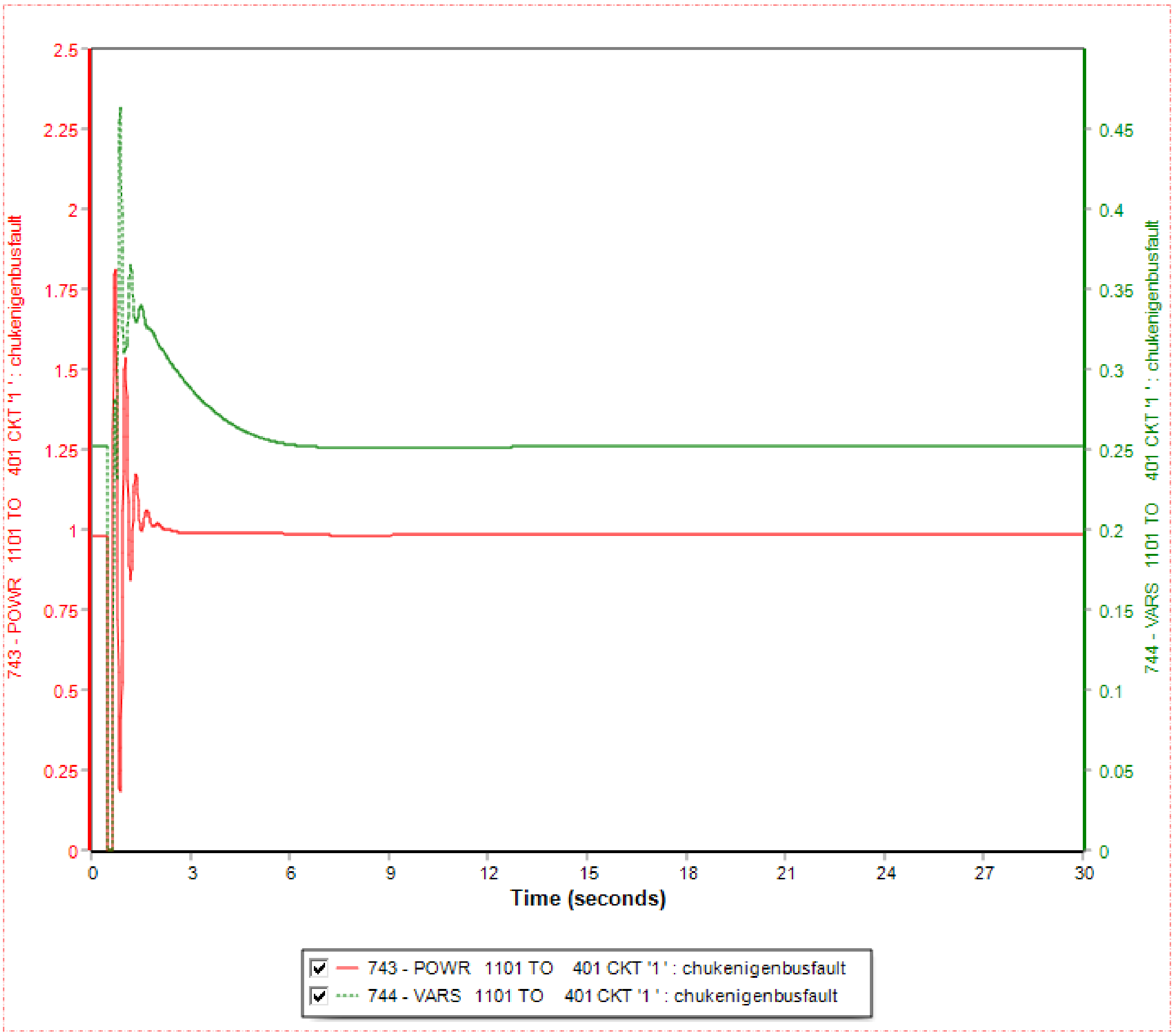


Figure 3-13 Power flow from Chukeni to Triveni Case 2

Figure 3-14 depicts the frequency deviation of the 11kV Jumla bus during the event. It is evident that the system frequency will overshoot but will settle to nominal value and thus stable.

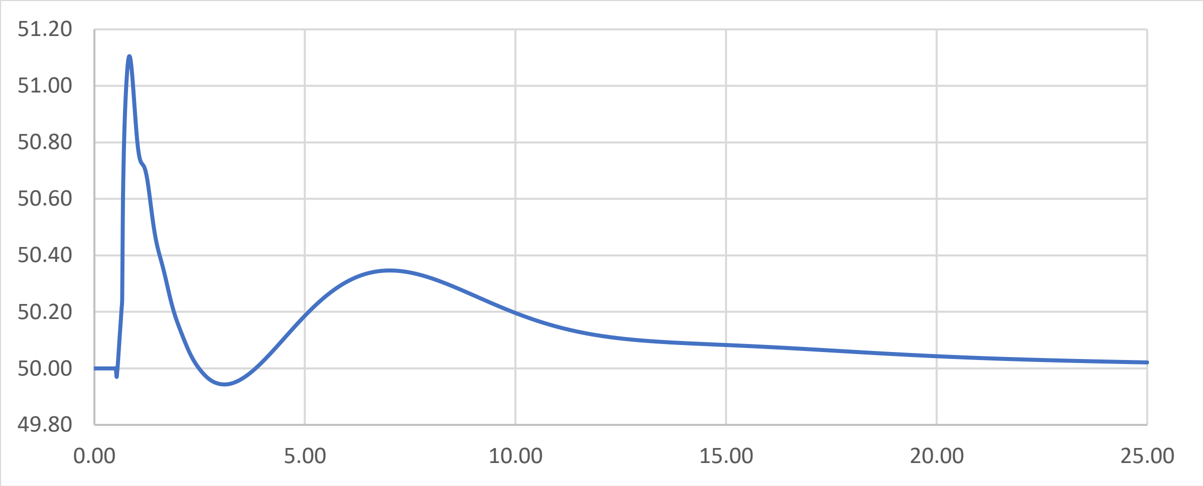


Figure 3-14: Frequency deviation of Jumla 11kV bus in Hz for case 2

Figure 3-15 shows the bus voltages during the three-phase bus fault will be within the tolerable limit of 1.1 p. u and stable.

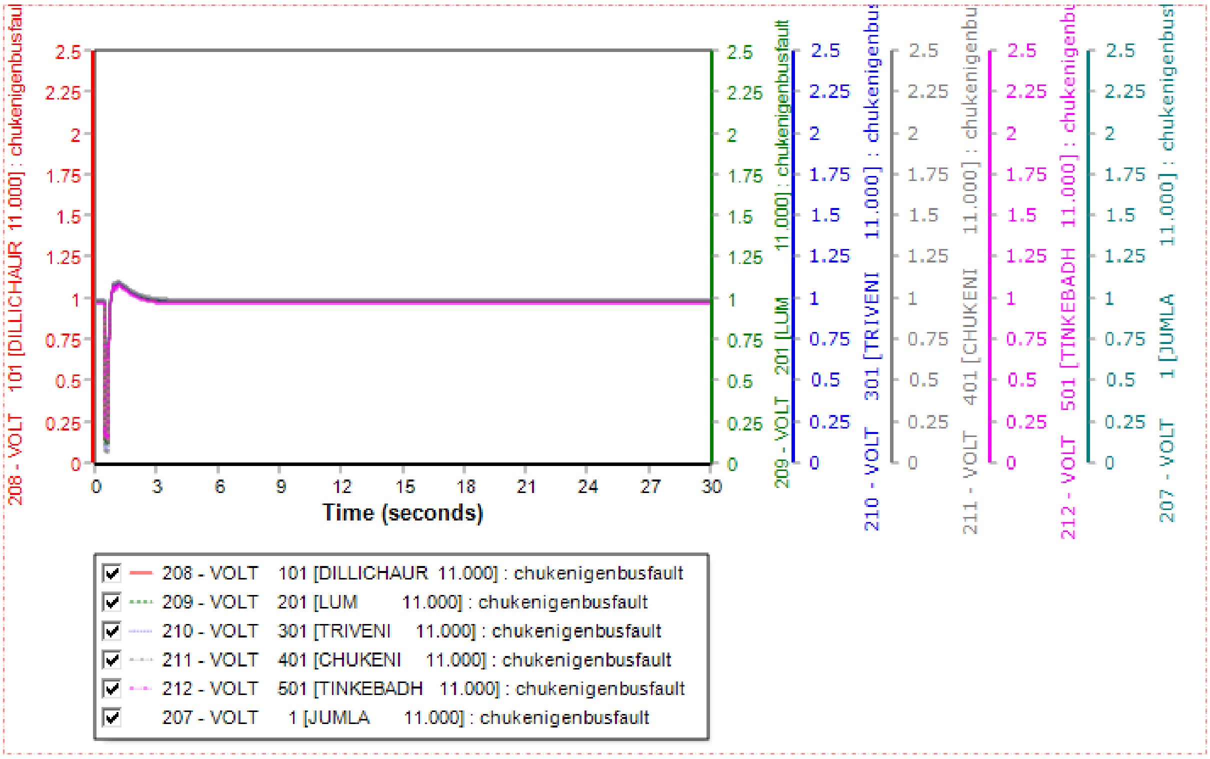


Figure 3-15 Bus Voltage of different 11 kV bus in p.u for Case 2

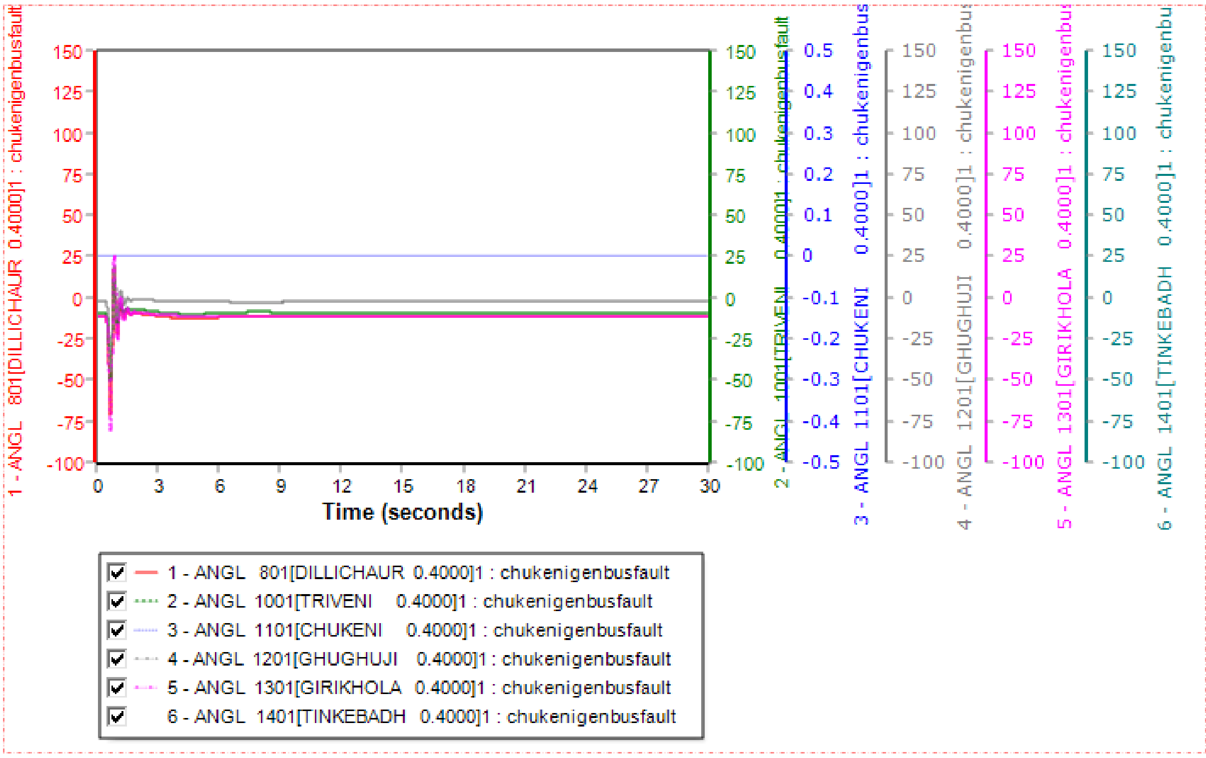


Figure 3-16 Rotor angle of different MHPS for Case 2

Figure 3-16 shows that the rotor angle deviation relative to Chukeni MHP of the different MHPs stabilizes after the fault has been cleared. This implies the generator will be stable during the three-phase line fault.

3.3.4 Case 3: Tripping of Chukeni without reclose

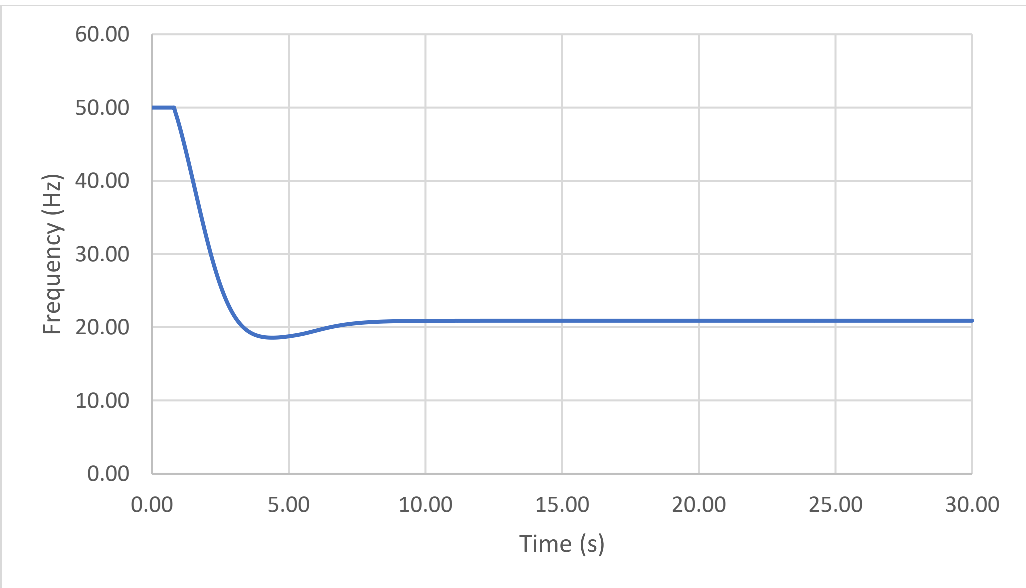


Figure 3-17 Frequency of 11 kV Jumla bus for Case 4

For this scenario, Chukeni MHP has been isolated from the system. Figure 3-17 depicts the frequency deviation of the 11kV Jumla bus during the event. It is evident that the system frequency will be unstable, and the frequency will drop beyond the limits. This is due to Chukeni being the largest generating unit and occupying the major share of total generation. To maintain the stability of the system, loads must be shed. Automatic load shedding relay can be installed for isolated Mini grid of Jumla.

3.3.5 Case 4: Three Phase fault on 11 kV Jumla Bus

Three-phase fault has been applied at 11kV bus of Jumla substation and cleared at 150 m.s. During the normal flow condition circuit from Thinke Badh to Jumla carries 520kW which drops down to zero after the application of the three-phase fault. The flow resumes to original condition after the removal of fault followed by some transient oscillations as shown in Figure 3-18.

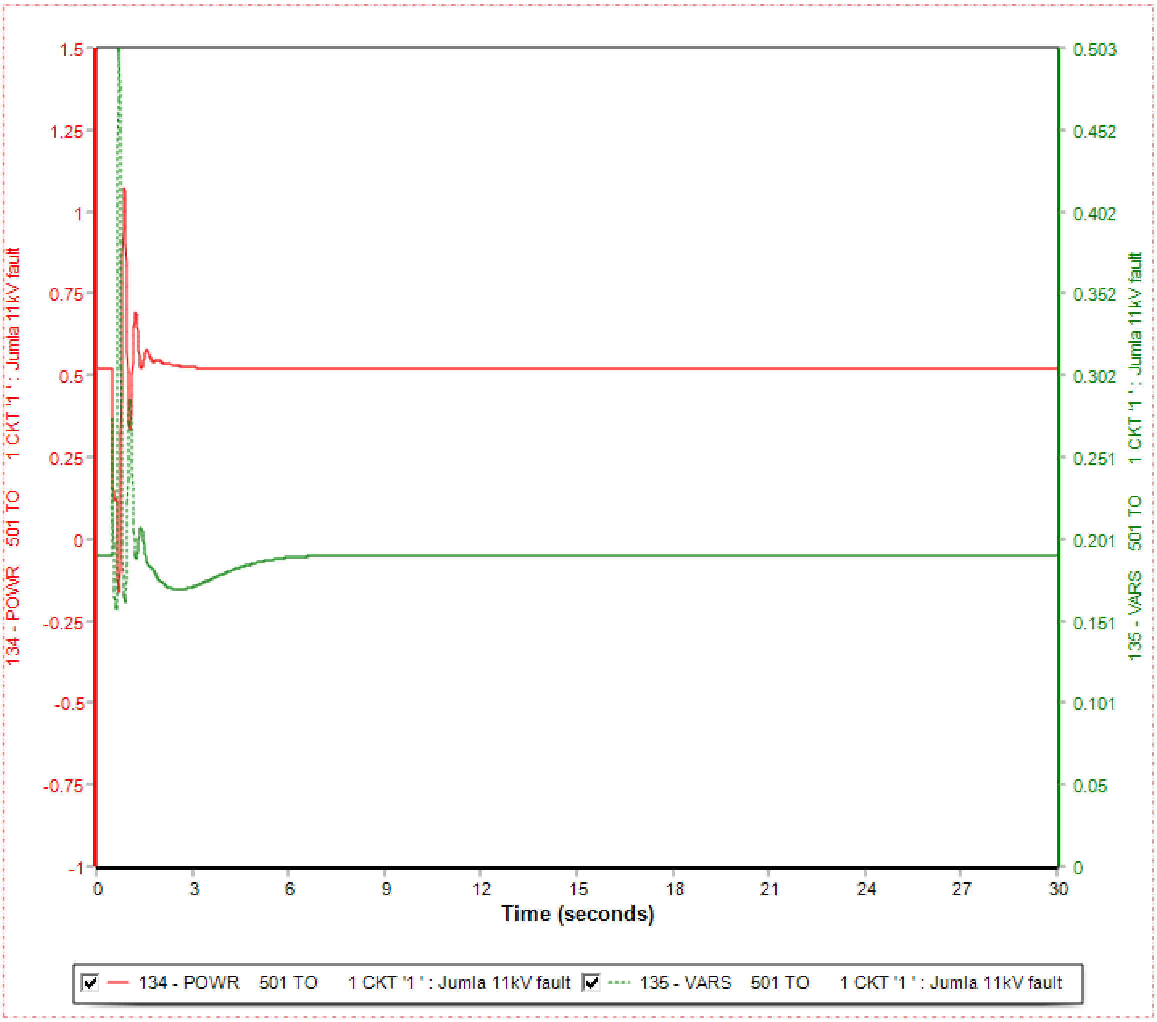


Figure 3-18 Power flow through Tinke Badh to Jumla

Figure 3-19 depicts the frequency deviation of the 11kV Jumla bus during the event. It is evident that the system frequency will be within the range as specified in the Grid code of NEA and thus stable.

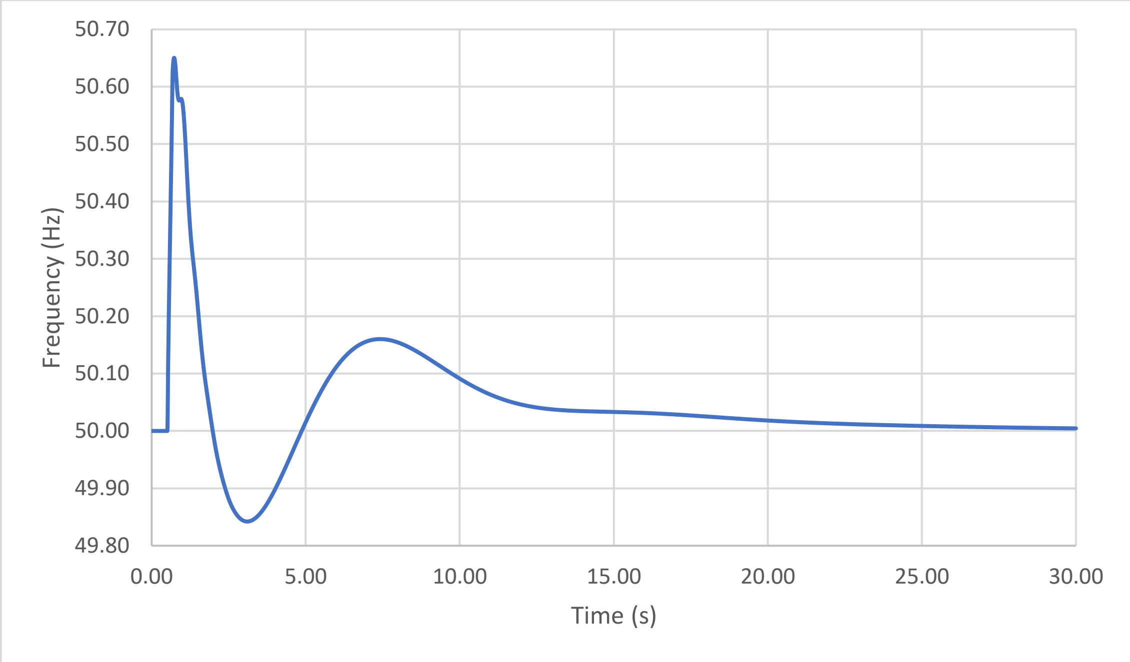


Figure 3-19 Frequency Deviation of Jumla 11 kV bus

Figure 3-20 shows the bus voltages during the three-phase bus fault, will be within the tolerable limit of 1.1 p. u and stable.

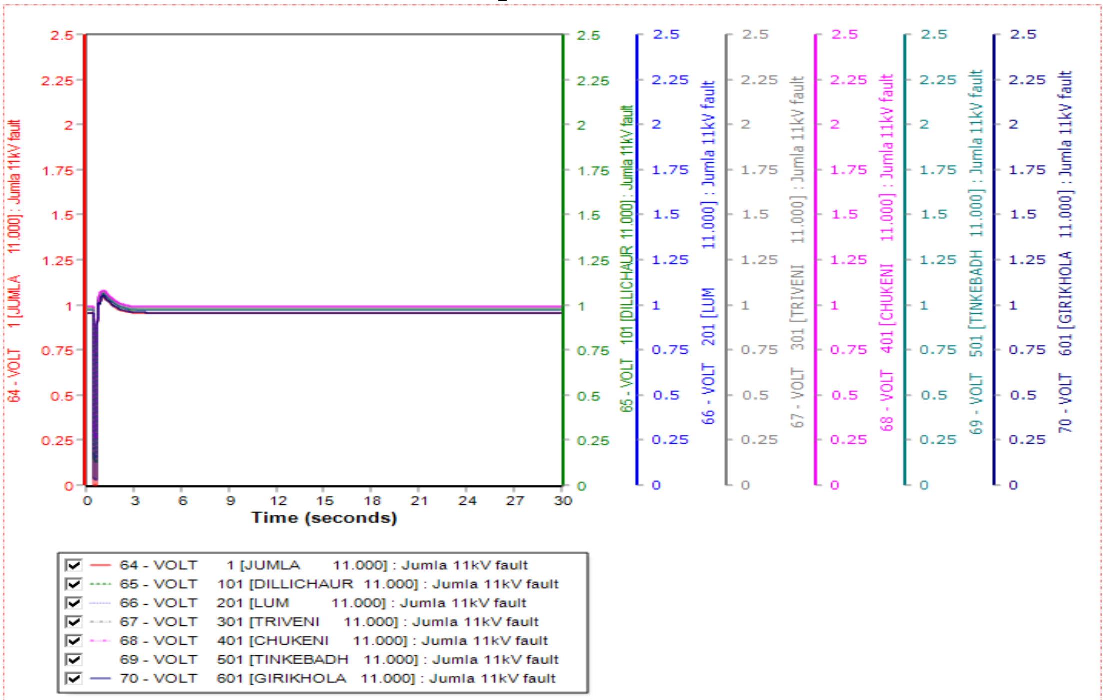


Figure 3-20 Bus Voltage of different 11 kV bus in p.u for Case 4

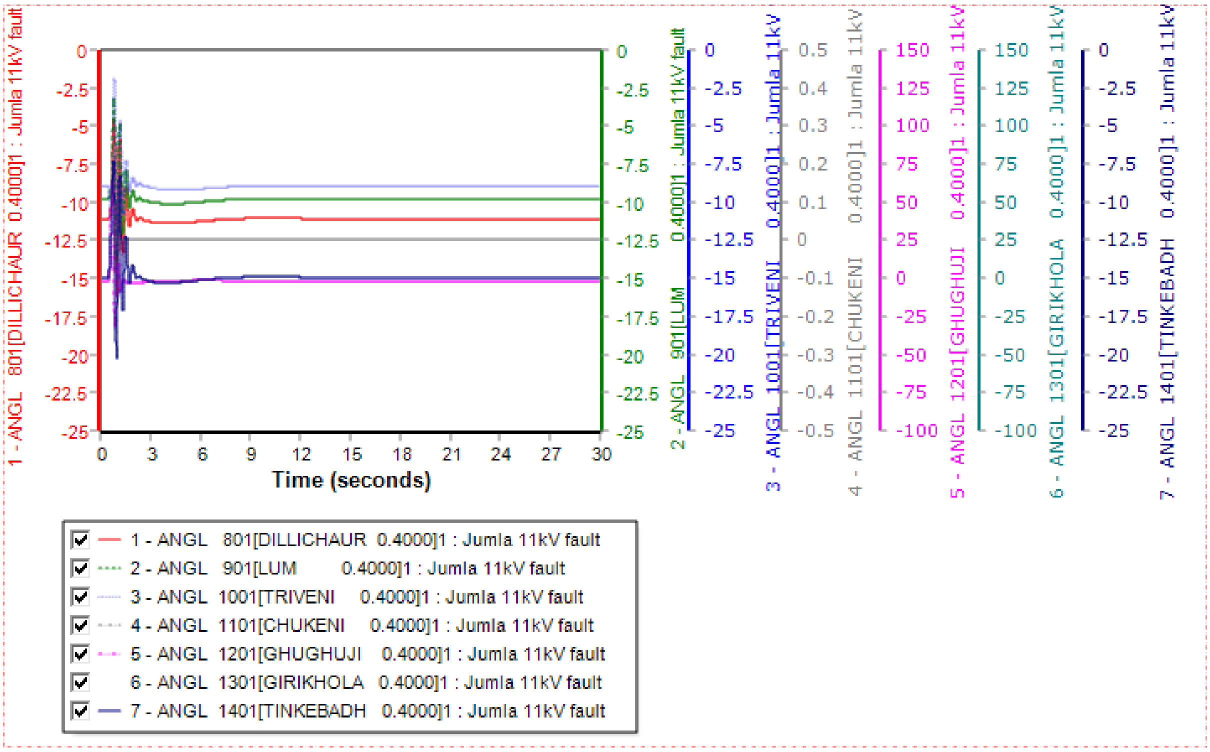


Figure 3-21 Rotor Angle Deviations of different MHPs

Figure 3-21 shows that the rotor angle deviation relative to Chukeni MHP of the different MHPs stabilizes after the fault has been cleared. This implies the generator will be stable during the three-phase line fault.

3.3.6 Case 5: Tripping of Ghughuti without reclose

For this scenario, Ghughuti MHP has been isolated from the system. Figure 3-23 depicts the frequency deviation of the 11kV Jumla bus during the event. It is evident that the system frequency will drop below 50 Hz but remain within the tolerable limit. Ghughuti being near the load center, loss of this generator must be accompanied by reduction of load to maintain the stable system.

Figure 3-22 depicts power generated by different MHPs during the event. It shows that the larger generating units namely Chukeni and Giri Khola will operate in overloaded condition to maintain the frequency of the system. To reduce the overloading, load must be shed from the system. Other MHP being ELC based, they are considered to supply constant power irrespective of the disturbance.

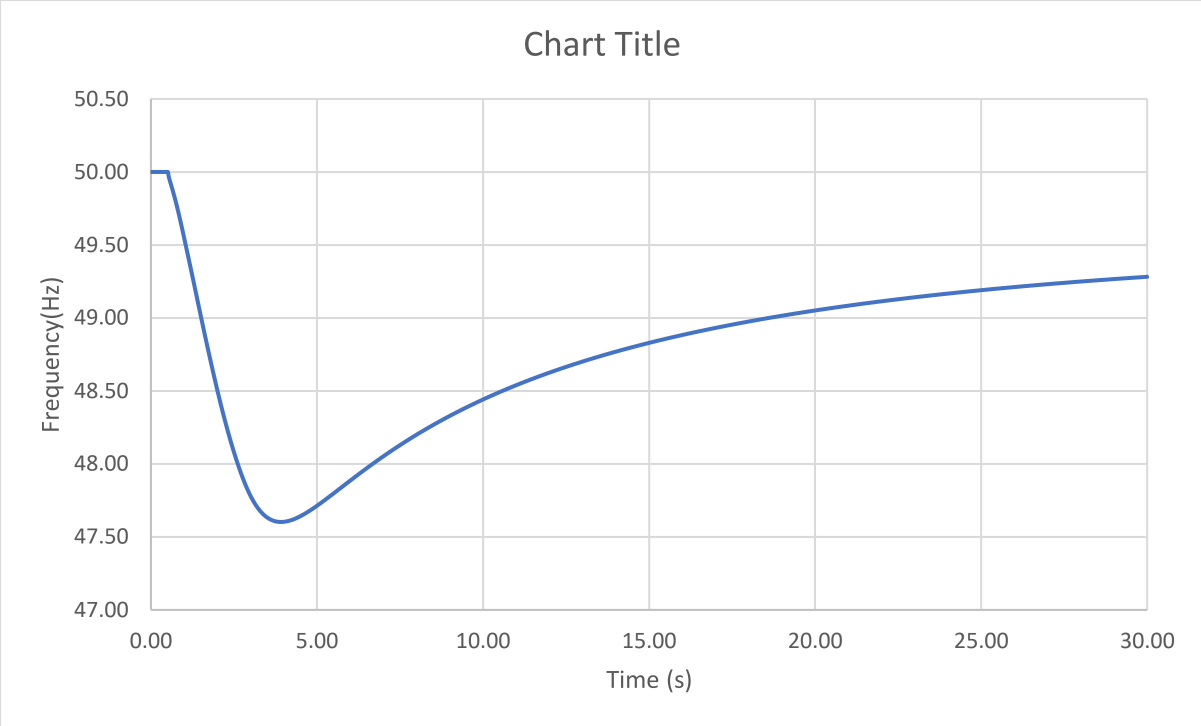


Figure 3-23 Frequency of 11 kV Jumla bus for Case 5

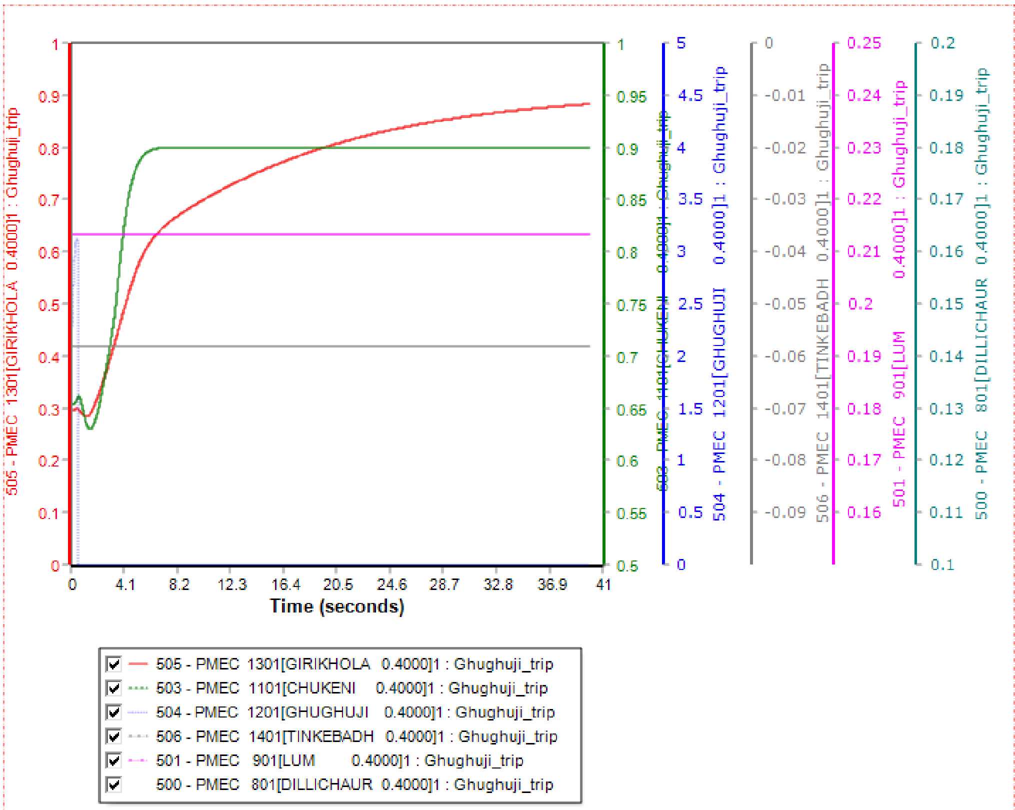


Figure 3-22 Power Generated by different MHP for Case 5 in p.u

Figure 3-24 depicts voltages of different 11 kV bus during the event. It shows that the bus voltage will remain 0.9 p. u for all the buses which is acceptable as per the Grid Code of Nepal.

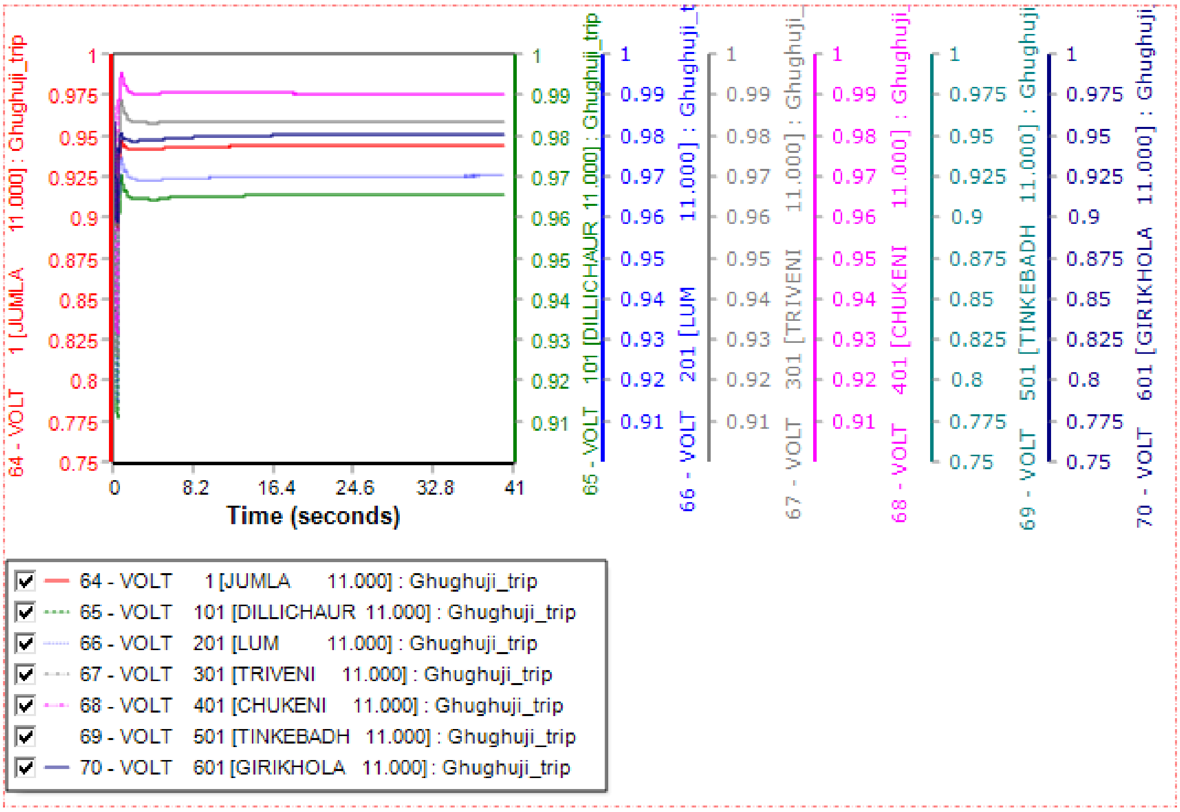


Figure 3-24 Voltages of different 11 kV bus in p.u for Case 5

3.3.7 Grid Connected Mini grid

Four different scenarios have been simulated during the stability study. They are as follows:

Case 1: Three Phase fault on the line from Chukeni to Triveni

Case 2: Three Phase Fault on 0.4 kV bus of Chukeni

Case 3: Tripping of Chukeni HEP without reclose

Case 4: Three Phase Fault on 11kV bus of Jumla

For each of the scenarios, the parameters like bus voltage, frequency deviation, rotor angle has been observed for different critical bus and generators.

3.3.8 Case 1: Three Phase Fault on the line from Chukeni to Triveni

The system shall be able to survive a permanent three phase to ground fault on a 11 kV line close to the bus to be cleared in 150 m.s. For this case, three-phase fault has been applied to transmission line circuit from Chukeni to Triveni.

During the normal flow condition, it generated rated 998 kW which drops down to zero after the application of the three-phase fault. The flow resumes to original condition after the removal of fault followed by some transient oscillations as shown in Figure 3-25.

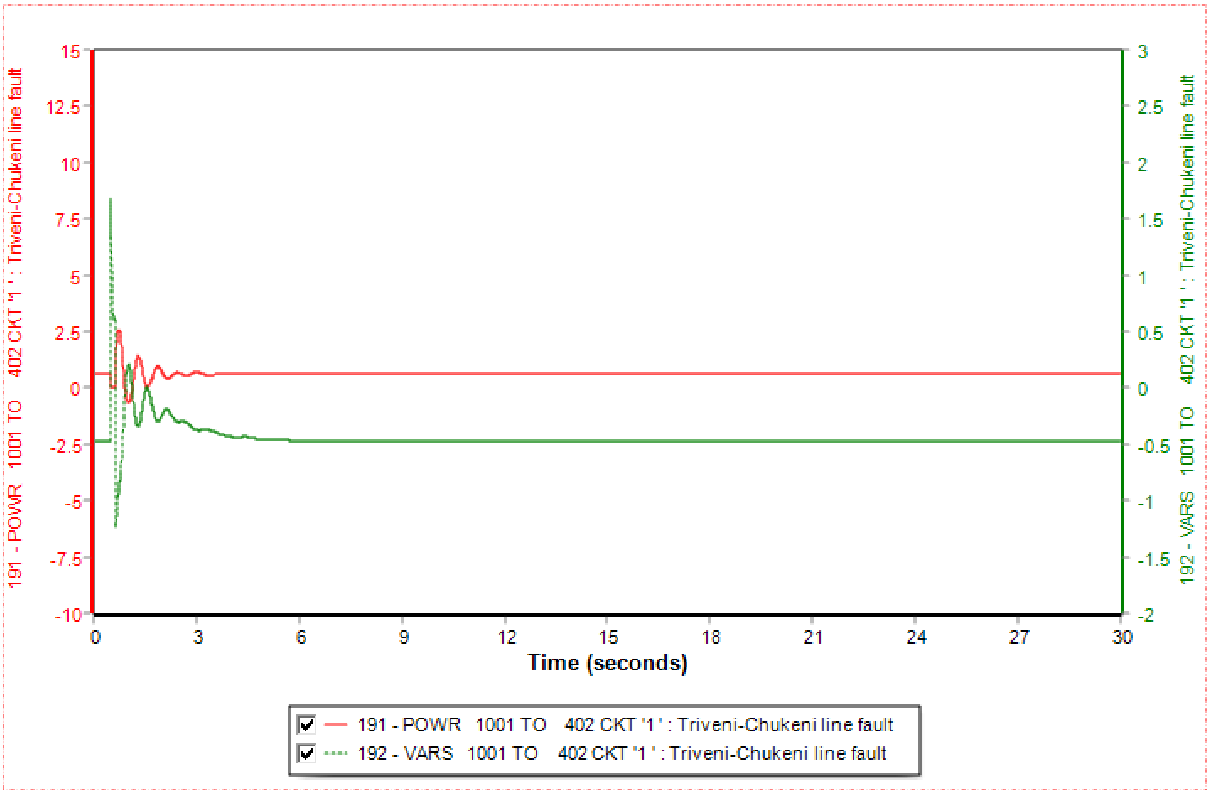


Figure 3-25 Power flow through Tinke Badh to Jumla Case 1

Figure 3-26 depicts the frequency deviation of the 11 kV Jumla bus during the event. It is evident that the system frequency has oscillatory nature. As Jumla is connected to national grid with very long 33 kV transmission line and western part of INPS has very few hydropowers under operation or that will be online by next two years, the system inertia is relatively small to damp the oscillations quickly. However, the frequency is within the tolerable limit and addition of hydropowers will improve the system damping. Furthermore, the ELC must have quick response to this event and stabilize the frequency. It will be within the range as specified in the Grid code of NEA thus stable if the fault is cleared within the specified time.

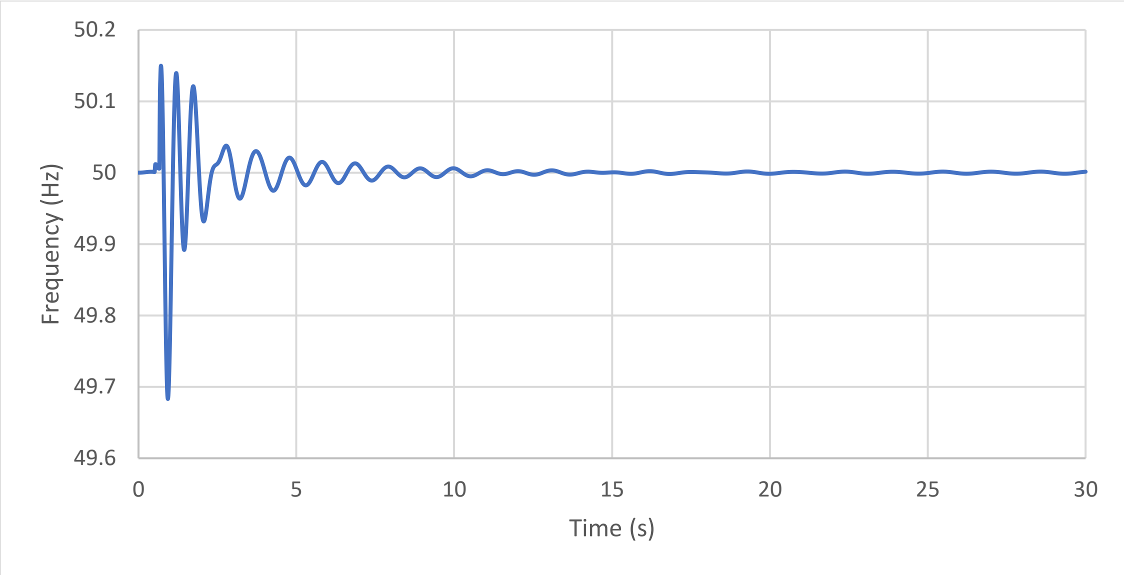


Figure 3-26 Frequency deviation of Jumla 11 kV bus in Hz for case 1

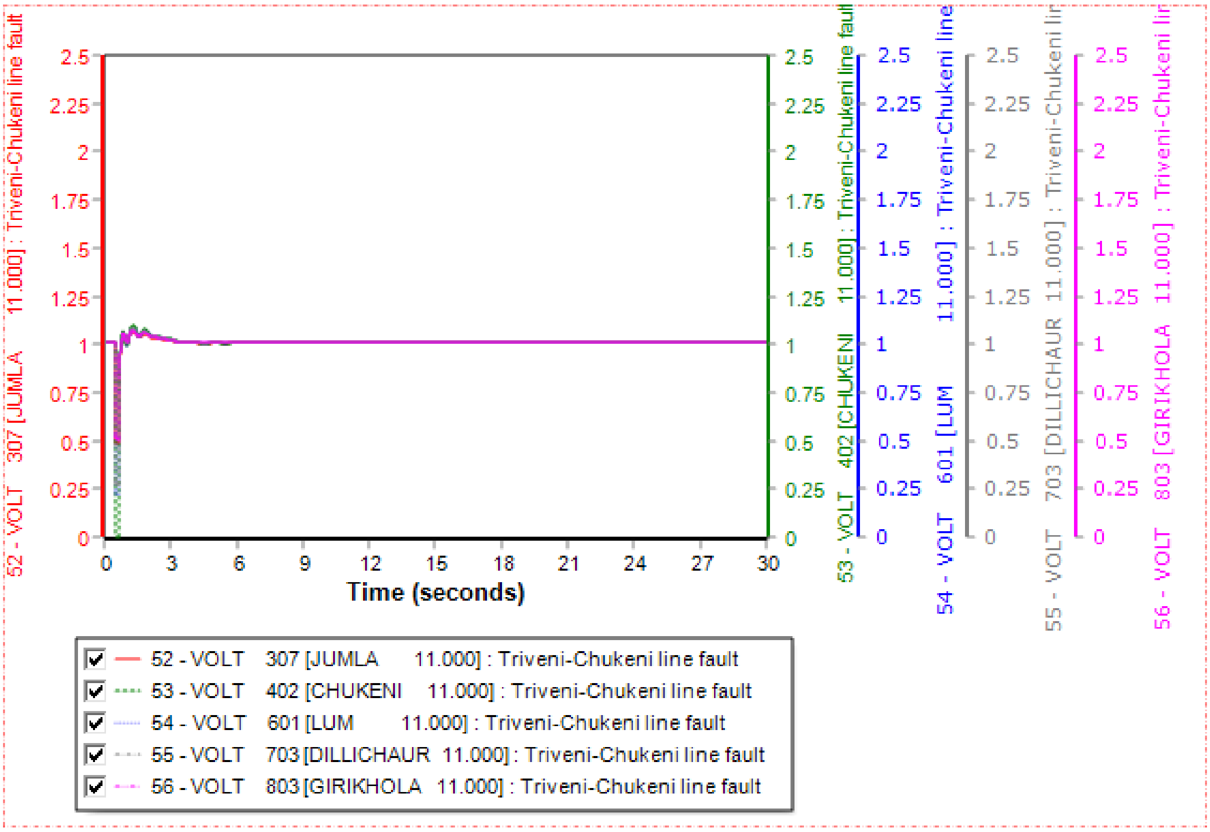


Figure 3-27 Bus Voltage of different 11 kV bus in p.u for Case 1

Figure 3-27 shows that during the three-phase line fault, the bus voltages will be within the tolerable limit of 1.1 p.u.

Figure 3-28 shows that the rotor angle deviation relative to Chukeni MHP of the different MHPs stabilizes after certain time after the fault has been cleared. This implies the generator will be stable during the three-phase line fault.

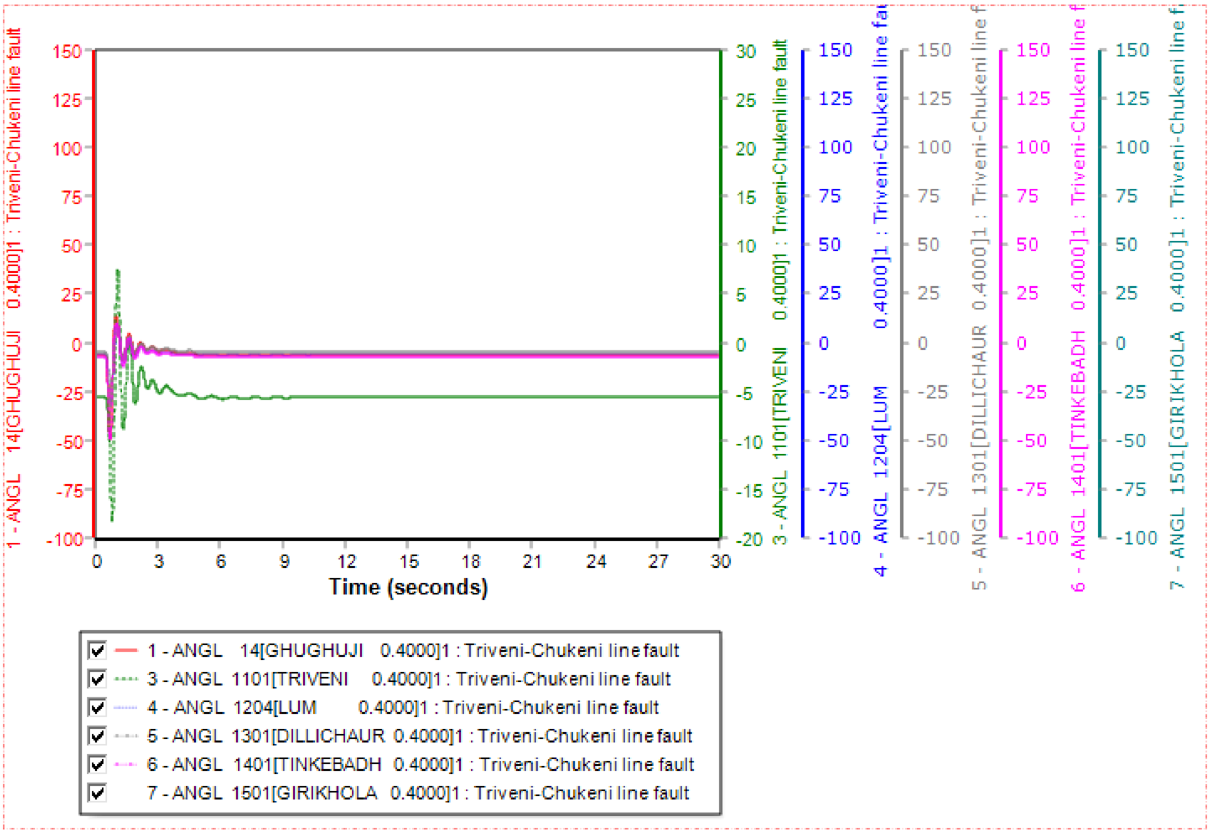


Figure 3-28 Rotor angle of different MHPS for Case 1

3.3.9 Case 2 Three Phase fault on 0.4 kV Chukeni Bus

Three-phase fault has been applied at generating bus of Chukeni MHP and cleared within 150 m.s. During the normal flow condition, it generated rated 998 kW which drops down to zero after the application of the three-phase fault. The flow resumes to original condition after the removal of fault followed by some transient oscillations as shown in Figure 3-29.

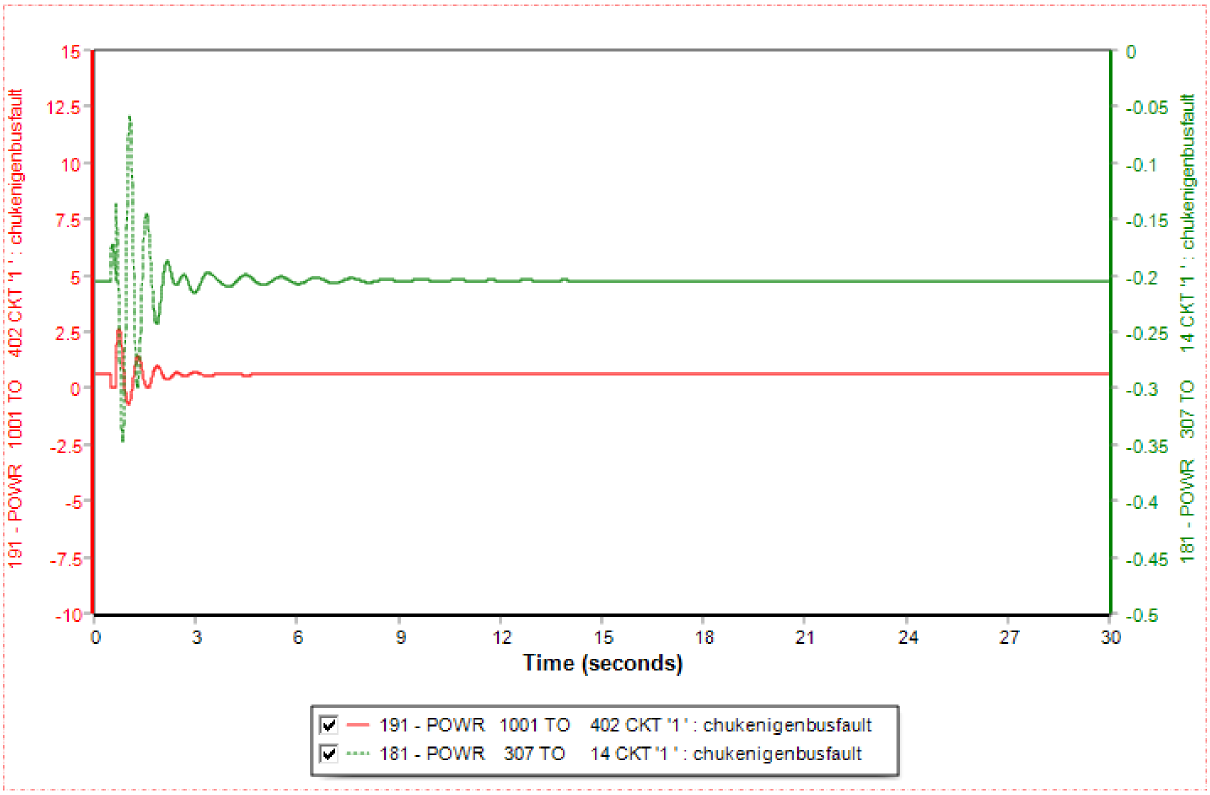


Figure 3-29 Power flow from Chukeni to Triveni Case 2

Figure 3-30 depicts the frequency deviation of the 11kV Jumla bus during the event. It is evident that the system frequency will be within the range as specified in the Grid code of NEA but oscillatory.

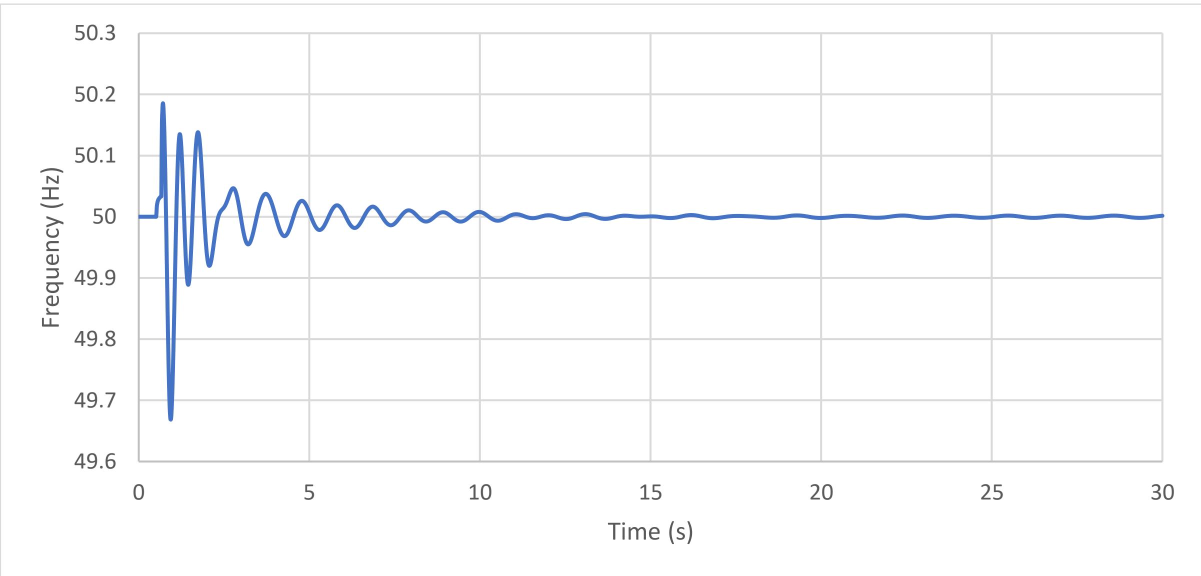


Figure 3-30: Frequency deviation of Jumla 11kV bus in Hz for case 2

Figure 3-31 shows the bus voltages during the three-phase bus fault will be within the tolerable limit of 1.1 p. u and stable.

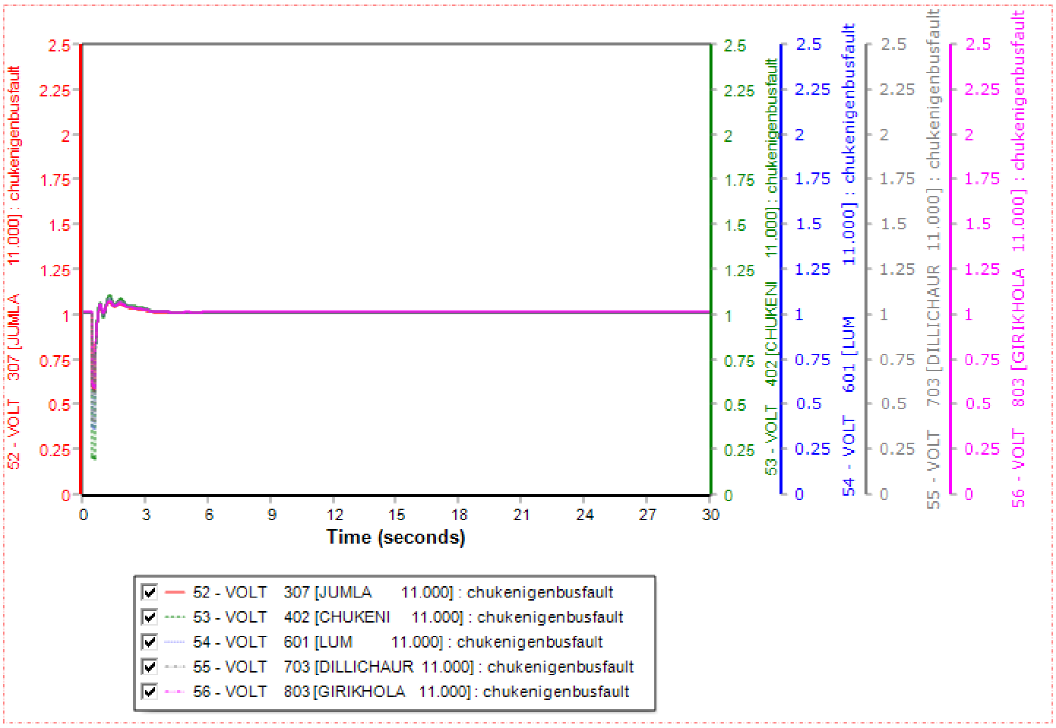


Figure 3-31 Bus Voltage of different 11 kV bus in p.u for Case 2

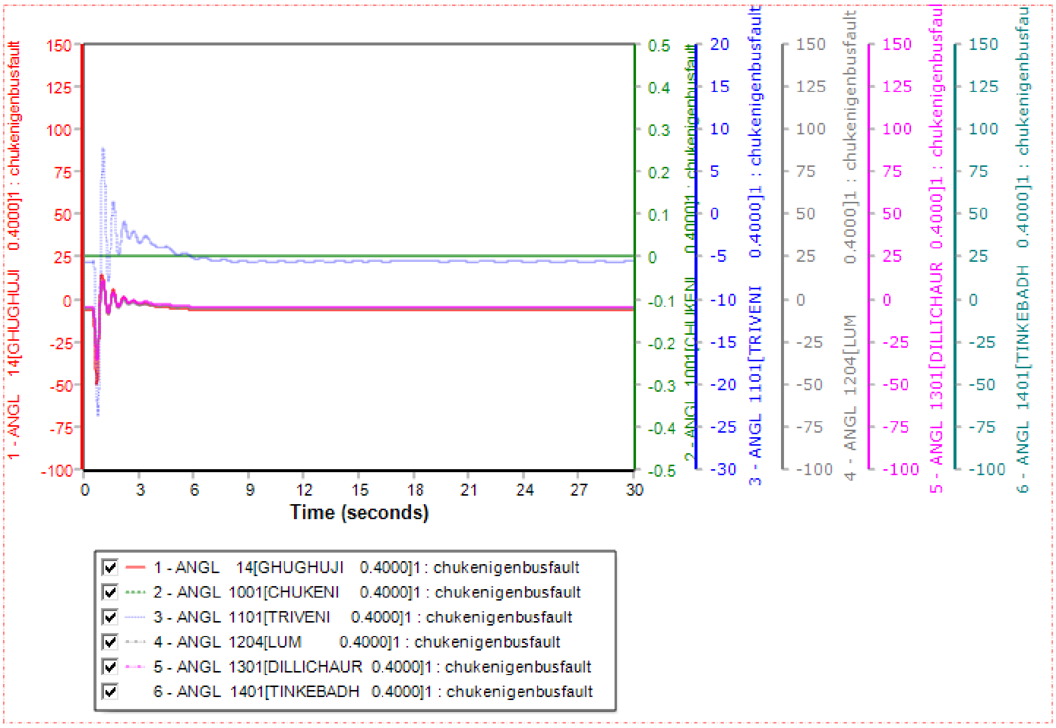


Figure 3-32 Rotor angle of different MHPS for Case 2

Figure 3-32 shows that the rotor angle deviation of different MHPs relative to Chukeni MHP, stabilizes after the fault has been cleared. This implies the generators will be stable during the three-phase line fault.

3.3.10 Case 3: Tripping of Chukeni without reclose

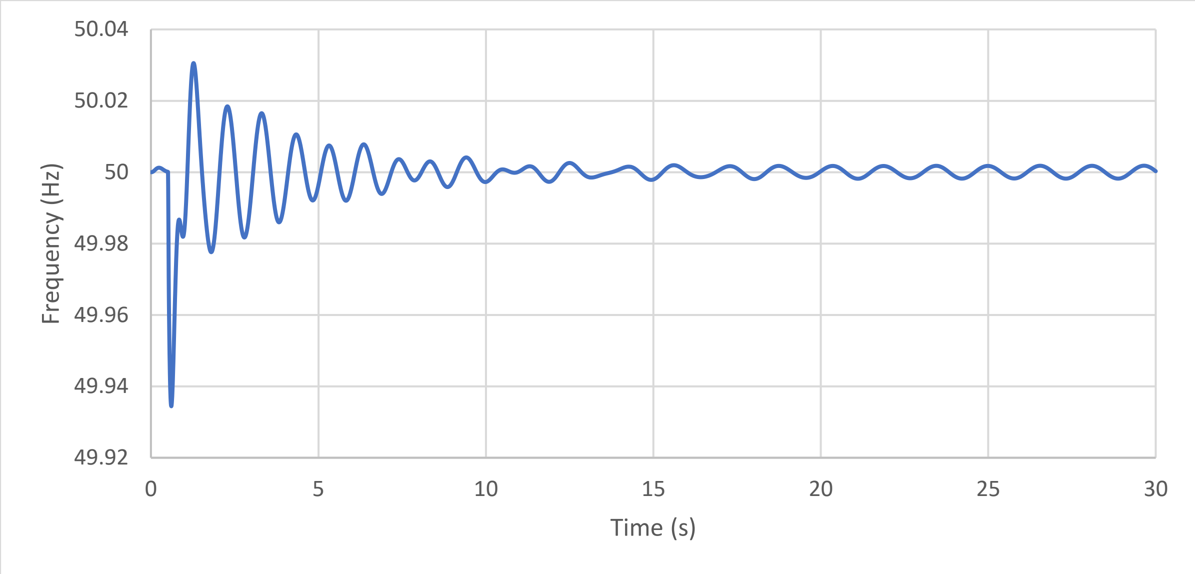


Figure 3-33 Frequency of 11 kV Jumla bus for Case 4

Figure 3-33 depicts the frequency deviation of the 11kV Jumla bus during the event. It is evident that the system frequency will be stable, and thus no-load curtailment is required to maintain the stability of the system. The deficit power is fed by the national grid as shown in Figure 3-34.

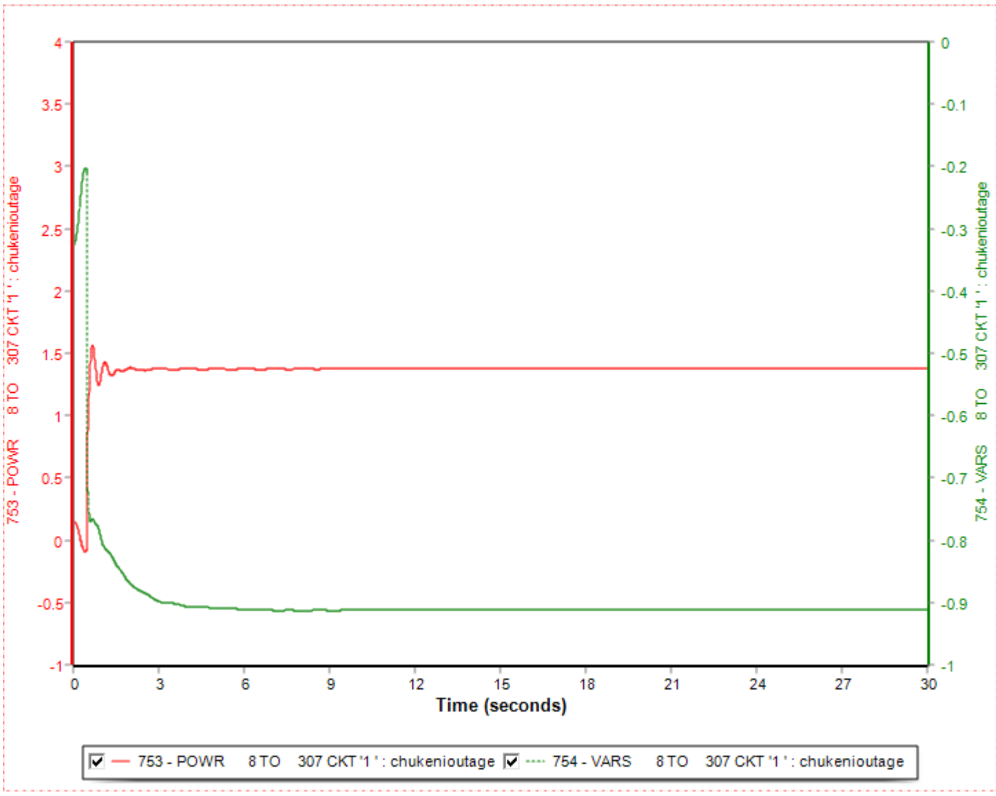


Figure 3-34 Power fed by national grid for case 3

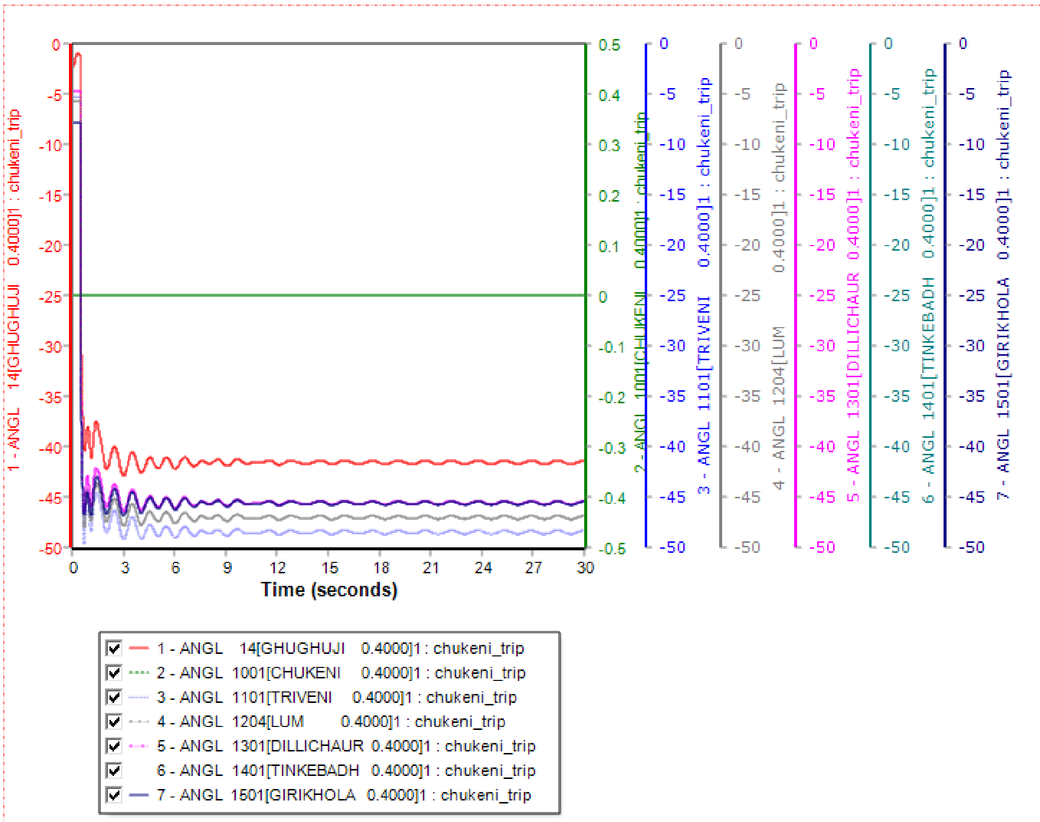


Figure 3-35 Rotor angle deviation of different MHP for case 3

3.3.11Case 4: Three Phase fault on 11 kV Jumla Bus

Figure 3-36 depicts the frequency deviation of the 11kV Jumla bus during the event. It is evident that the system frequency will be within the range as specified in the Grid code of NEA and thus stable.

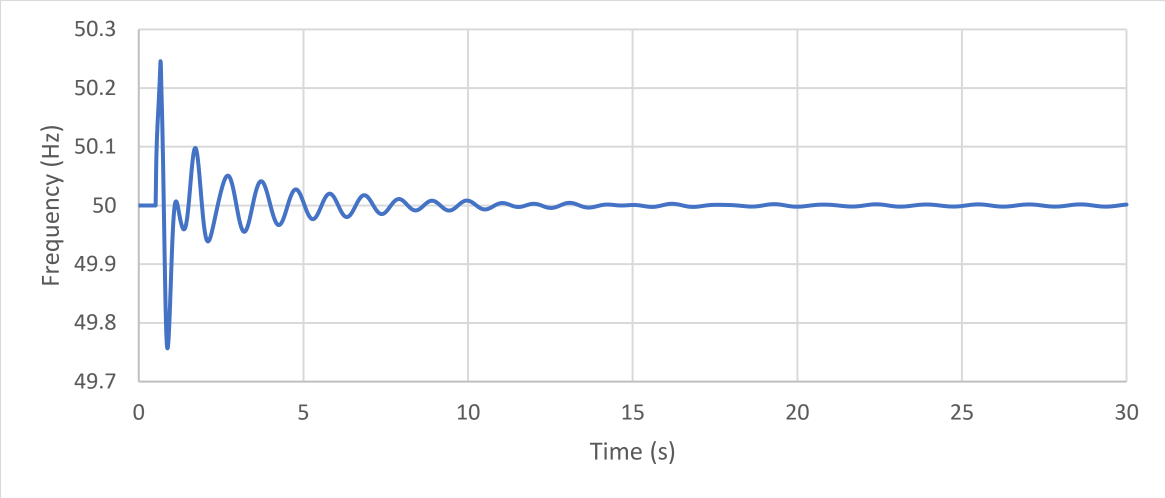


Figure 3-36 Frequency deviation of Jumla 11kV bus in Hz for case 4

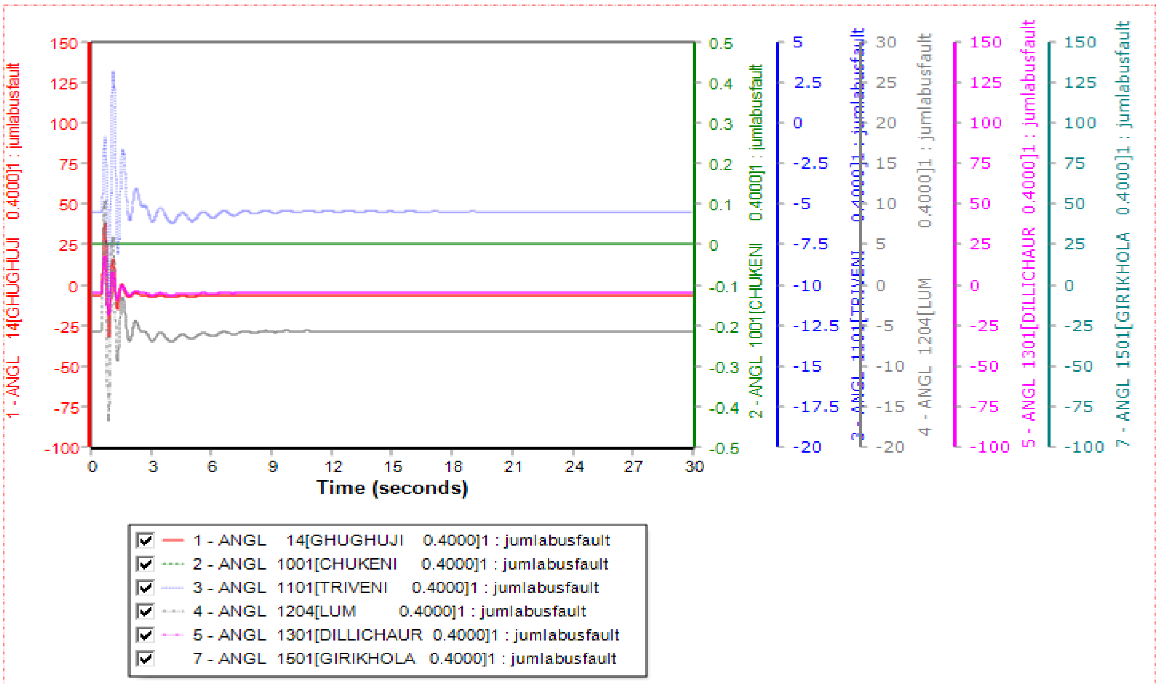


Figure 3-37 Rotor Angle deviation relative to Chukeni for Case 4

Figure 3-37 shows that the rotor angle deviation relative to Chukeni MHP of the different MHPs stabilizes after certain time after the fault has been cleared. This implies the generator will be stable during the three-phase line fault.

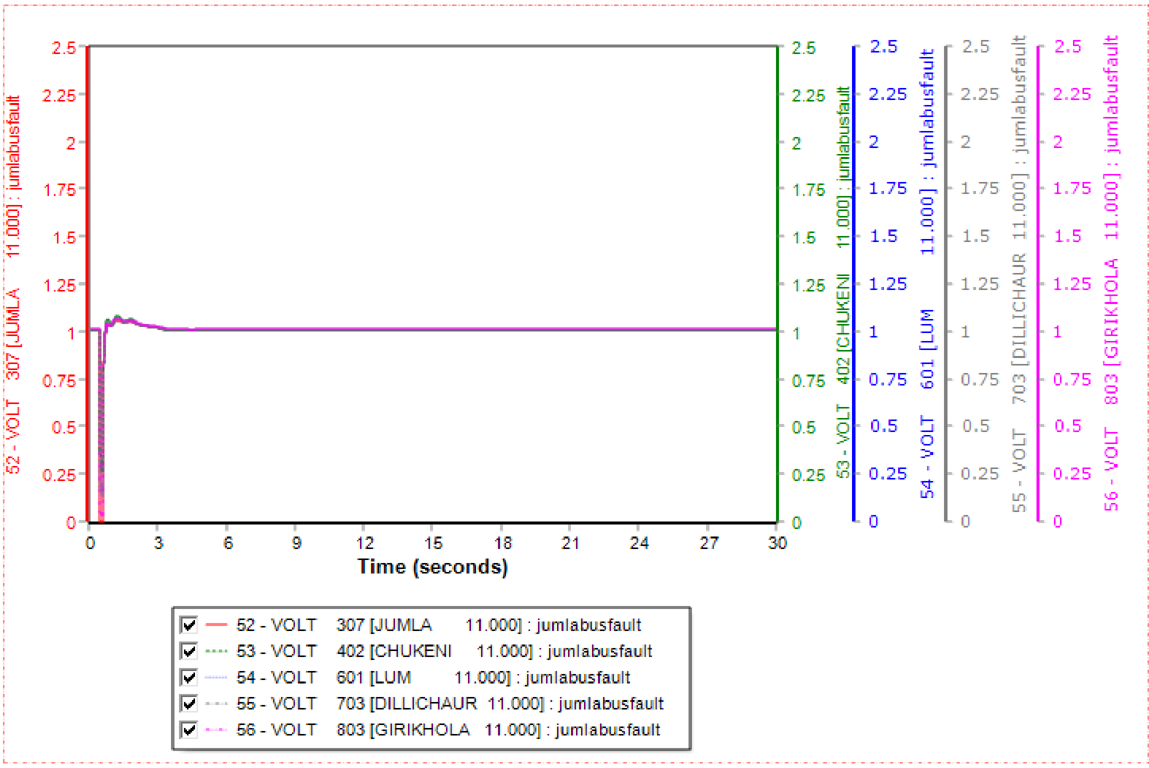


Figure 3-38 Bus Voltage of different 11 kV buses

Figure 3-38 shows the bus voltages during the three-phase bus fault will be within the tolerable limit of 1.1 p. u and stable.

3.3.12 Case 5: Tripping of Ghughuti without reclose

Figure 3-40 depicts the frequency deviation of the 11kV Jumla bus during the event. It is evident that the system frequency will be oscillatory but within the tolerable limit as per the grid code.

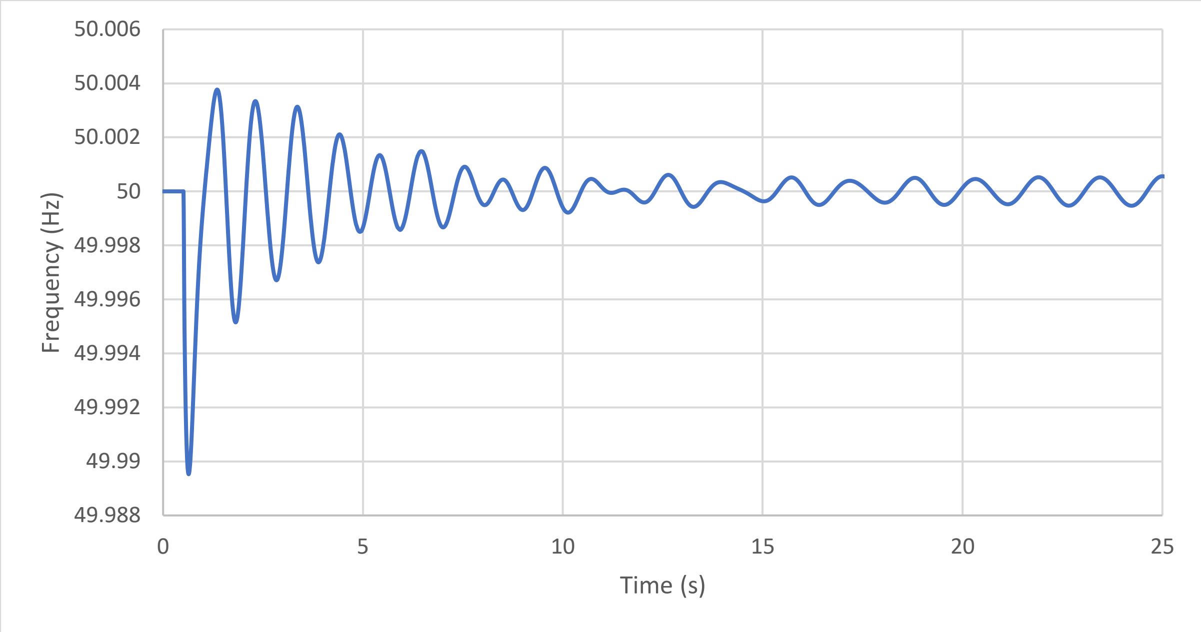


Figure 3-40 Frequency of 11 kV Jumla bus for Case 5

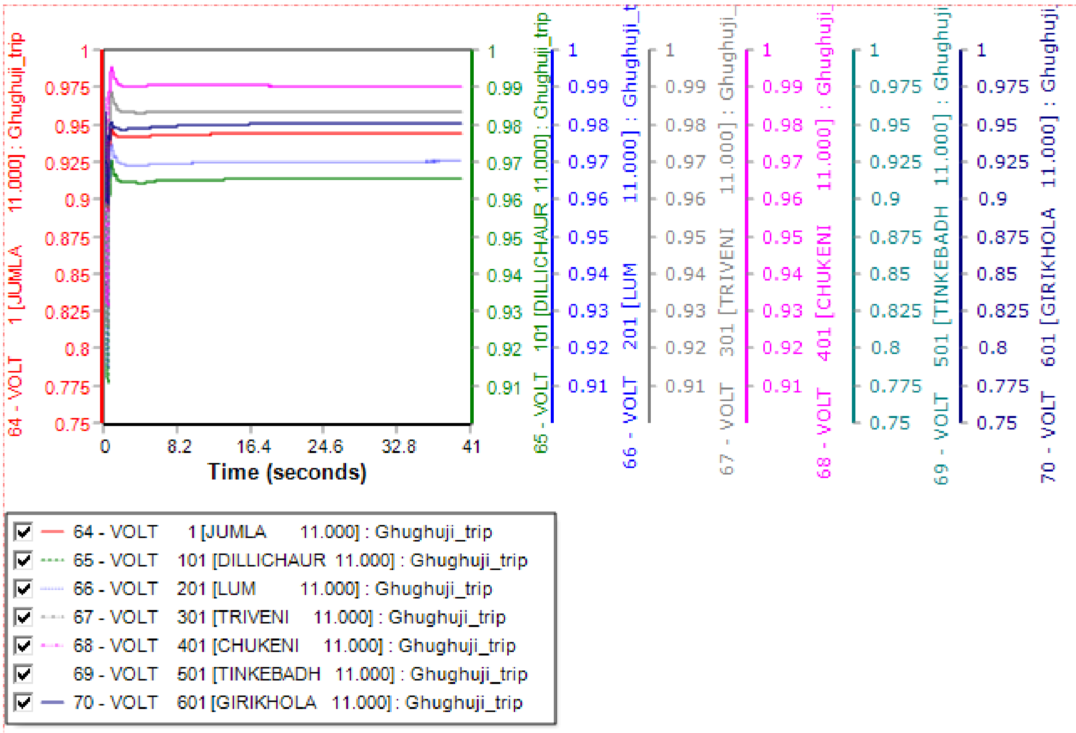


Figure 3-39 Voltages of different 11 kV bus in p.u for Case 5

Figure 3-39 depicts voltages of different 11 kV bus during the event. It shows that the bus voltage will remain 0.95 p. u for all the buses which is acceptable as per the Grid Code of Nepal.

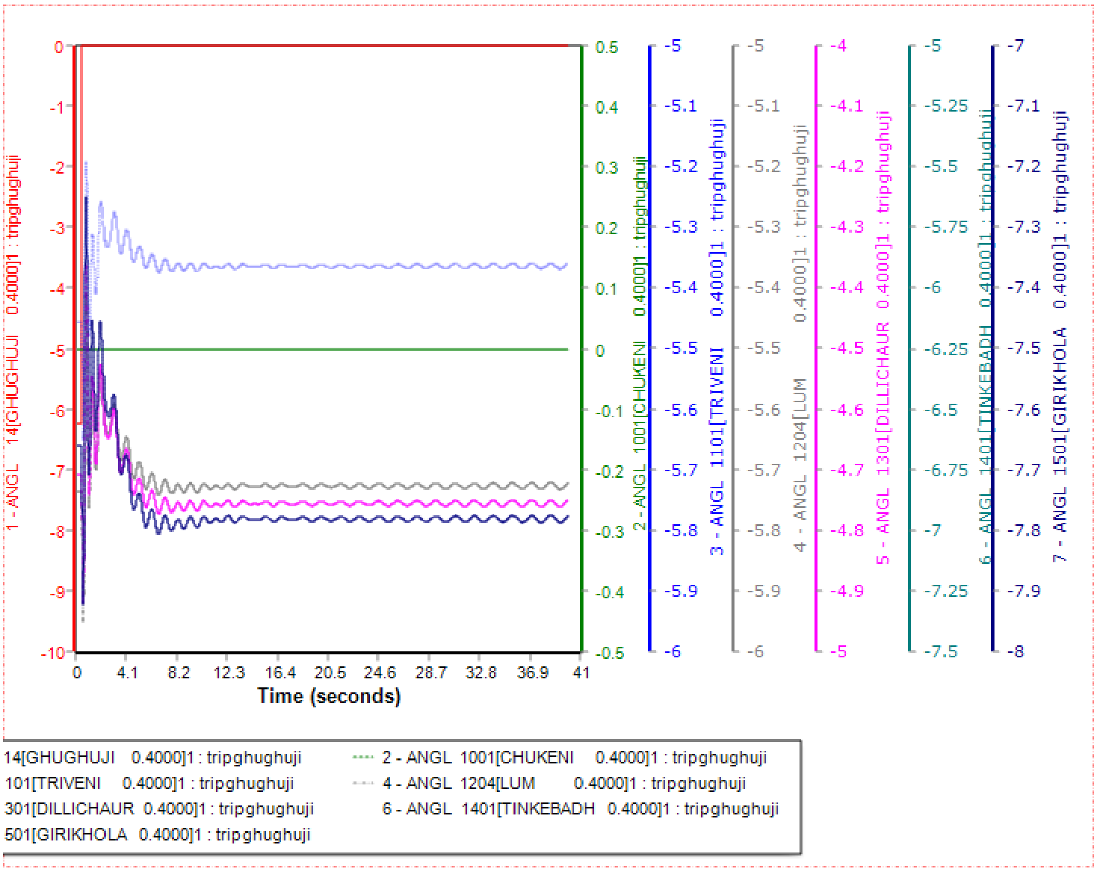


Figure 3-41 Rotor Angle Deviation for Case 5

Figure 3-41 shows that the rotor angle deviation relative to Chukeni MHP of the different MHPs stabilizes after certain time after the fault has been cleared. This implies the generator will be stable during the three-phase line fault.

4 Simulation Analysis of the Mini Grid System for Option 2

4.1 Isolated Mini grid

For this scenario, the peak generation of the Mini grid in insufficient to meet the peak demand of Jumla Bazar, thus the Mini grid must operate at reduced load. The peak installed capacity sums up to 600 kW so the peak load must be reduced to meet generation and maintain bus voltages within the tolerable limit. The decrease in amount of water flow in river further increases the curtailment of loads in Jumla bazar during dry season as well. During peak period of wet season, Mini grid can serve load of around 460 kW while during the dry season, the MHPs are barely capable of meeting the local demand, thus it has no excess energy to supply to Jumla Mini grid. However, it does not mean total curtailment of loads in Jumla Bazar because Jugad Khola and Ghughuti are supplying loads in Jumla Bazar with partial contribution of Thinke Badh.

Consultant has performed the load flow analysis and transient analysis for this option with similar assumptions as of Option 1.

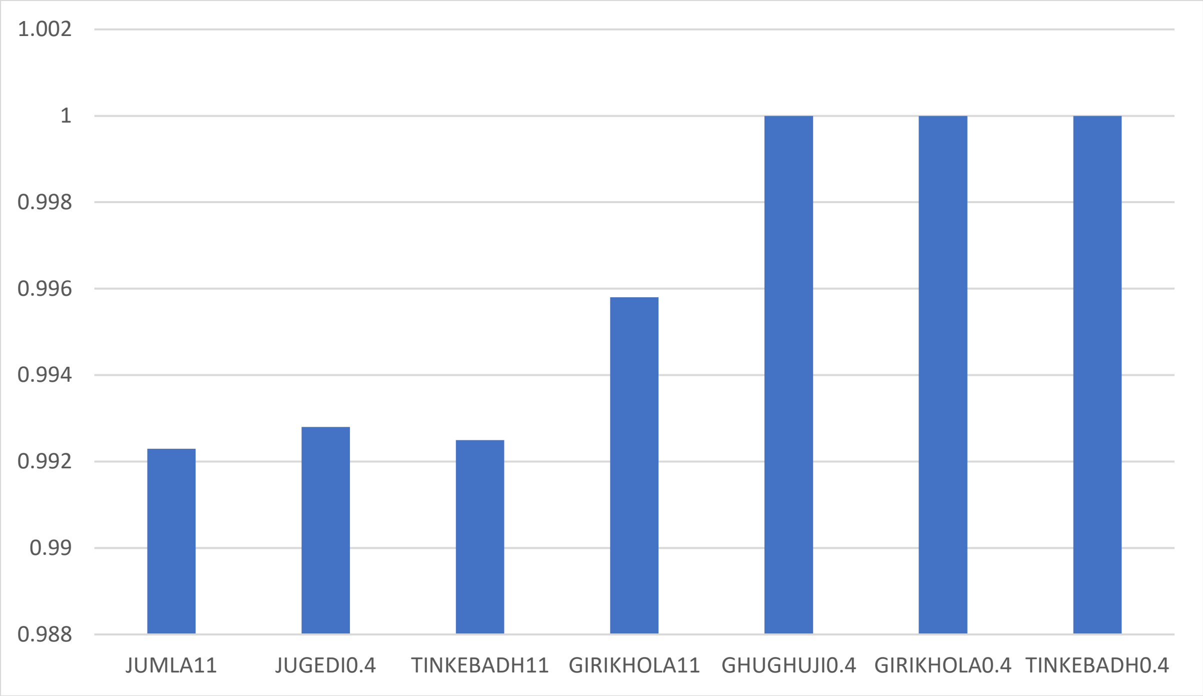


Figure 4-1 Bus voltage in p.u during wet peak period

4.1.1 Transient Analysis

4.1.1.1 Case 1: Three Phase Fault on the line from Giri Khola to Jumla

The system shall be able to survive a permanent three phase to ground fault on a 11 kV line close to the bus to be cleared in 150 m.s. For this case, three-phase fault has been applied to transmission line circuit from Giri Khola to Jumla.

During the normal flow condition each circuit carries 40 which drops down to 4 kW in reverse direction after the application of the three-phase fault. The flow resumes to original condition after the removal of fault followed by some transient oscillations as shown in Figure 4-2.

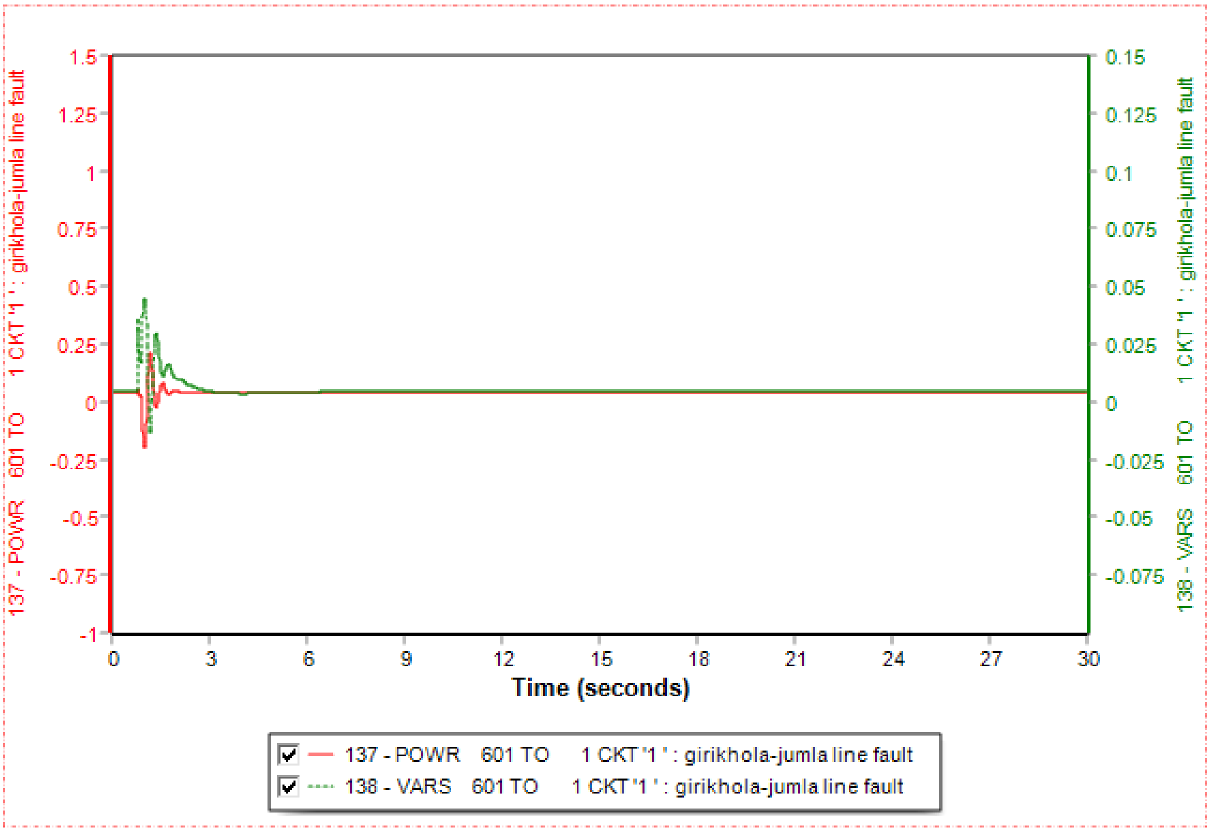


Figure 4-2 Power flow through Tinke Badh to Jumla Case 1 Option 2

Figure 4-16 depicts the frequency deviation of the 11 kV Jumla bus during the event. It is evident that the system frequency will be overshoot beyond the tolerable limit for fraction of a second but will later settle to nominal value if the fault is cleared within the specified time. The overshoot is due to the lower values of Inertia constant of generators.

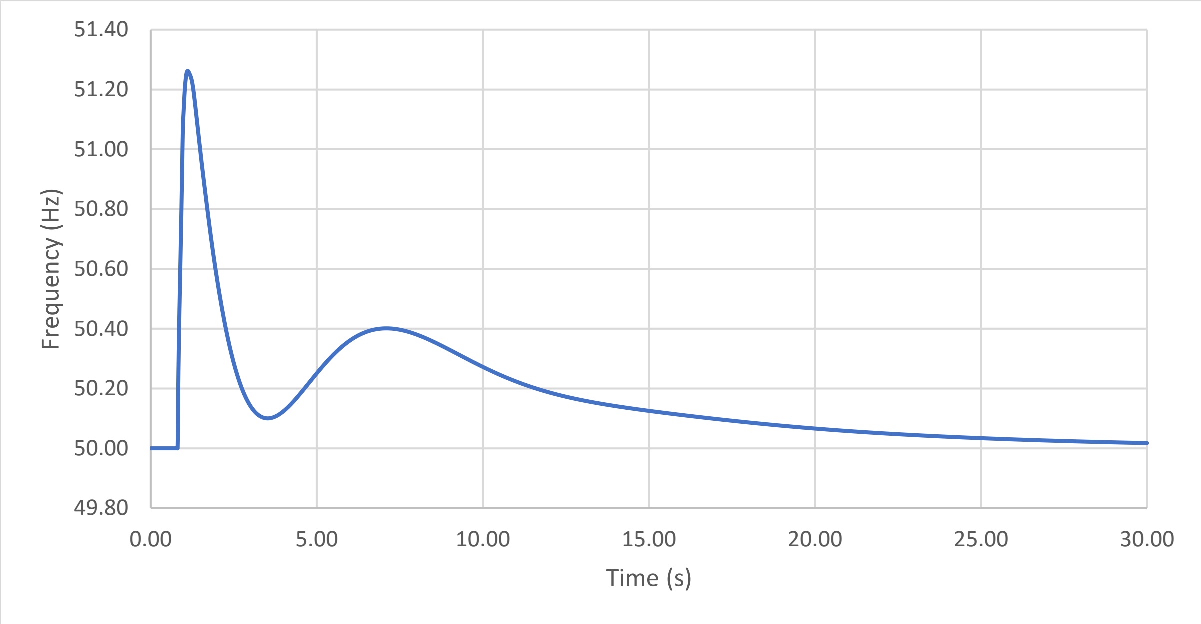


Figure 4-3 Frequency deviation of Jumla in Hz for Case 1 Option 2

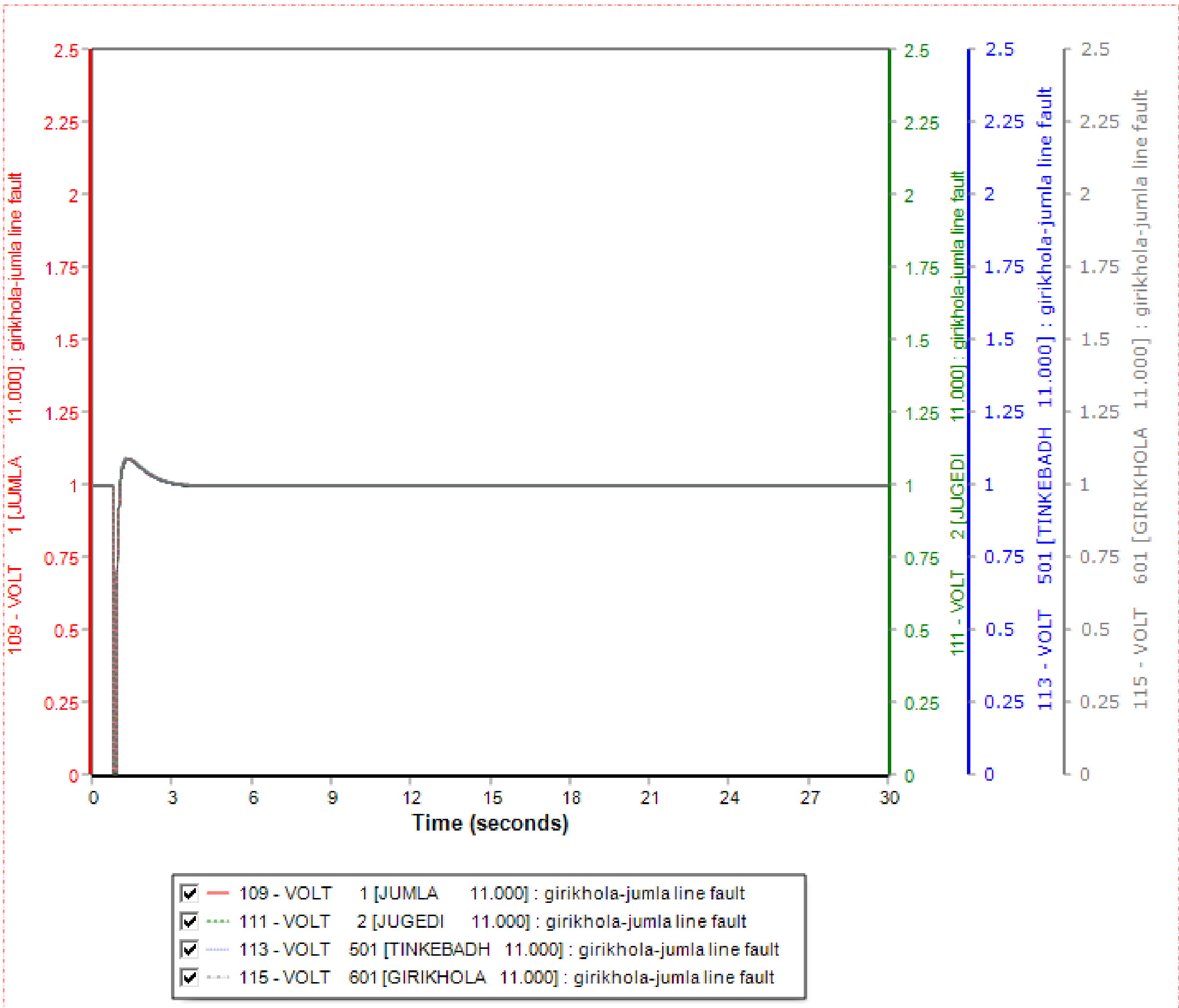


Figure 4-4 Bus Voltage of different 11 kV bus in p.u for Case 1 Option 2

Figure 4-17 shows that during the three-phase line fault, the bus voltages will be within the tolerable limit of 1.1 p.u.

Figure 4-5 shows that the rotor angle deviation relative to Ghughuti MHP stabilizes after certain time after the fault has been cleared. This implies the generator will be stable during the three-phase line fault.

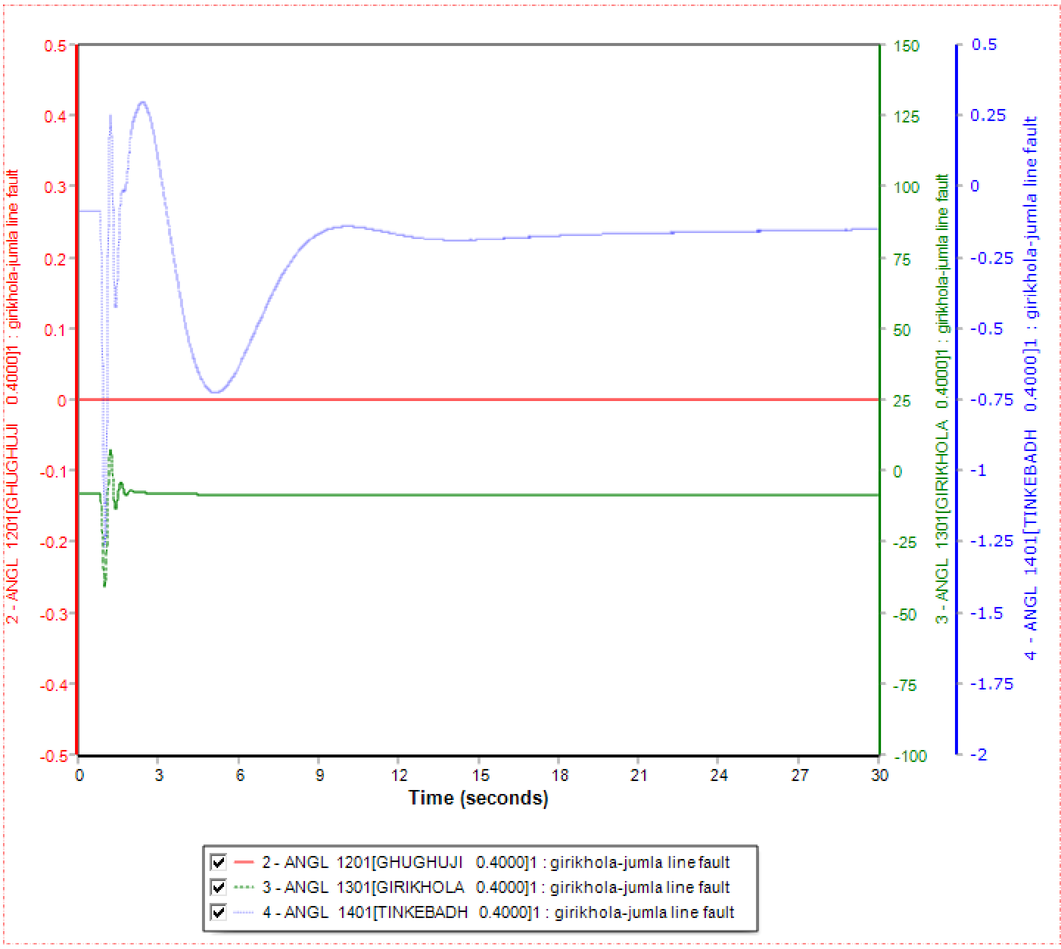


Figure 4-5 Rotor angle of different MHPS for Case 1 Option 2

4.1.1.2 Case 2 Three Phase fault on 0.4 kV Giri Khola Bus

During the normal flow condition circuit carries 40kW which drops down to 0 kW after the application of the three-phase fault. The flow resumes to original condition after the removal of fault followed by some transient oscillations as shown in Figure 4-6.

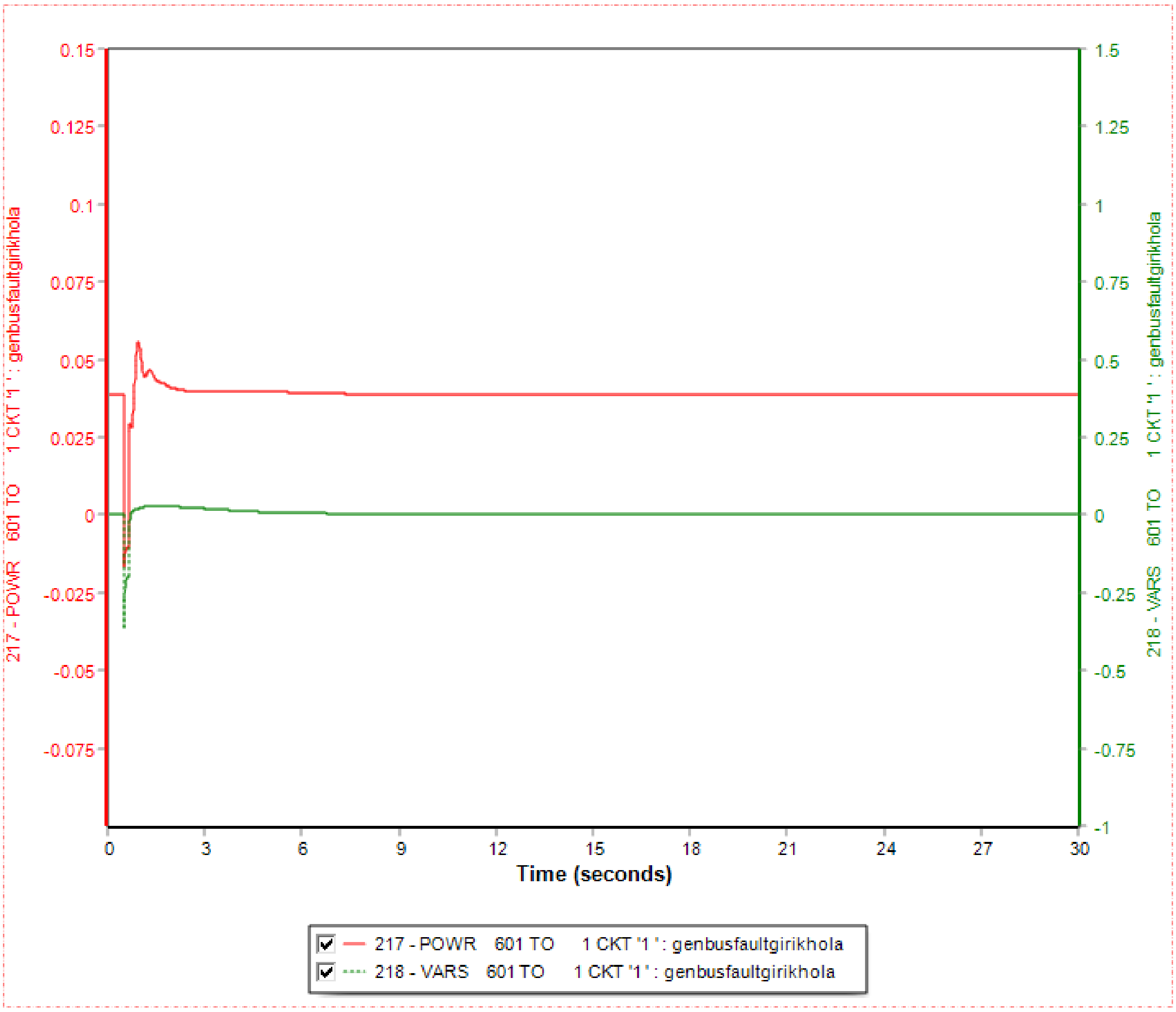


Figure 4-6 Power flow from Giri Khola to Jumla Case 2 Option 2

Figure 4-7 depicts the frequency deviation of the 11kV Jumla bus during the event. It is evident that the system frequency will overshoot but will settle to nominal value and thus stable.

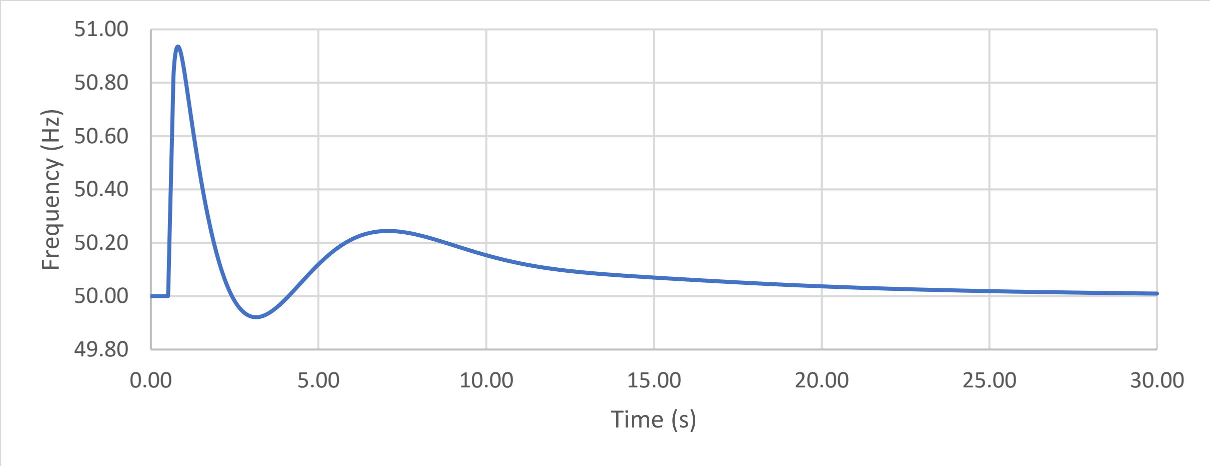


Figure 4-7: Frequency deviation of Jumla 11kV bus in Hz for Case 2 Option 2

Figure 4-8 shows the bus voltages during the three-phase bus fault will be within the tolerable limit of 1.1 p. u and stable.

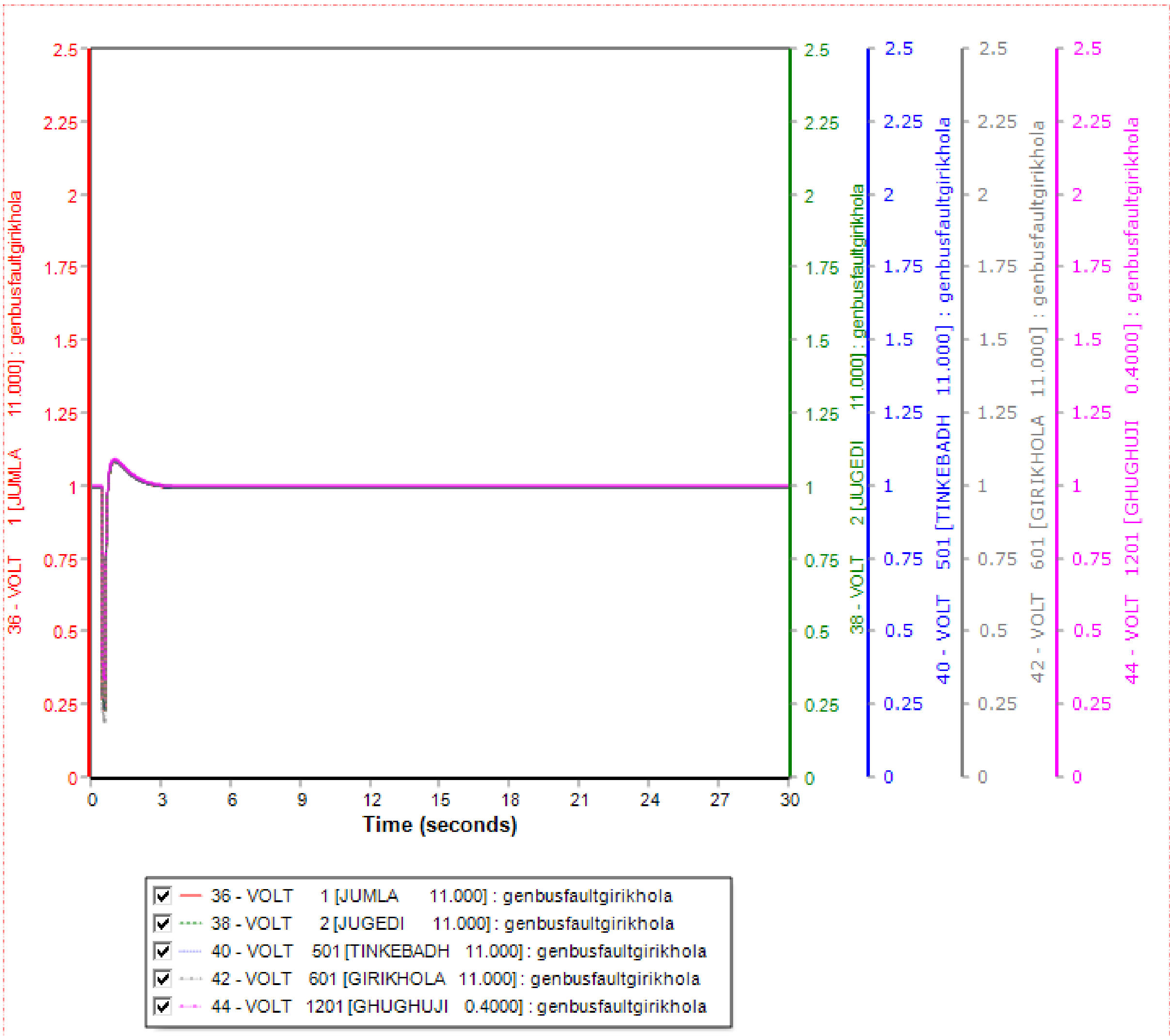


Figure 4-8 Bus Voltage of different 11 kV bus in p.u for Case 2 Option 2

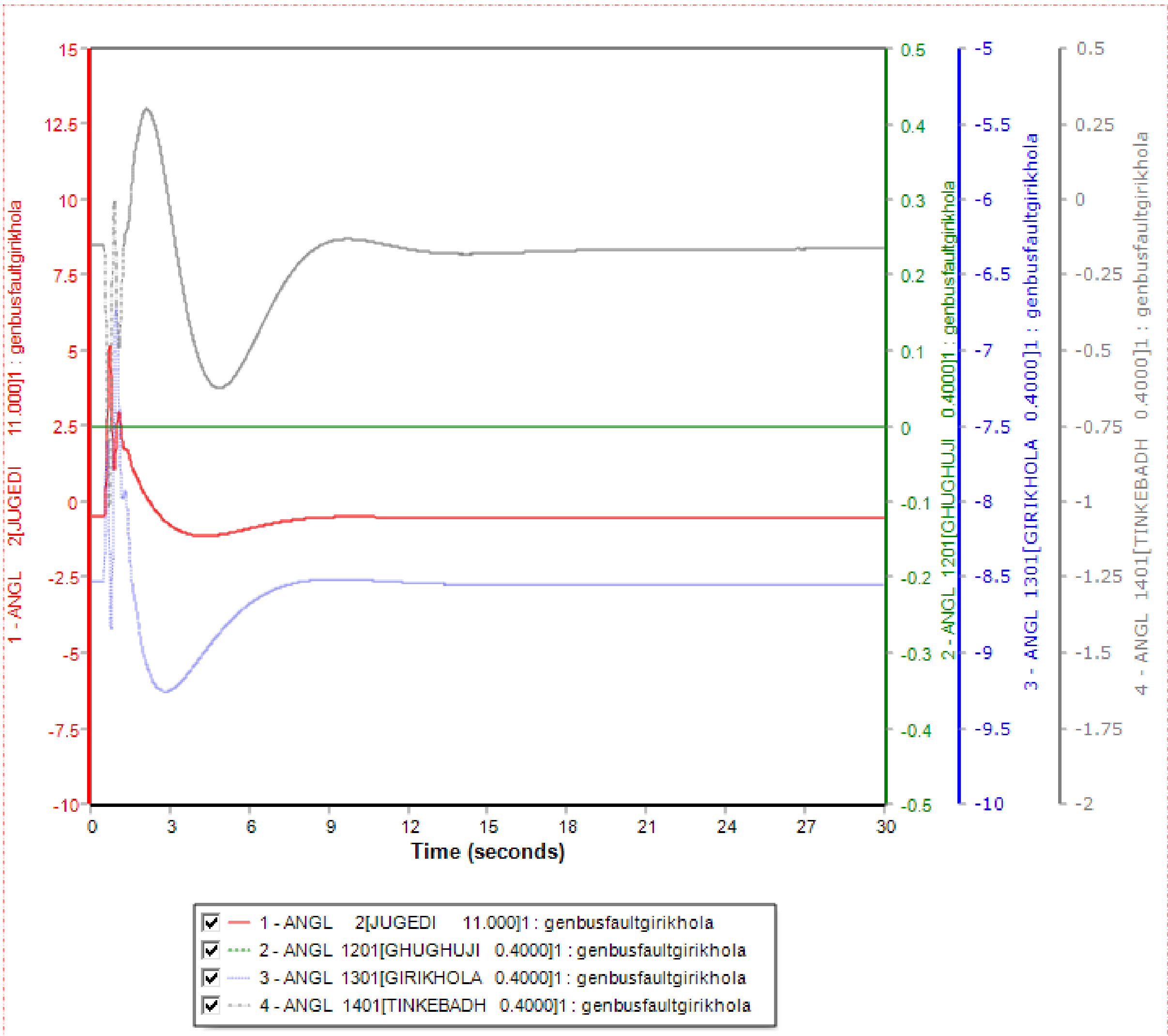


Figure 4-9 Rotor angle of different MHPS for Case 2 Option 2

Figure 4-9 shows that the rotor angle deviation relative to Ghughuti MHP of the different MHPs stabilizes after certain time after the fault has been cleared. This implies the generator will be stable during the three-phase line fault.

4.1.1.3 Case 3: Three Phase fault on 11 kV Jumla Bus

During the normal flow condition circuit from Thinke Badh to Jumla carries 30 kW which drops down to zero after the application of the three-phase fault. The flow resumes to original condition after the removal of fault followed by some transient oscillations as shown in Figure 4-10.

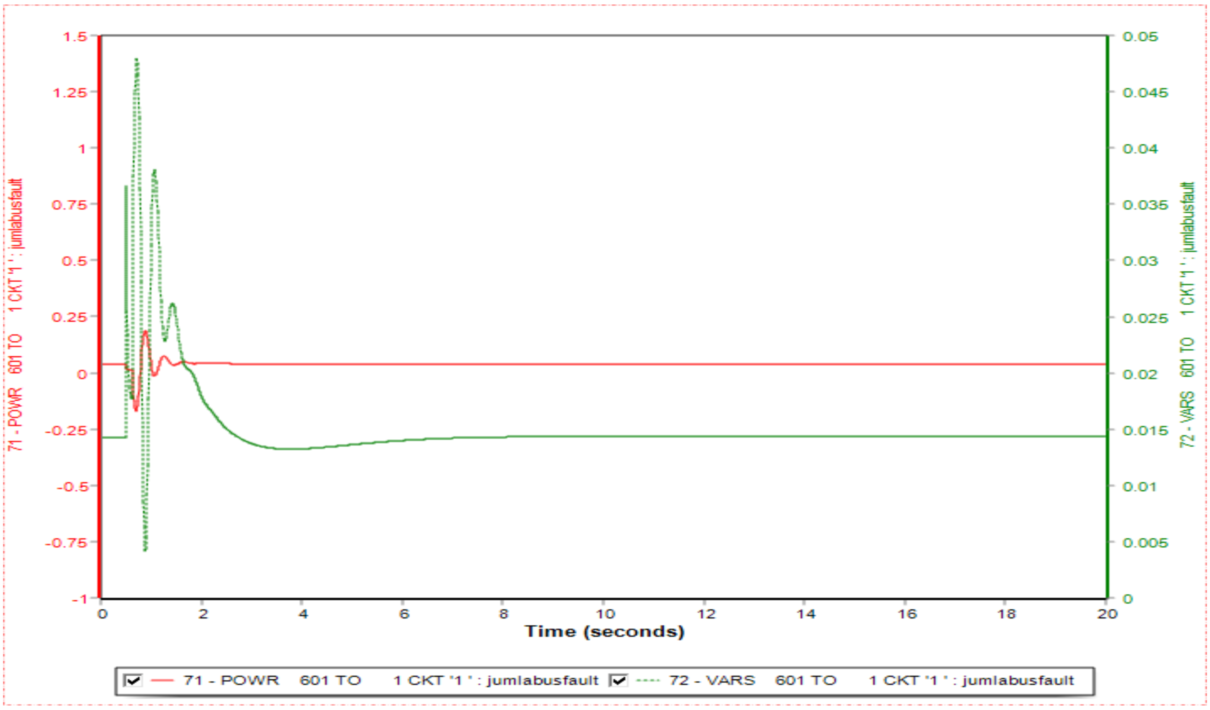


Figure 4-10 Power flow through Giri Khola to Jumla Case 3 Option 2

Figure 4-11depicts the frequency deviation of the 11kV Jumla bus during the event. It is evident that the system frequency will be within the range as specified in the Grid code of NEA and thus stable.

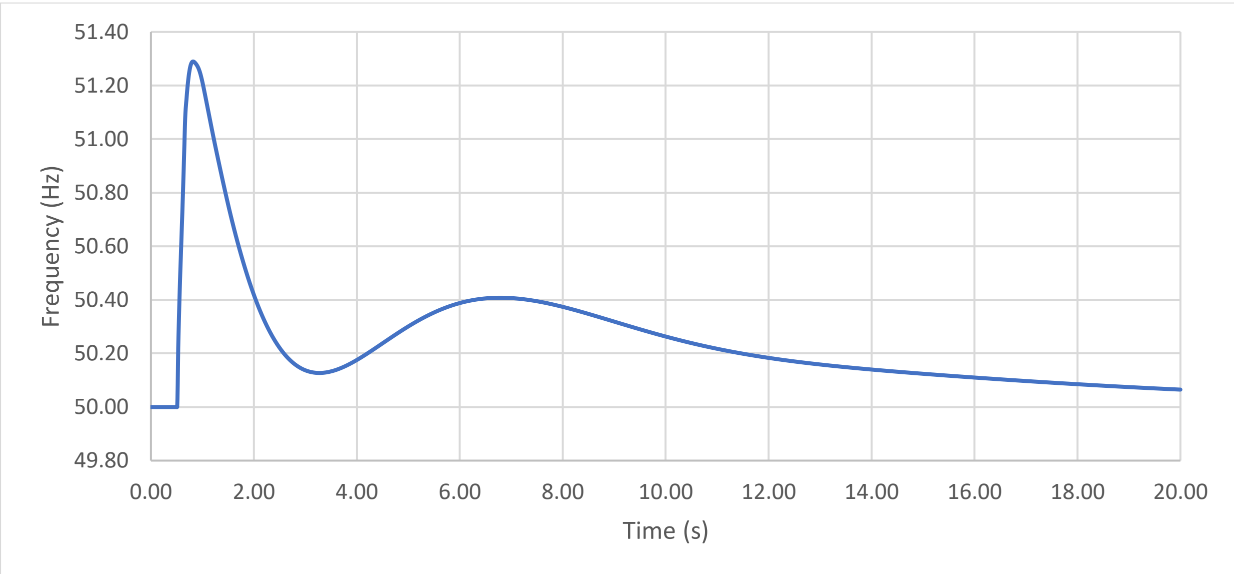


Figure 4-11 Frequency Deviation of Jumla 11 kV bus Case 3 Option 2

Figure 4-12 shows the bus voltages during the three-phase bus fault will be within the tolerable limit of 1.1 p. u and stable.

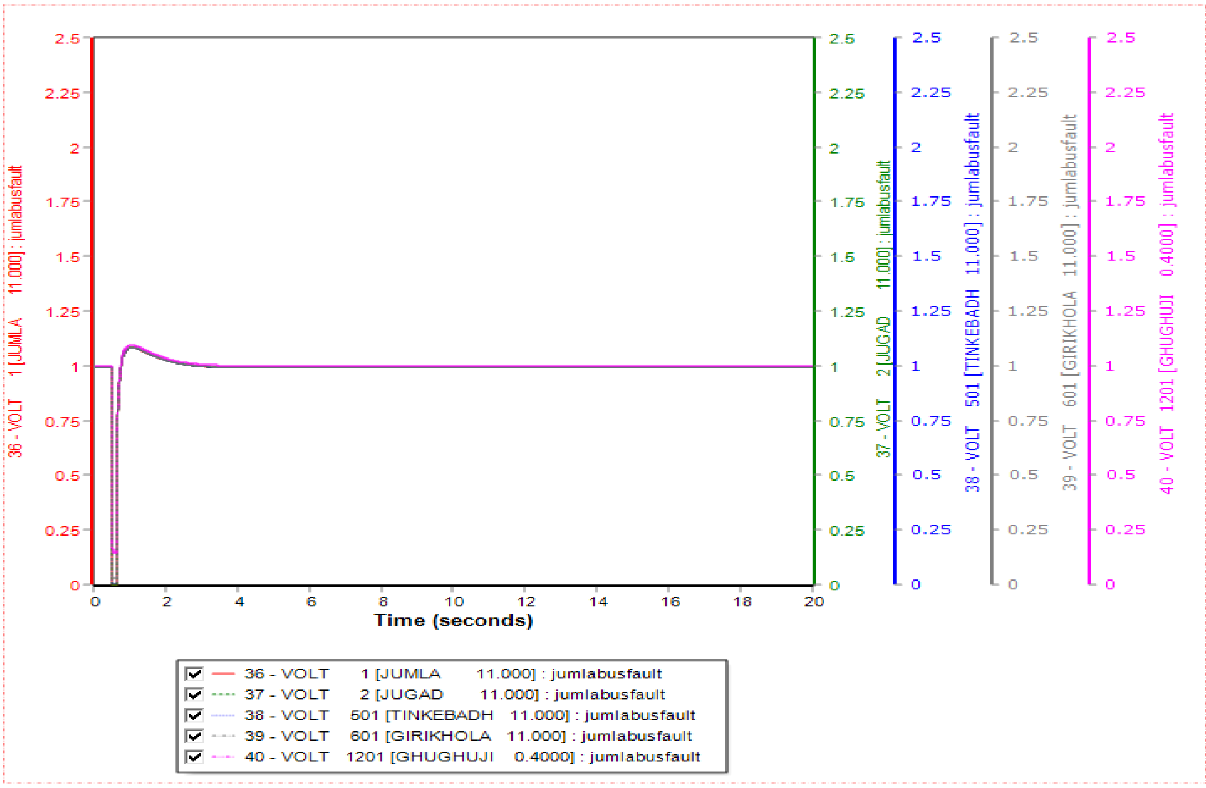


Figure 4-12 Bus Voltage of different 11 kV bus in p.u for Case 3 Option 2

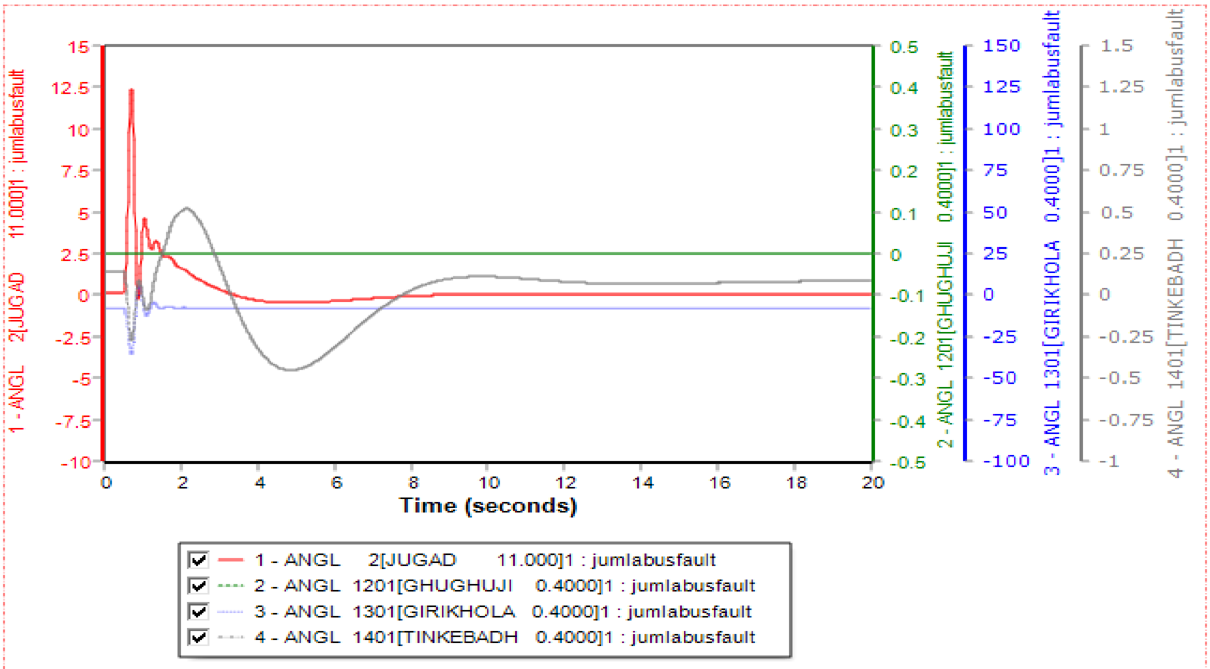


Figure 4-13 Rotor Angle Deviations of different MHPs Case 3 Option 2

Figure 4-13 shows that the rotor angle deviation relative to Ghughuti MHP of the different MHPs stabilizes after the fault has been cleared. This implies the generator will be stable during the three-phase line fault.

4.1.1.4 Case 4: Tripping of Giri Khola without reclose

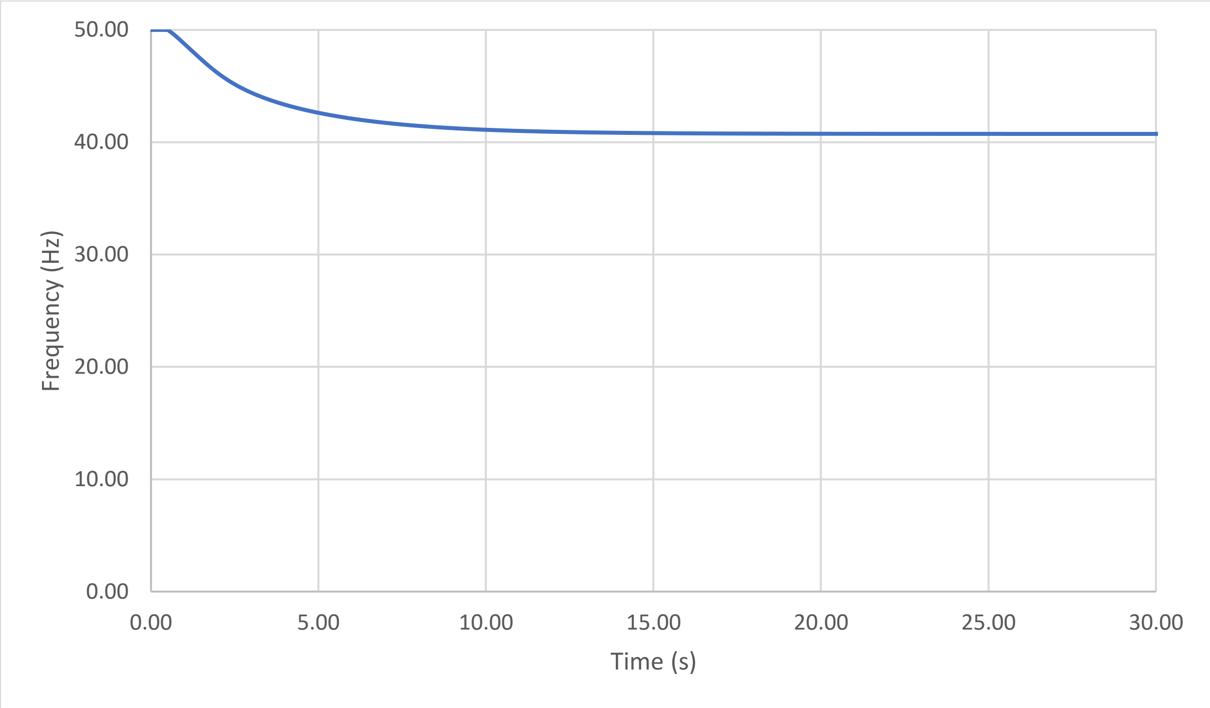


Figure 4-14 Frequency of 11 kV Jumla bus for Case 5

Figure 4-14 depicts the frequency deviation of the 11kV Jumla bus during the event. It is evident that the system frequency will be unstable, and the frequency will drop beyond the limits. This is due to Giri Khola being the largest generating unit and occupying the major share of total generation. To maintain the stability of the system, loads must be shed. Automatic load shedding relay can be installed for isolated Mini grid of Jumla.

4.2 Grid Connected Mini grid

4.2.1 Wet Peak Period

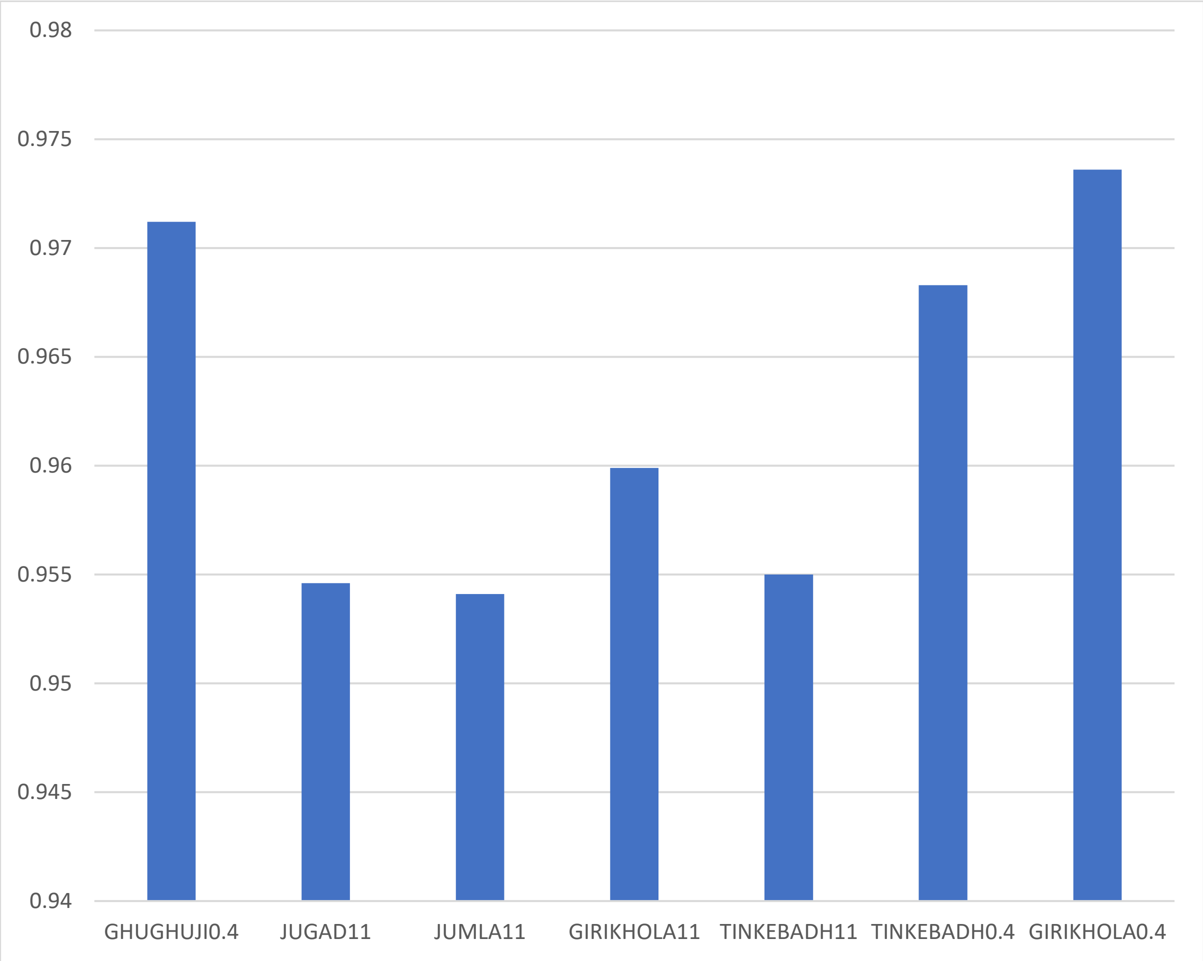


Figure 4-15 Bus voltages of different bus during grid connected wet off-peak period.

Figure 4-15 depicts that during Wet Peak period all the bus voltages will be within the limits of ± 5% of the rated voltage. Total loss during the peak period will be around 4.88 kW. As the local generation is insufficient to meet the peak demand, national grid supplies the deficit power and maintains the reliability of the power supply. During this scenario, national grid supplies 495 kW to Jumla Mini grid. The load flow report for this scenario has been attached in the Annex.

4.2.2 Wet Off Peak Period

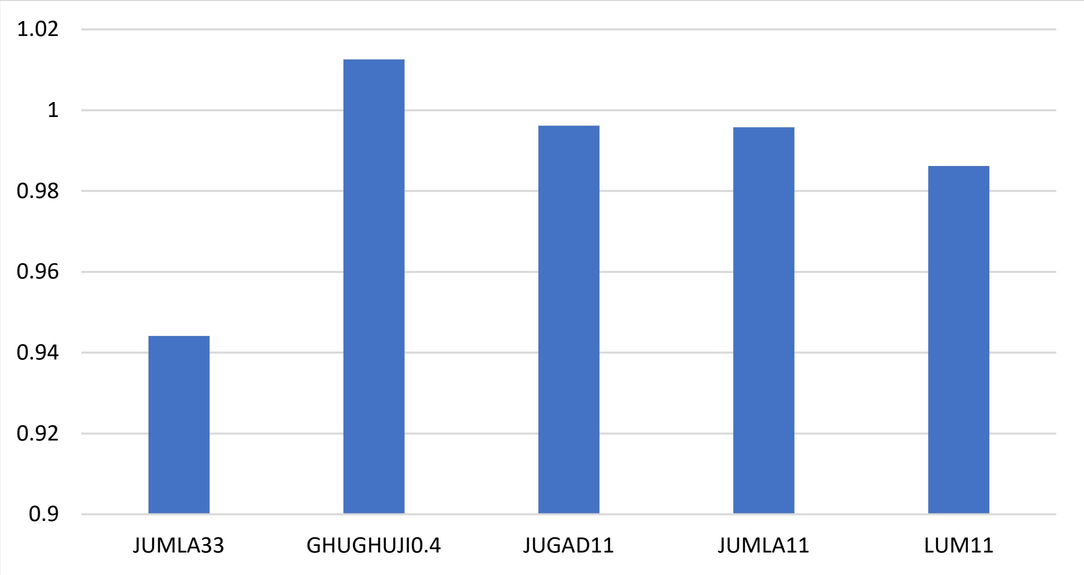


Figure 4-16 Bus voltages of different bus during grid connected wet off-peak period.

Figure 4-16 depicts that during Wet Off-Peak period all the bus voltages will be within the limits of ± 5% of the rated voltage. Total loss during the off-peak period will be around 1.92 kW. Mini grid will import around 100 kW from national grid. The load flow report for this scenario has been attached in the Annex.

4.2.3 Dry Peak Period

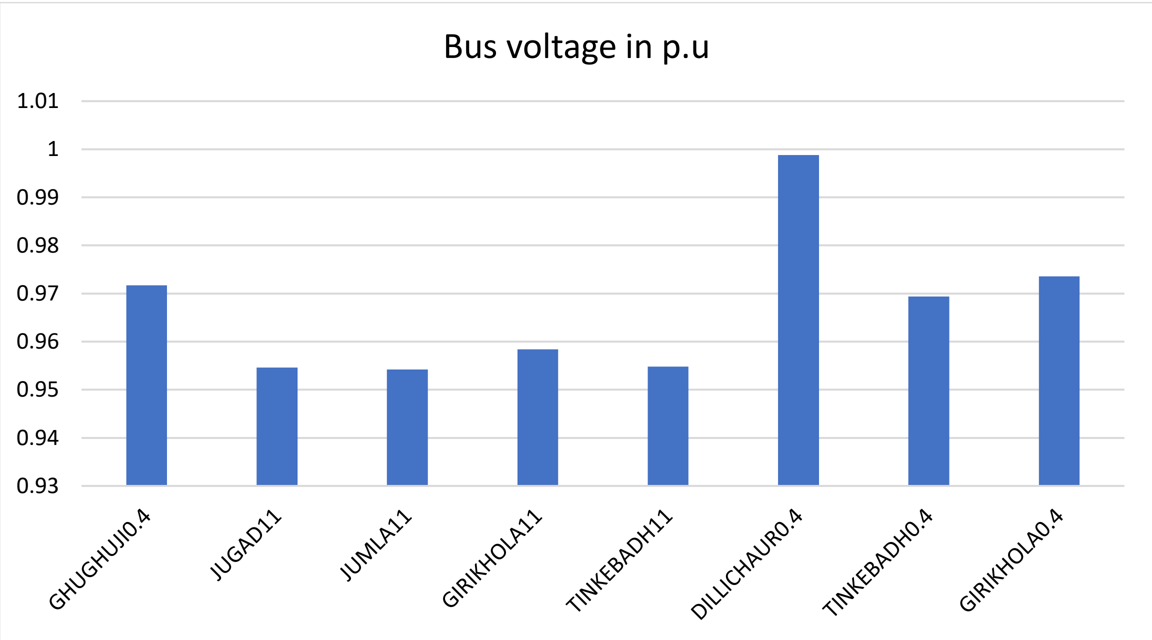


Figure 4-17 Bus voltages of different bus during grid connected dry peak period.

Figure 4-17 depicts that during Dry Off-Peak period all the bus voltages will be within the limits of ± 5% of the rated voltage. Total loss during the peak period will be around 15.5 kW. As the local generation is insufficient to meet the peak demand, national grid supplies the deficit power and maintains the reliability of the power supply. During this scenario, national grid supplies 734 kW to Jumla Mini grid. The load flow report for this scenario has been attached in the Annex.

4.2.4 Dry Off Peak Period

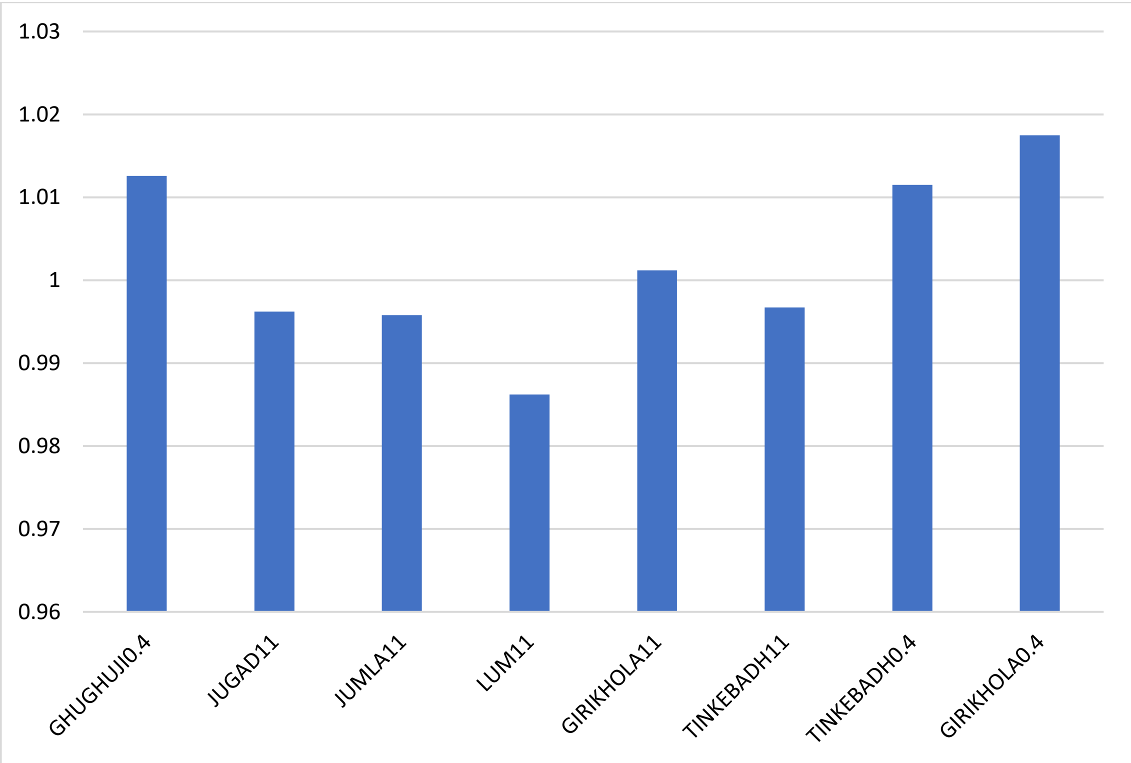


Figure 4-18 Bus voltages of different bus during grid connected dry off-peak period

Figure 4-18depicts that during Dry Off-Peak period all the bus voltages will be within the limits of ± 5% of the rated voltage. Total loss during the peak period will be around 1.54 kW. Peak demand of the Mini grid reduces significantly during off peak period. However, mini grid still needs to import 111 kW from national grid. The load flow report for this scenario has been attached in the Annex.

5 BoQ, Cost Estimation and Economic Analysis for Mini Grid

The items to be procured for interconnection are primarily the grid interconnection equipment and the 11 kV line materials. The Consultant understands the design and construction of both the 11 kV lines are being carried out by AEPC. The line connecting Chukeni to Khalanga Bazar will be the backbone of the mini grid. This line passes nearby the MHP along the way from Chukeni to Khalanga Bazar. Triveni, Lum Dillichaur does not have to build transmission line of its own but can use that of Chukeni. Similar is the case for Tinke Badh MHP although it has its own transmission line under operation. Giri Khola needs to construct transmission line of its own. Ghughuti and Juged have its own transmission line and are under operation. Thus, for this case, only the Bill of Quantity for Interconnections are presented here. Apart from the Transformer, the Consultant has enlisted the equipment required for safe operation to ensure replacement of components, if not in working condition in field.

5.1 Sustainable Implementation of Mini Grid

The Consultant proposed to design the Mini grid in such a way that, the data can be retrieved of field for any further enhancement or error mitigation during operation. The following is proposed for this case,

Installation of Smart ToD meter by NEA in each MHPs and Point of Coupling to ensure daily load data and generation data is available for observation from central office in Kathmandu, which will allow to assess the health of the Mini Grid.

5.2 Grid Interconnection Panels

The Grid Interconnection Panel for ELC based MHPs shall have at least the facility as indicated in Table 5-1. The reference has been taken from existing Baglung Mini grid, Nepal.

Table 5-1: Requirements for Grid Interconnection Panel for ELC based MHPs[21]

S.N.	Particulars	Description
1.	Q/V Control Unit	AVR with droop facility suitable for parallel operation
		Automatic Power Factor Regulator
		Digital Potentiometers, Excitation Adjusting Potentiometers
		Voltmeter for Excitation Voltage, Ammeter for Excitation Current
		Droop CT (100/5 Amp, 5 VA, 5p10 class)
2.	P/F Control Unit	Digital ELC with droop compensation, Driver Card
		Electronic Load Monitor (ELM), Thyristors

5.3 Grid Interconnection Schemes

The Grid Interconnection Scheme proposed here is slightly varied from the initially approved standard for MHPs requiring less than 100 kVA transformer. The evacuation scheme is discussed in this section. The status of the MHPs for evacuation arrangement are indicated in Table 5-2. A separate Bill of Quantities is developed for interconnection of each MHP to the grid. Cost is then developed for both Option I and Option II.[22]

Table 5-2: List of MHPs intended for Interconnection as MHPs.

SN	Project Name	kW	11/0.4 kV Transformer Status	Transformer Capacity Required	Interconnection Scheme
1	Giri Khola	200	Available		Scheme I

[21] Reference from Baglung Mini Grid, Nepal
22 Schemes have been developed with reference of Grid Interconnection Standard of MHP, and Paper " Micro Hydropower in Nepal: A Journey from Stand-alone System to Distributed Generation" Jiwan Kumar Mallik; Satish Gautam; Surendra Mathema; Binod Koirala; Hitendra Dev Shakya Available in: https://ieeexplore.ieee.org/document/9067728

SN	Project Name	kW	11/0.4 kV Transformer Status	Transformer Capacity Required	Interconnection Scheme
2	Ghughuti	200	Available		
3	Thinke Badh	100	Available		Scheme I
4	Triveni	45	Not Available	100 kVA	Scheme II
5	Lum	31	Not Available	50 kVA	Scheme II
6	Dillichaur	50	Not Available	100 kVA	Scheme II
7	Chukeni	998	Available		
8	Jugad	58	Available		Scheme II

5.3.1 Scheme I for Grid Interconnection

The scheme I for grid interconnection represents the proposed scheme for connecting Micro Hydro Power Plant in the grid. The plant is supposed to be connected to the grid at 11 kV with presence of Vacuum Circuit Breaker for interconnection. BoQ of the scheme is divided into six parts. Description of each section of BoQ is presented here. It is to be understood that VCB at 11 kV is major contributor of cost in this case. As small MHPs do not generate enough revenue to justify it, this scheme is applied only for MHPs needing 100 kVA (85 kW) or larger transformer. The detail Bill of Quantities (BoQ) of the Scheme is provided in Table 5-3 followed by the single line diagram at Figure 5-1.

5.3.1.1 Controller Panel with all digital relays

The controller panel constitutes of the relay essential for the operation of the plant in grid connected mode. The list of protection relays and regulators required are presented in the Table 5-3. The CTs and PTs will be installed for supply to the relay panel.

5.3.1.2 DC Supply System

DC Supply system is required for operation of relays and sensors. It includes a set of batteries, and charger cum inverter system.

5.3.1.3 Switches, Disconnectors and Surge Arresters

The scheme demands VCB at 11 kV for interconnection despite the cost challenges. The Air Circuit Breaker is used at low voltage level for synchronization. Pole mounted isolator is recommended at 11 kV side of the line. MCCB is used at 400 V bus bar of the MHP. The dc system and the station load of the power plant is supplied via MCBs tapping out of the 400 V bus bar.

Surge Arrestor are installed on both sides of the transformer, i.e., one at High Tension (HT) side and other at Low Tension (LT) side.

5.3.1.4 Metering and Synchronizing Equipment

Metering is carried out in two locations, one at the output of generator and other for metering purpose at 11 kV side. At low voltage side, the generator terminal will be fitted with digital meters for measurement of generator output.

The CT at metering side will have two cores for main and check meter. PT can have one core used for measurement and other for protection.

Synchronizer consists of synchronoscope, Dual frequency and voltage meter, dark lamp set, differential etc. essential for the synchronization depending upon the technology of the synchronoscope.

5.3.1.5 Transformer and Accessories

11/0.4 kV transformer will be used to step up the output of the MHP to 11 kV. The transformer shall be installed either on floor in a foundation or mounted on a pole at H-Pole Structure. Transformer shall have delta at low voltage side and grounded star connected at high voltage side. The earthing shall be for

- transformer neutral at High Voltage side,
- lightning arrestors
- transformer body

5.3.1.6 Conductors

The conductors will interconnect the output of MHP to the transformer and eventually to the grid. Nominal amount of PVC insulated cables will be required for station supply, DC supply system. XLPE cable, typically for a length of 30 m to 50 m will be necessary for supply from 400 V bus bar to transformer terminal. As the cable will be capacitive, surge arrestor is employed at the transformer terminal.

Few meters of ACSR conductor will be required for interconnection of HT side of transformer to the 11 kV grid.

Table 5-3: Bill of Quantities for Grid Interconnection Scheme I of MHPs (MHPs >85 kW)

S.N.	Particular	Unit	Qty	Remarks
1	**Controller Panel with all digital relays**			
1.1	Electronic Load Controller compatible for grid interconnection of MHP, ELC	set	1	Alternatively, Governor Based for MHPs >100 kW
1.2	Automatic Voltage Regulator, AVR	set	1	
1.3	Automatic Power Factor Regulator, APFR	set	1	
1.4	Over/Under Frequency Relay, O/U FR	nos.	1	
1.5	Over/Under-Voltage Relay, O/U VR	nos.	1	

S.N.	Particular	Unit	Qty	Remarks
1.6	Reverse Power Relay, RPR	nos.	1	
1.7	Voltage Restrained Over-current Relay, VR O/C R	nos.	1	
1.8	Phase -Imbalance Relay, PUR	nos.	1	
1.9	Over-Current Relay, O/C R	nos.	1	
1.1	Generator-Earth Fault Relay, EFR	nos.	1	
1.11	Main Fail Relay	nos.	1	
1.12	Rate of Change of Frequency and Voltage Vector Shift Relay	nos.	1	
1.13	Turbine Shut Down Relay	nos.	1	
2	**DC Supply System**			
2.1	Inverter cum Battery charger with 24-V Battery System, Input 230 V, Output 230V Sine Wave with accessories all complete	set	1	
3	**Switches, Disconnectors and Surge Arresters**			
3.1	Air Circuit Breaker, ACB	set	1	
3.2	Molded Case Circuit Breaker, MCCB	set	1	
3.3	Miniature Circuit Breaker, MCB	set	2	1 each for DC System and Station Supply

S.N.	Particular	Unit	Qty	Remarks
3.4	Vacuum Circuit Breaker with Protection (O/U voltage relay, OC relay), VCB	set	1	
3.5	Lightning Arrester, High Voltage Side, LA	set	1	
3.6	Lightning Arrester, Low Voltage Side, LA	set	1	
3.7	Disconnecting Switch (Isolator), HT, DS	set	1	
4	**Metering and Synchronizing Equipment**			
4.1	Digital kW, kWh, PF, Frequency meter, ammeter & voltmeter with selector switch with essential accessories including current and voltage transformers	set	1	For Generator Measurement
4.2	Synchronizer (synchronoscope, Dual frequency and voltmeter, dark lamp set, differential etc.) with Auto & Manual Selector Switch with essential accessories	set	1	
4.3	Time of Day Smart Metering Unit with CT/PT with essential accessories at 11 kV level	set	1	For Energy Metering, Main and Check
5	**Transformer and Accessories**			

S.N.	Particular	Unit	Qty	Remarks
5.1	Transformer	nos.	1	Transformer with accessories
5.2	Transformer foundation	set	1	Foundation in ground or Two poles with stand for transformer
	H – Pole and Stay Set	set	1	
5.3	Earthing Set, wires including PVC pipes	set	1	Earthing Arrangement for Transformer
6	**Conductors**			
6.1	ACSR Dog Conductor	lot	1	ACSR Conductor for interconnection of transformer HT side to tapping point
6.2	XLPE Cable	lot	1	Approx. 50 m cable for power evacuation from 400 V bus to transformer terminal
6.3	400 V Copper Cables, Copper Bus bar with accessories	lot	1	At 400 V level

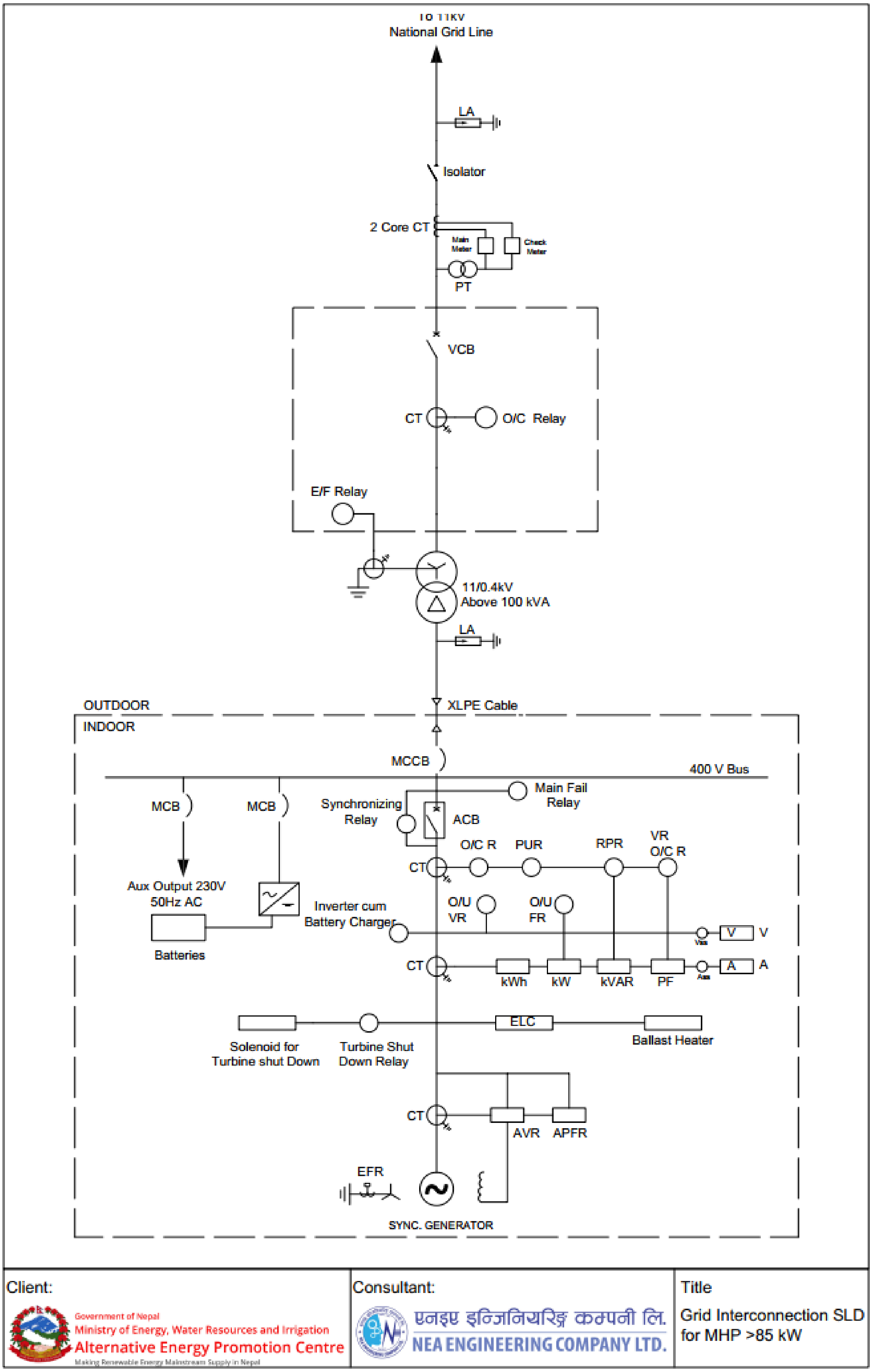


Figure 5-1: Scheme I for Grid Interconnection of MHPs

5.3.2 Scheme II for Grid Interconnection

Scheme I for Grid Interconnection demands VCB at 11 kV, which increases the cost of scheme by a great margin. For power plants with lower capacity, it may not be feasible to interconnect to the grid. Hence, this scheme is proposed which eliminates the need of VCB for interconnection.

This scheme will be applied for MHPs with transformer requirement up to 100 kVA, i.e., MHPs up to 85 kW. The detail Bill of Quantities (BoQ) of the Scheme is provided in Table 5-4 followed by the single line diagram at Figure 5-2.

5.3.2.1 Controller Panel with all digital relays

The controller panel constitutes of the relay essential for the operation of the plant in grid connected mode. The list of protection relays and regulators required are presented in the Table 5-4. The CTs and PTs will be installed for supply to the relay panel.

5.3.2.2 DC Supply System

DC Supply system is required for operation of relays and sensors. It includes a set of batteries, and charger cum inverter system.

5.3.2.3 Switches, Disconnectors and Surge Arresters

The scheme eliminates the need of VCB at 11 kV for interconnection. The Air Circuit Breaker is used at low voltage level for synchronization. Alternatively, Contactor can be used for MHPs <20 kW. Pole mounted DO Fuse is recommended at 11 kV side of the line. MCCB is used at 400 V bus bar of the MHP. The dc system and the station load of the power plant is supplied via MCBs tapping out of the 400 V bus bars.

Surge Arrestor are installed on both sides of the transformer, i.e., one at High Tension (HT) side and other at Low Tension (LT) side.

5.3.2.4 Metering and Synchronizing Equipment

Metering is carried out in two locations, one at the output of generator and other for metering purpose at 11 kV side. At low voltage side, the generator terminal will be fitted with digital meters for measurement of generator output.

The CT at metering side will have two cores for main and check meter. PT can have one core used for measurement and other for protection.

Synchronizer consists of synchronoscope, Dual frequency and voltage meter, dark lamp set, differential etc. essential for the synchronization depending upon the technology of the synchronoscope.

5.3.2.5 Transformer and Accessories

11/0.4 kV transformer will be used to step up the output of the MHP to 11 kV. The transformer shall preferably be mounted on a pole at H-Pole Structure. Transformer shall have delta at low voltage side and grounded star connected at high voltage side. The earthing shall be for

- transformer neutral at High Voltage side,
- lightning arrestors
- transformer body

5.3.2.6 Conductors

The conductors will interconnect the output of MHP to the transformer and eventually to the grid. Nominal amount of PVC insulated cables will be required for station supply, DC supply system. XLPE cable, typically for a length of 30 m to 50 m will be necessary for supply from 400 V bus bar to transformer terminal. As the cable will be capacitive, surge arrestor is employed at the transformer terminal.

Few meters of ACSR conductor will be required for interconnection of HT side of transformer to the 11 kV grid.

Table 5-4: Bill of Quantities for Grid Interconnection Scheme II of MHPs (MHPs <85 kW)

S.N.	Particular	Unit	Qty	Remarks
1	**Controller Panel with all digital relays**			
1.1	Electronic Load Controller compatible for grid interconnection of MHP, ELC	set	1	
1.2	Automatic Voltage Regulator, AVR	set	1	
1.3	Automatic Power Factor Regulator, APFR	set	1	
1.4	Over/Under Frequency Relay, O/U FR	nos.	1	
1.5	Over/Under-Voltage Relay, O/U VR	nos.	1	
1.6	Reverse Power Relay, RPR	nos.	1	
1.7	Voltage Restrained Over-current Relay, VR O/C R	nos.	1	
1.8	Phase -Imbalance Relay, PUR	nos.	1	
1.9	Over-Current Relay, O/C R	nos.	1	
1.1	Generator-Earth Fault Relay, EFR	nos.	1	
1.11	Main Fail Relay	nos.	1	
1.12	Rate of Change of Frequency and Voltage Vector Shift Relay	nos.	1	
1.13	Turbine Shut Down Relay	nos.	1	

S.N.	Particular	Unit	Qty	Remarks
2	**DC Supply System**			
2.1	Inverter cum Battery charger with 24-V Battery System, Input 230 V, Output 230V Sine Wave with accessories all complete	set	1	
3	**Switches, Disconnectors and Surge Arresters**			
3.1	Air Circuit Breaker, ACB	set	1	Alternatively, Contactor for plants <20 kW
3.2	Molded Case Circuit Breaker, MCCB	set	1	
3.3	Miniature Circuit Breaker, MCB	set	2	1 each for DC System and Station Supply
3.5	Lightning Arrester, High Voltage Side, LA	set	1	
3.6	Lightning Arrester, Low Voltage Side, LA	set	1	
3.7	Drop Out Fuse, HT, DO	set	1	
4	**Metering and Synchronizing Equipment**			
4.1	Digital kW, kWh, PF, Frequency meter, ammeter & voltmeter with selector switch with essential accessories including current and voltage transformers	set	1	For Generator Measurement

S.N.	Particular	Unit	Qty	Remarks
4.2	Synchronizer (synchronoscope, Dual frequency and voltmeter, dark lamp set, differential etc.) with Auto & Manual Selector Switch with essential accessories	set	1	
4.3	Time of Day Smart Metering Unit with CT/PT with essential accessories at Low Voltage Level	set	1	For Energy Metering, Main and Check
5	**Transformer and Accessories**			
5.1	Transformer	nos.	1	Transformer with accessories
5.2	H – Pole and Stay Set	set	1	Foundation in ground or Two poles with stand for transformer
5.3	Earthing Set, wires including PVC pipes	set	1	Earthing Arrangement for Transformer
6	**Conductors**			
6.1	ACSR Dog Conductor	lot	1	ACSR Conductor for interconnection of transformer HT side to tapping point

S.N.	Particular	Unit	Qty	Remarks
6.2	XLPE Cable	lot	1	Approx. 50 m cable for power evacuation from 400 V bus to transformer terminal
6.3	400 V Copper Cables, Copper Bus bar with accessories	lot	1	At 400 V level

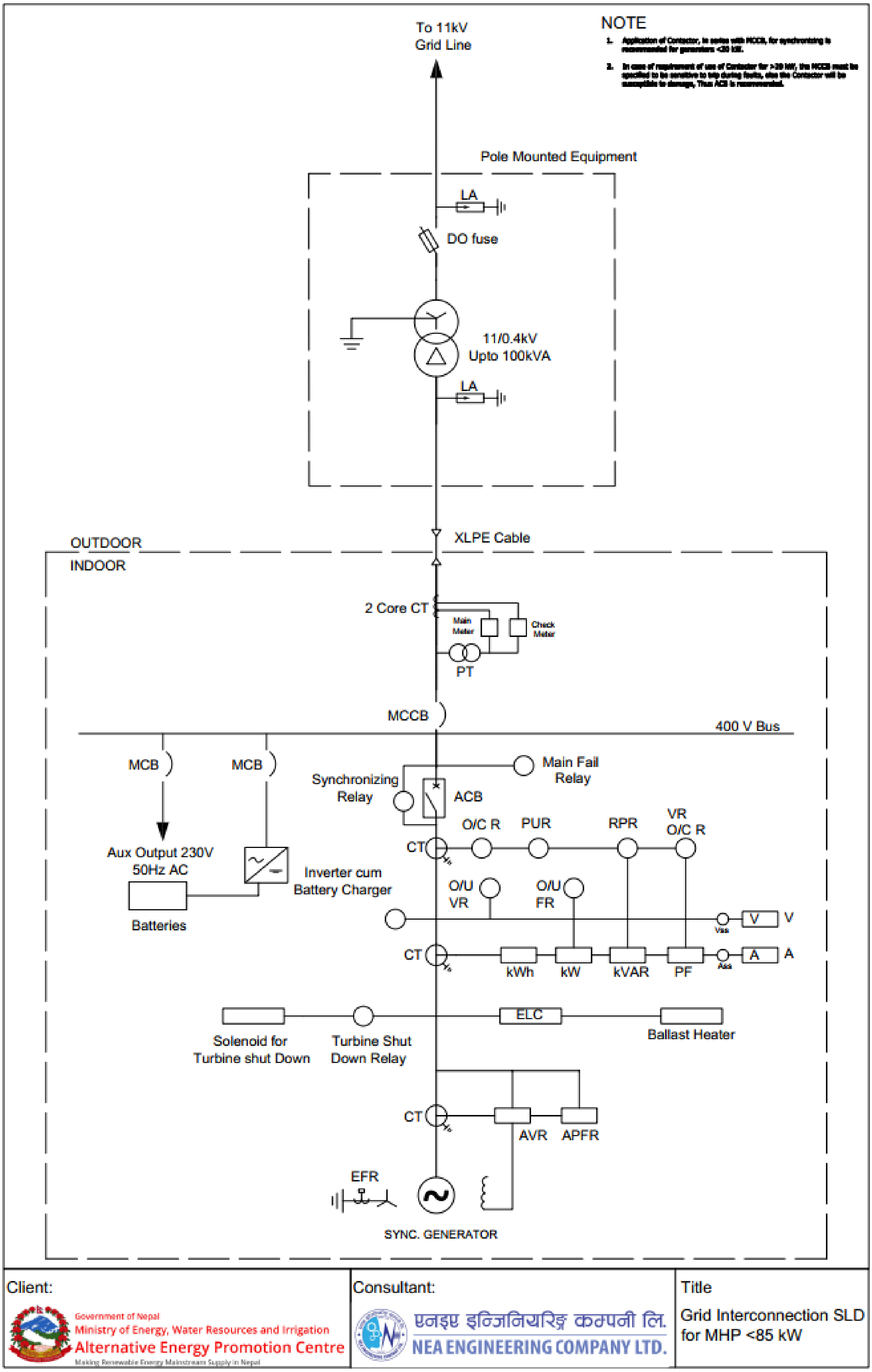


Figure 5-2: Scheme II for Grid Interconnection of MHPs, less than 85 kW

5.4 Cost Estimation and Economic Analysis

5.4.1 Cost Estimate Development

The cost estimation has been developed by referring to the price of items in Bill of Quantities. The reference for the price is taken from existing rates in AEPC, and rates observed in distribution projects of NEA. The estimate is prepared for price of CIP and Installation/Erection, Testing and Commissioning. For items with no separate cost for the later part, the same cost is included as lump sum. Transportation cost is too included in lumpsum basis.

5.4.2 Summary of Cost Estimate

The cost estimate has been carried out for both the options described earlier. The cost for implementing Option I is approximately Eleven Million and Five Hundred Thousand Nepali Rupees excluding of taxes and contingency. Similarly, the cost for implementing Option II is approximately Six Million and Seventy Thousand Nepali Rupees excluding of taxes and contingency. The details of the cost for interconnection of each MHP to grid are provided in the Annex of this document.

In addition to the cost mentioned above, additional 13 percent Value Added Tax is implied on the cost. A contingency of 5 percent is added to the cost estimate. Table 5-5 represents the breakdown of summary of cost estimate for grid interconnection of MHPs for Option I, constituting seven MHPs indicated in the Terms of Reference.

Table 5-5: Summary of Cost Estimate for Grid Interconnection of MHPs - Option I

S.N.	Particular	Amount
1	Grid Interconnection of Giri Khola	1,112,735.82

S.N.	Particular	Amount
2	Grid Interconnection of Ghughuti	674,500.00
3	Grid Interconnection of Thinke Badh	3,268,411.53
4	Grid Interconnection of Triveni	2,180,231.17
5	Grid Interconnection of Lum	2,080,231.17
6	Grid Interconnection of Dillichaur	2,180,231.17
7	Grid Interconnection of Chukeni	In another scope
Total (NPR)		**11,496,340.86**
Taxable Amount (NPR)		11,496,340.86
VAT @ 13.00%		1,494,524.31
Grand Total including VAT		12,990,865.17
Contingency @ 5.00%		649,543.26
Grand Total amount including VAT and Contingency		**13,640,408.43**

Similarly, Table 5-6 presents the breakdown of summary of cost estimate for grid interconnection of MHPs for Option II, constituting four MHPs in the vicinity of Jumla Bazaar.

Table 5-6: Summary of Cost Estimate for Grid Interconnection of MHPs - Option II

S.N.	Particular	Amount
1	Grid Interconnection of Giri Khola	1,112,735.82
2	Grid Interconnection of Ghughuti	674,500.00
3	Grid Interconnection of Thinke Badh	3,268,411.53
4	Grid Interconnection of Juged	1,658,490.00
Total (NPR)		**6,714,137.34**
Taxable Amount (NPR)		6,714,137.34
	VAT @ 13.00%	872,837.85
Grand Total including VAT		7,586,975.20
	Contingency @ 5.00%	379,348.76
Grand Total amount including VAT and Contingency		**7,966,323.96**

5.4.3 Economic Analysis

The financial implications faced by the implementation consists of the interconnecting transmission line (distribution voltage level), equipment in MHPs and the transformer for interconnecting to the higher voltage level of the transmission line.

The revenue generation by the MHPs depend upon the methodology that will be adopted. Currently, the MHPs are collecting revenue from the consumers. A typical approach would be to pay the MHPs, as per the amount of energy provided to the mini grid or grid.

This could lead to loss of revenue for the user communities as some energy is spilled during the off-peak hours. Currently, MHPs appear to be charging a fixed rate to consumers in some cases and add up per unit costs when the consumer uses power more than certain level. The approach is like the billing method of NEA. After grid development, one way is to let NEA do all the billing works, which the Consultant believes could result in loss of revenue of some MHPs, which is not desirable for the user communities.

This arrangement demands further discussions to decide on the Revenue Collection Technique. The Consultant proposes to develop a user community group like CREE groups for rural electrification. The group could be made responsible for collection of revenue and payment to respective MHPs, and NEA based on the import – export of Electricity.

The Consultant had proposed to calculate financial indicators like IRR, NPV, etc. for the project, however, it requires both the income and expenses of the project. Annual energy generation of MHPs is essential for revenue estimation. During field visit, it was observed that, the annual energy generation of MHPs are not recorded. On the other hand, the cost included in this study is just a fraction of total cost required, the calculation of NPV and IRR appears not be relevant. The cost should include costs for 11 kV lines and operation and maintenance of MHPs etc. The Consultant understands, Mini Grid as a need rather than option to the Client for Jumla. It has been observed that, technically mini grid implementation is possible.

The Consultant assumes that, households, shops, offices, and industries, adhere to other source of energy in absence of electricity. The households typically go for kerosene or other sources, whereas diesel generator is often preferred in shops and offices like banks, and industries. The alternative fuel displaced by electrical supply represents the cost saving to the economy of the nation.

There is excess of firewood and other energy source in the region of impact of the Mini grid. Thus, the consumption of kerosene and other fuels are comparatively less in Jumla. Figure 5-3 depicts the household demand function of the electricity.

The demand of electricity usually has an upper bound, represented by point A in the Figure 5-3. The price and quantity of electricity correspond to the same point.

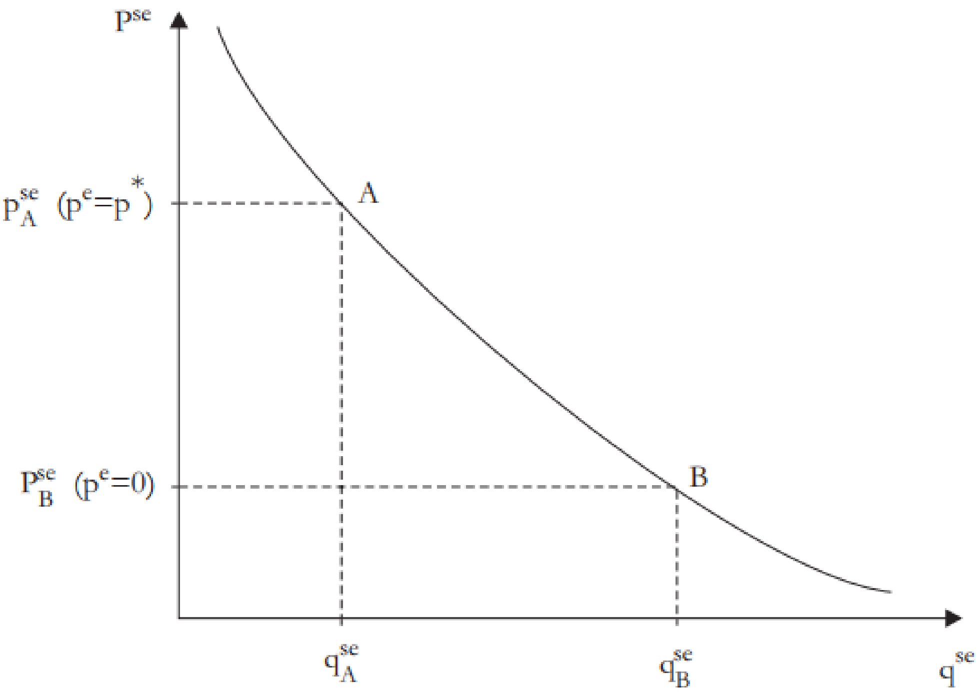


Figure 5-3: Household Demand Function for the services of Electricity Consuming Equipment[23]

Where, P_A and q_A are the price and quantity of kerosene respectively, for the kerosene being used annually for lighting purposes in an unelectrified area. P_B and q_B represent the price and quantity of electricity consumed for similar households in electrified area. The total value of economic benefit is obtained as the sum of economic value of replacement of kerosene (or

[23] Measuring willingness to pay for electricity by Peter Choynowski accessible at - https://think-asia.org/bitstream/handle/11540/1791/tn-03-measuring-willingness.pdf?sequence=1

other fuel) in households, replacement of diesel and petrol in commercial and industrial areas.

The economic value of replacements are given as the product of price and demand of the quantity that the electricity will replace. Mathematically, for any product p,

$$EV_p = \left(P_p \times Q_p \right)$$

The price of Kerosene, Diesel and Petrol in Nepal is NPR 103.00, NPR 103.00, and NPR 120.00, respectively. One liter of kerosene is assumed to correspond to 10.35 kWh equivalent of energy providing price per kW to be NPR 9.95 per kWh. In case of Diesel per kWh consumption of electricity requires 0.3 liters of Diesel i.e., NPR 30.9 per kWh and 1 liter of petrol is typically equivalent to 9.1 kWh of energy i.e., NPR 13.19 per kWh.

The detail data of consumers is not available in the region. Following assumptions is taken for the purpose.

The capacity of MHP is used to prepare a base for number of consumers. 70% of capacity is used by Domestic Consumers, 20% by commercial and 10% by Industrial. The per household demand is considered to be 200 W. For commercial and industrial load, it is taken to be 750 W and 1.25 kW, respectively.

The Consultant assumes, the demand of the household consumption will be fulfilled by kerosene and commercial and industrial by petrol, in absence of electricity supply. Assuming percentage of load increase with mini grid in Jumla is 40%, 50% and 60% respectively for domestic, commercial, and industrial consumers, the amount of added benefit per consumer is, NPR 4,184.49, NPR 16,345.65, and NPR 32,691.30 respectively for three categories of consumer per year.

The list of assumptions for economic analysis are enlisted in Table 5-7.

Table 5-7: List of Assumptions for Economic Analysis

SN	Particular	Amount	Remarks
1	Investment cost of MHP per kW	400,000.00	Assumption
2	Plant Factor of MHP	60.00%	Assumption
3	Percentage of Dry Season Energy in Total Energy	40.00%	Assumption
4	Annual Operation & Maintenance Cost as percentage of Investment Cost	5.00%	Assumption
5	Escalation Rate of Annual O & M cost	6.00%	Assumption
6	Wet Season Energy Sale Rate per kWh	4.8	NEA Rate for Wet Season
7	Dry Season Energy Sale Rate per kWh	8.4	NEA Rate for Dry Season
8	Plant Outage percentage	4.00%	Assumption
9	Percentage of Domestic Consumers	70.00%	Assumption
10	Percentage of Commercial Consumers	20.00%	Assumption
11	Percentage of Industrial Consumers	10.00%	Assumption
12	per Consumer consumption, Domestic	350	Assumption
13	per Consumer consumption, Commercial	1000	Assumption

SN	Particular	Amount	Remarks
14	per Consumer consumption, Industrial	2500	Assumption
15	Load Factor, Domestic	60.00%	Assumption
16	Load Factor, Commercial	50.00%	Assumption
17	Load Factor, Industrial	50.00%	Assumption
18	Percentage of energy increased, Domestic	40.00%	Assumption
19	Percentage of energy increased, Commercial	50.00%	Assumption
20	Percentage of energy increased, Industrial	60.00%	Assumption
21	Demand of Alternative Fuel, Domestic	2.016	kWh, per consumer demand * 24 hours* load factor
22	Demand of Alternative Fuel, Commercial	6	kWh, per consumer demand * 24 hours* load factor
23	Demand of Alternative Fuel, Industrial	18	kWh, per consumer demand * 24 hours* load factor
24	Price of Petrol, per kWh	9.95	Based on current rate of NOC

SN	Particular	Amount	Remarks
25	Price of Diesel, per kWh	30.90	Based on current rate of NOC
26	Price of Kerosene, per kWh	13.19	Based on current rate of NOC
27	Benefit for Domestic	7,322.85	NPR per year
28	Benefit for Commercial	21,794.20	NPR per year
29	Benefit for Industrial	65,382.61	NPR per year
30	Rate of Growth of Fuel Cost	0.0025	% per year

The economic analysis presented that; the Option I is economically feasible at 16.61% for ten years. The EIRR for Option II is obtained to be extremely high, due to sunk costs in these power plants at 497.34%. This unusual high value will be justified with payments related for loan repayment of Giri Khola MHP and investment costs of transmission lines for interconnection.

Table 5-8: EIRR for Option I of the proposed interconnection scheme

Year	Capital Cost, NPR	O & M Cost, NPR	Total Costs, NPR	Energy Sale Revenue, NPR	Added Benefit, Domestic, NPR	Added Benefit, Commercial, NPR	Added Benefit, Industrial, NPR	Total Benefit, NPR	Net Cash Flow, NPR
1	410,696,341	-	410,696,341	-	-	-	-	-	-410,696,341
2	-	32,730,000	32,730,000	95,054,045	23,784,624	7,078,757	4,247,254	130,164,680	97,434,680
3	-	34,678,800	34,678,800	95,054,045	23,844,085	7,096,454	4,257,872	130,252,457	95,573,657
4	-	36,744,528	36,744,528	95,054,045	23,903,696	7,114,195	4,268,517	130,340,453	93,595,925
5	-	38,934,200	38,934,200	95,054,045	23,963,455	7,131,981	4,279,188	130,428,669	91,494,469
6	-	41,255,252	41,255,252	95,054,045	24,023,364	7,149,811	4,289,886	130,517,106	89,261,854
7	-	43,715,567	43,715,567	95,054,045	24,083,422	7,167,685	4,300,611	130,605,763	86,890,196
8	-	46,323,501	46,323,501	95,054,045	24,143,630	7,185,604	4,311,363	130,694,643	84,371,142
9	-	49,087,911	49,087,911	95,054,045	24,203,990	7,203,568	4,322,141	130,783,744	81,695,833
10	-	52,018,185	52,018,185	95,054,045	24,264,500	7,221,577	4,332,946	130,873,068	78,854,883
EIRR									**16.61%**

Table 5-9: EIRR for Option II of the proposed interconnection scheme

Year	Capital Cost, NPR	O & M Cost, NPR	Total Costs, NPR	Energy Sale Revenue, NPR	Added Benefit, Domestic, NPR	Added Benefit, Commercial, NPR	Added Benefit, Industrial, NPR	Total Benefit, NPR	Net Cash Flow, NPR
1	6,714,137	-	6,714,137	-	-	-	-	-	-6,714,137
2	-	11,160,000	11,160,000	32,660,195	8,172,303	2,432,233	1,459,340	44,724,071	33,564,071
3	-	12,079,600	12,079,600	32,660,195	8,192,734	2,438,314	1,462,988	44,754,231	32,674,631
4	-	12,789,376	12,789,376	32,660,195	8,213,216	2,444,409	1,466,646	44,784,466	31,995,090
5	-	13,541,739	13,541,739	32,660,195	8,233,749	2,450,520	1,470,312	44,814,777	31,273,038
6	-	14,339,243	14,339,243	32,660,195	8,254,333	2,456,647	1,473,988	44,845,163	30,505,920
7	-	15,184,597	15,184,597	32,660,195	8,274,969	2,462,788	1,477,673	44,875,626	29,691,028
8	-	16,080,673	16,080,673	32,660,195	8,295,656	2,468,945	1,481,367	44,906,164	28,825,491
9	-	17,030,514	17,030,514	32,660,195	8,316,395	2,475,118	1,485,071	44,936,779	27,906,265
10	-	18,037,345	18,037,345	32,660,195	8,337,186	2,481,305	1,488,783	44,967,471	26,930,126
EIRR (EIRR is on higher side due to sunk costs)									**497.34%**

6 CONCLUSION AND RECOMMENDATIONS

Usually, perturbation causes a transient that is oscillatory in nature, but if the system is stable the oscillations will be damped. The system is said to be stable in which synchronous machines, when perturbed, will either return to their original state if there is no change in exchange of power or will acquire new state asymptotically without losing synchronism.

As the system is relatively small with majority of the generators being hydro, the isolated Mini grid will be stable except for the case when Chukeni MHP is slated from the system. This study is based on the standard values of models and assumptions made by the Consultant and thus may not represent the actual behavior of the system and is prone some margin of error.

In addition to the technical parameters, the Consultant understands that revenue sharing dispute can be a hurdle in Mini Grid implementation. Regarding the Revenue, the Consultant has proposed the following for cost effective operation of Mini Grid.

1. Form a User Community with participation of Utility (NEA), Consumers (Local Community), Local Government, and AEPC (as a facilitator)
2. Agree on the implementation of Smart ToD meter-based measurement for each MHPs point of coupling and any other common coupling point. The idea behind it is to have logged voltage, current and energy data for at least each hour, accessible from remote location, say AEPC Head Office.
3. Agree on common billing mechanism for every consumer; the Consultant proposes to make use of NEA's Billing arrangement for this.
4. Develop a revenue sharing arrangement between MHPs, where each MHP will be paid for,

a. Its capacity and availability
b. Energy supplied by the plant.
c. Consumption of energy generated by the plant, i.e., a locational based pricing arrangement.

As the Smart ToD meter with data logging facility is available, the details can be retrieved, and a revenue sharing algorithm can be laid out. The Mini Grid user community will simply keep an amount from net income sufficient to pay for its staff – office staff, logistics, revenue collection, maintenance of mini grid (MHPs O&M under scope of MHPs), and the rest can be shared among the MHPs. The Consultant believes, AEPC can play a role in having this arrangement. Practical implementation with interconnection of 4 MHPs, as indicated in Option II, will help to prepare the ground for interconnection of all MHPs in the region.

A joint meeting was organized between NEA, AEPC and NEC. A business model to support loan repayment of MHPs was discussed. It is suggested to allow option for MHPs, commissioned less than 5 years ago, to have a distribution area with net metering facility where they are allowed 2 to 3 years for operating distribution system in their service area. Further study and clarification is required for this scheme. The Consultant recommends drafting this in preparation of Interconnection Master Plan of MHPs.

In addition to the recommendations above, the Consultant extends its recommendation on Micro Hydro Projects Interconnection Equipment Standards and Specifications.

1. The step-up transformer used for micro hydro has Delta connection on the high voltage side and neutral grounded star on the low voltage side. Having this scheme will pose an issue to detect ground fault on the transmission line. Broken Delta connected PT or Grounding Transformer can be used to detect the ground faults but for smaller micro hydro plants these are cost

inefficient. Thus, it is recommended to change the transformer connection to have Delta on the low voltage side and grounded neutral star connection on the high voltage side.

2. Micro hydro with substantial local loads are supplied by directly connecting at the 400 V generation bus. In case of inadvertent fault on the local supply line, generators are vulnerable to such faults. Considering the rural nature of the distribution system, these faults will be frequent. Generator terminals will be subjected to overvoltage during these faults. Thus, to protect the generators, it is recommended to remove the local supply directly through generator bus. Local loads can be supplied through an isolating transformer. It will increase the cost but is necessary to protect the generators.
3. The requirement for Vacuum Circuit Breaker is not economically justified for smaller plants. The function of VCB at 11 kV can be accomplished by the 400 Volt Air Circuit Breaker. Thus, it is recommended to set a benchmark in terms of capacity of the plant to use VCB. The short circuit analysis of the Jumla mini grid showed the fault current being less than 1 kA for faults at 11 kV buses which further aids in removing the VCB for smaller plants. Consultant recommends removing the need of 11 kV VCB for MHPs less than 85 kW.
4. As per the current provision of PPA with NEA, in case of meters and associated current and voltage transformer, there must be an inspection of meters being tested at national or international lab by joint team of NEA and MHP. The cost of inspection is to be covered by the MHP. Cost of witnessing at international lab is expensive and adds further burden on MHP. Thus, in case of testing at national lab, the cost can be covered by the MHP but if the tests cannot be done at national lab, MHP must submit test

certificates provided by the manufacturer complying all the relevant standards for approval. NEA must approve the test certificates if it complies all the requirements stipulated by the relevant standard.

5. The choice of interconnection voltage for MHPs less than 85kW is up to the MHPs. They can connect either at 400 V or 11 kV depending upon its availability. If MHPs opts to connect at 400 V, it must consider the current carrying capacity of 400 V feeders and the protection issues that are related with it. MHPs are liable for deteriorating impact of line faults on the generators that are directly connected at 400 V. On either case, VCB is not required for the interconnection.
6. Simplify PPA procedure by combining PPA document, Connection Agreement and Operating Procedure including condition on project completion and connection date. AEPC should draft the simplified PPA procedure and submit to NEA for approval and implementation.
7. It is recommended to waive the provision of penalty on either party for not dispatching or receiving energy as per the contract energy table for MHPs.
8. NEA should provide one window service from its nearest DC office to the MHP for complete PPA process.
   i. Application along with all necessary documents will be submitted by power producer
   ii. Site visit to confirm T-connection point, validation of MHP interconnection diagram, verification of energy table etc.
   iii. Forward to concerned department for PPA finalization and approval.

iv. Signing of PPA document by NEA (district office or provincial office) and Power Producer.

v. Testing and Commissioning witnessed by NEA

    1. Nearest DC office
    2. AEPC

7 ANNEX

7.1 List of Works to be performed

- By NEA
  - Assess and Update/Allow alternative schemes than the Standard Process for proper implementation of the work for MHPs evacuating from 11/0.4 kV transformer less than 100 kVA.
- By AEPC
  - Play role as facilitator between NEA and the Community.
- By Community and Local Government
  - Develop Environment for Sustainable Operation of MHPs in Mini Grid and Grid Interconnection to National Grid in Future including acceptance of Revenue Sharing Methodology

7.2 MHPs in Jumla – Information Collected by NEA

नेपाल विद्युत प्राधिकरण
जुम्ला वितरण केन्द्र

जुम्ला जिल्लाका लघुजलविद्युतहरुको विवरण

सि.नं.	गाउपालीका/ न.पा	वडा नं.	आयोजनाको नाम	उत्पादन क्षमता (वाट)	कैफियत
१	कनकसुन्दरी	७, ८	छालसेरी	१७	
२	कनकसुन्दरी	५	हिमा नदी	१७	
३	कनकसुन्दरी	२	मालिका खोला		
४	कनकासुन्दरी	३	विराट		
५	कनकासुन्दरी	३ लुम	घट्टखोला		
६	कनकासुन्दरी	५ लुड्कु	महेन्द्रमल्ली	२०	
७	कनकासुन्दरी	३ गौरी	नौमुली	२	
८	कनकासुन्दरी	३ ओखर पाटा	घट्टखोला	२	
९	कनकासुन्दरी	४ लेखपोर	भैलपाटा	३	
१०	कनकासुन्दरी	१	चौघा		
११	कनकासुन्दरी	१	निउरीघाट		
१२	कनकासुन्दरी	२	रोत नौमुली	५५	निर्माणाधिन
१३	हिमा	१ आचार्यलिहि	भिखिखोला	२२	
१४	हिमा	१ बड्की	ओदीघाट	३२	
१५	हिमा	२ ओदी	ओदीघाट	१८	
१६	हिमा	७ चिउडीमची	मालुवाकोट्का	३०	
१७	हिमा	६ पातरखोला	खागलखोला	२८	निर्माणाधिन
१८	चन्दननाथ न.पा	३	घोडेन	५८	
१९	चन्दननाथ न.पा	१	ठिन्कपा	९८	
२०	गोठी चौर	१	चोत्रा	१०	
२१	गोठी चौर	२	वाखीला	५०	
२२	गोठी चौर	३	दोचालगाड	८६	
२३	गोठी चौर	५	नौमुले	७६.५	
२४	गोठी चौर	१	अदालीखोला	४३	निर्माणाधिन
२५	तातोपानी	४	आलापादेवी	२१४	
२६	तातोपानी	२	घट्टखोला	२०	
२७	तातोपानी	८	डुमिल्या	२५	
२८	तातोपानी	७	दारीमखोला	२	
२९	तातोपानी		धलाल	१५	
३०	तातोपानी		डागीबाडा वायु तथा सौर्य	२५	
३१	तातोपानी	४	गिठीखोला	७	
३२	तातोपानी	४	हाकु	२१	
३३	तातोपानी	४	जयन्पुर	१	
३४	तिला	२,७	रारा	३६	
३५	तिला	४	नालगाड	८	
३६	तिला	४	भेरीखोला	२३	
३७	तिला	६	सुडी		
३८	तिला	७	घोडेसिन		
३९	तिला		पुरु		
४०	तिला		जुम्लाकोट		
४१	तिला	९	मालापानी		
४२	तिला	९	छिपु साखाखोला		
४३	पातारासी	५	माथी लोर्पा	१२.५	
४४	पातारासी	५	तल लोर्पा	५	
४५	पातारासी	५	जप्न	१४	
४६	पातारासी	६	उर्थु	१४	
४७	पातारासी	६	बाता	१८	
४८	पातारासी	६	घोडासिन	८	
४९	पातारासी	७	पट्मारा	१३	
५०	पातारासी	७	रिनी	९	
५१	पातारासी	४	लुम	२८	
५२	पातारासी	४	लाम्री	५८	
५३	पातारासी	४	लाम्री	५	
५४	पातारासी	३	चौर	१३	
५५	पातारासी	२	हुरी	२८	
५६	पातारासी	१	महोरी	६	
५७	पातारासी	२	चुकेनी	९९८	निर्माणाधिन
५८	पातारासी	१	तल्फी	२३	
५९	पातारासी	१	गडीगाउ	४५	

7.3 **Load Flow Results**

The load flow results are presented here for four timeframe, wet peak, wet off peak, dry peak and dry off peak for both grid connected and isolated mode.

7.3.1 **Grid Connected Mode** – Voltage Profiles

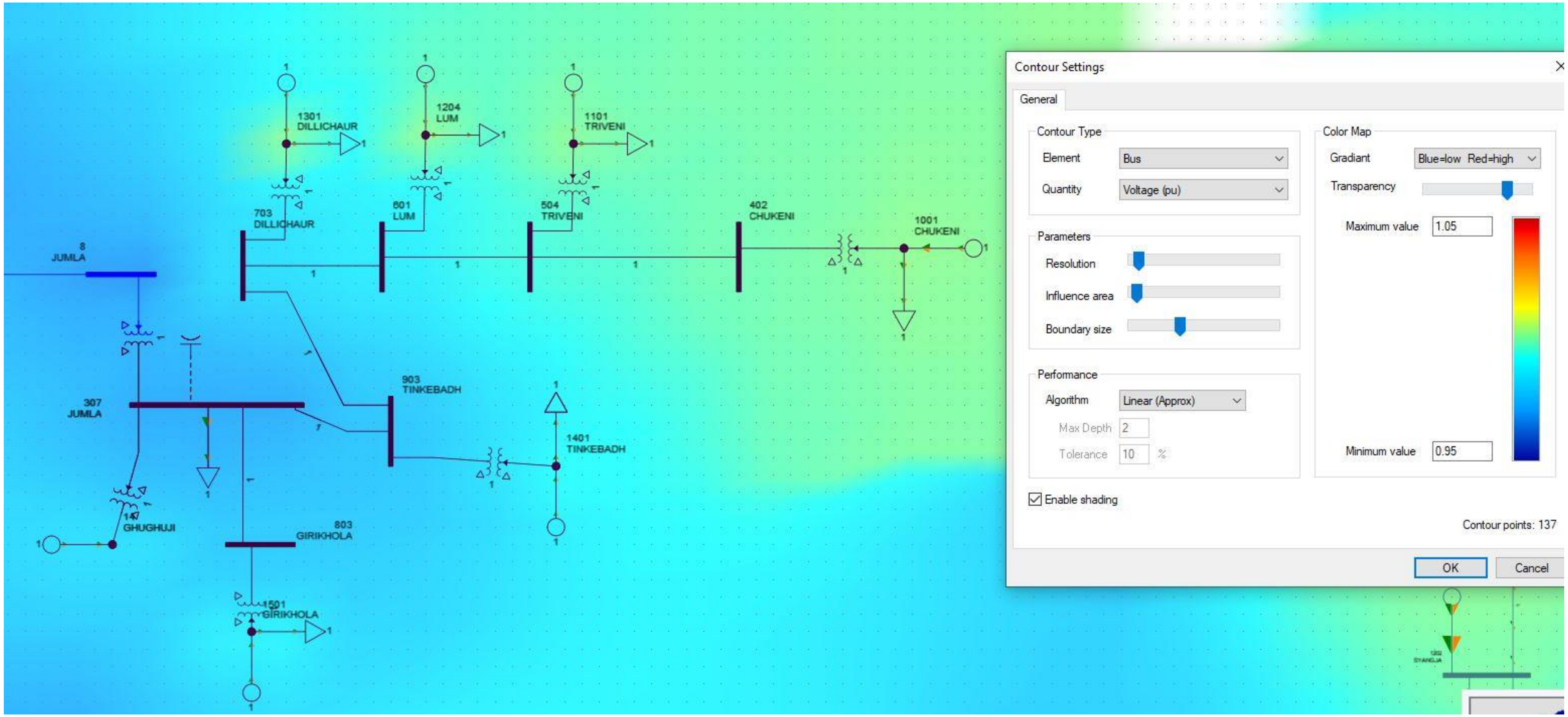


Figure 7-1:Voltage Profile for Grid Connected Mode - Dry Off peak

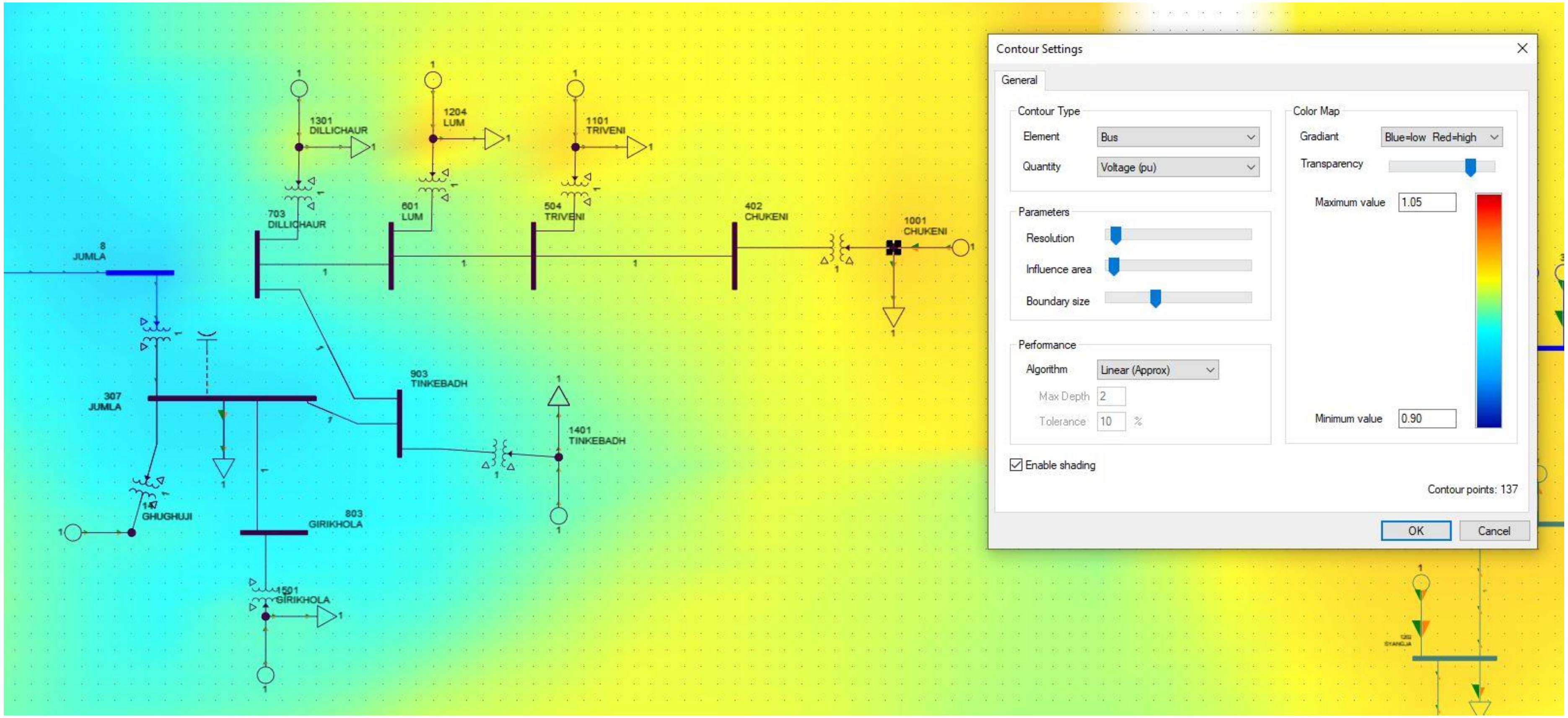


Figure 7-2: Voltage Profile for Grid Connected Mode - Dry Peak

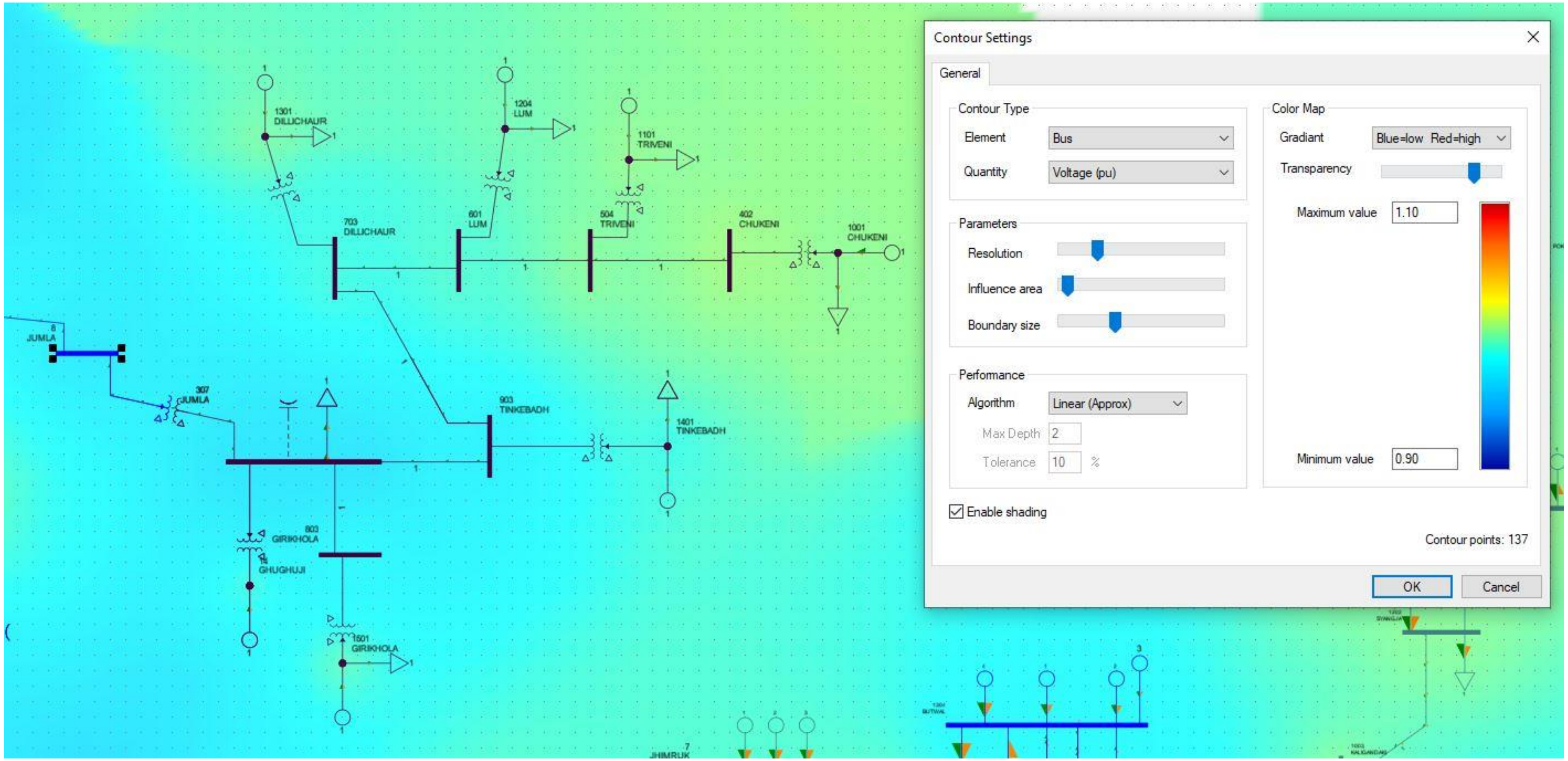


Figure 7-3: Voltage Profile for Grid Connected Mode - Wet Off Peak

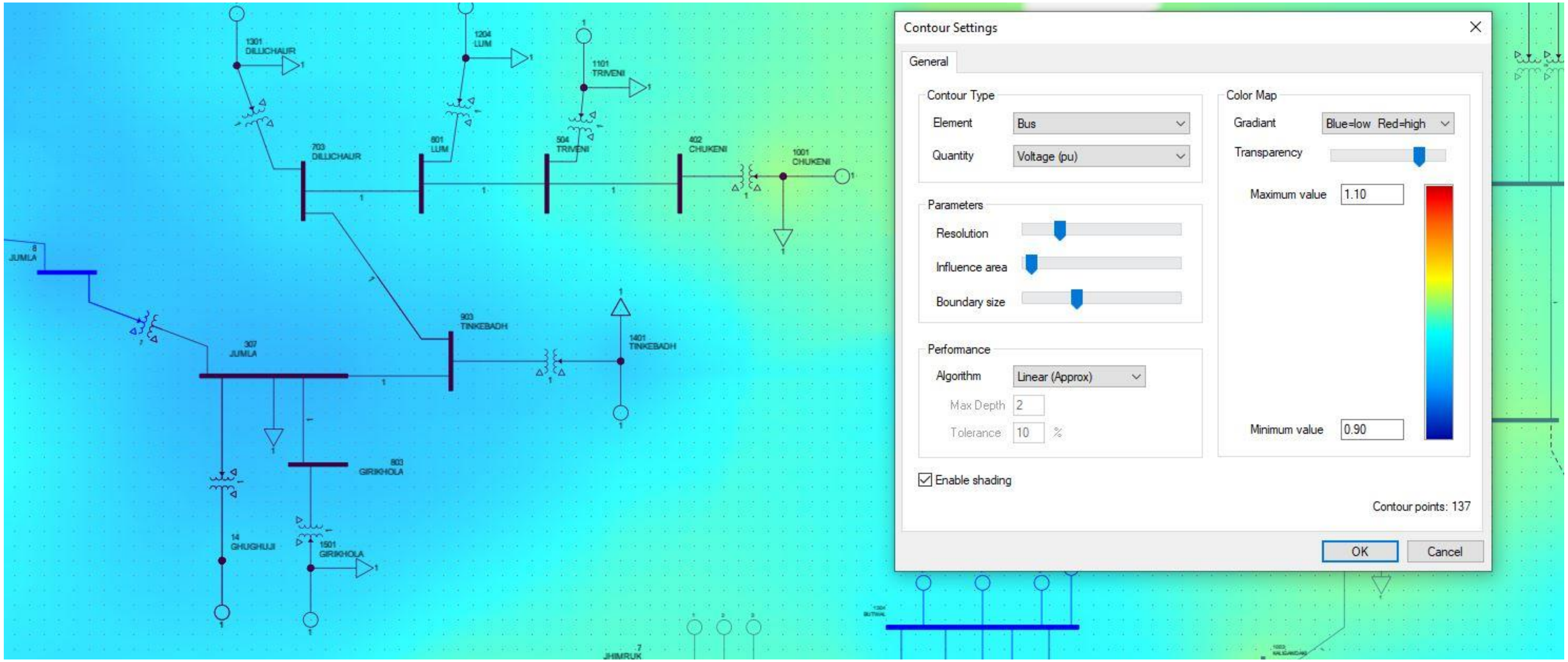


Figure 7-4: Voltage Profile for Grid Connected Mode - Wet Peak

7.3.2 Isolated Mode – Voltage Profiles

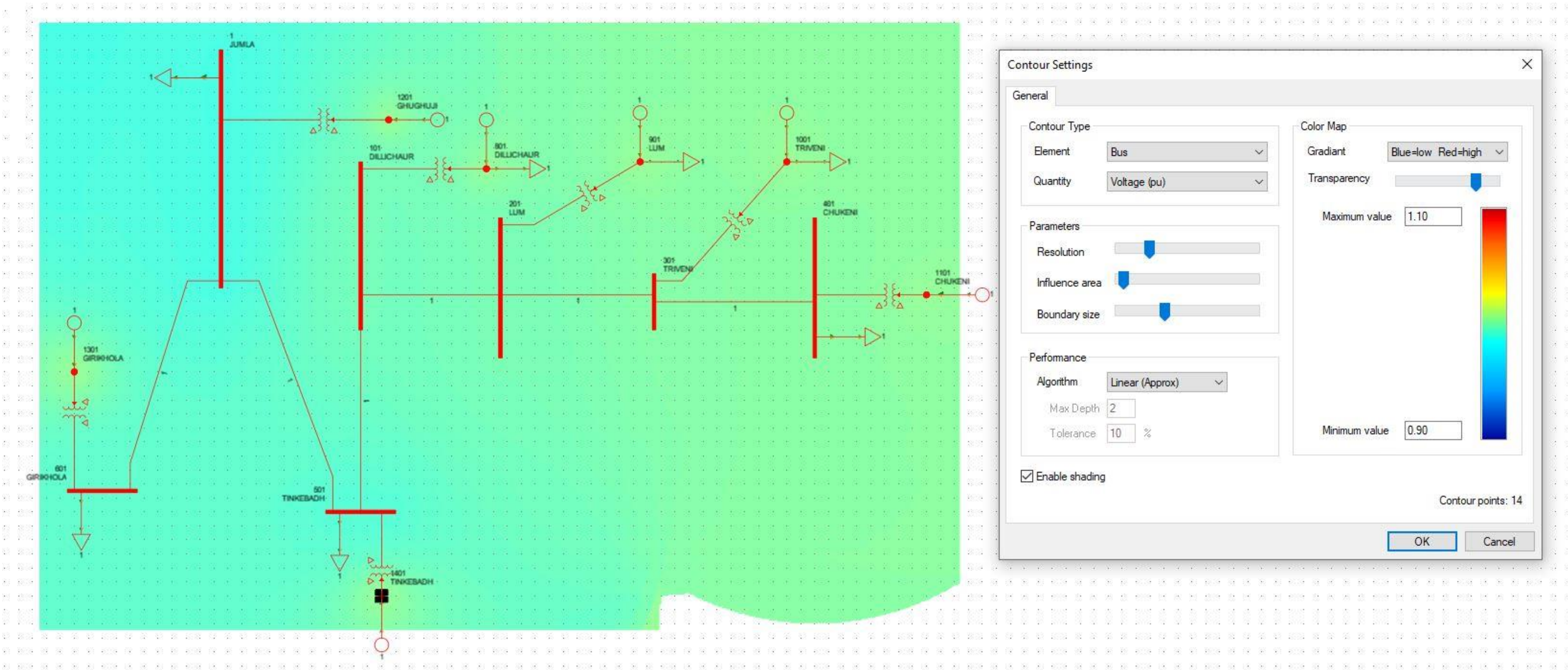


Figure 7-5: Voltage Profile for Isolated Mode - Dry Off Peak

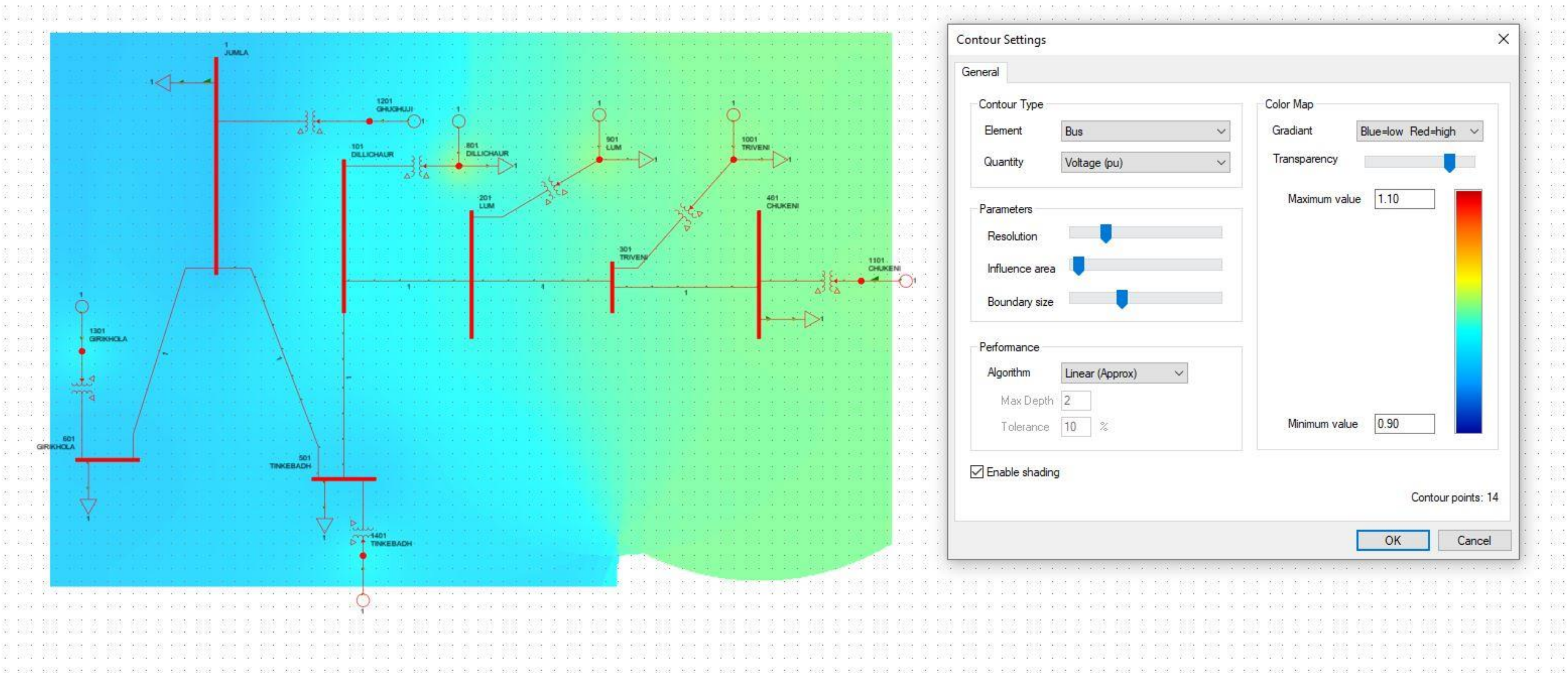


Figure 7-6: Voltage Profile for Isolated Mode - Dry Peak

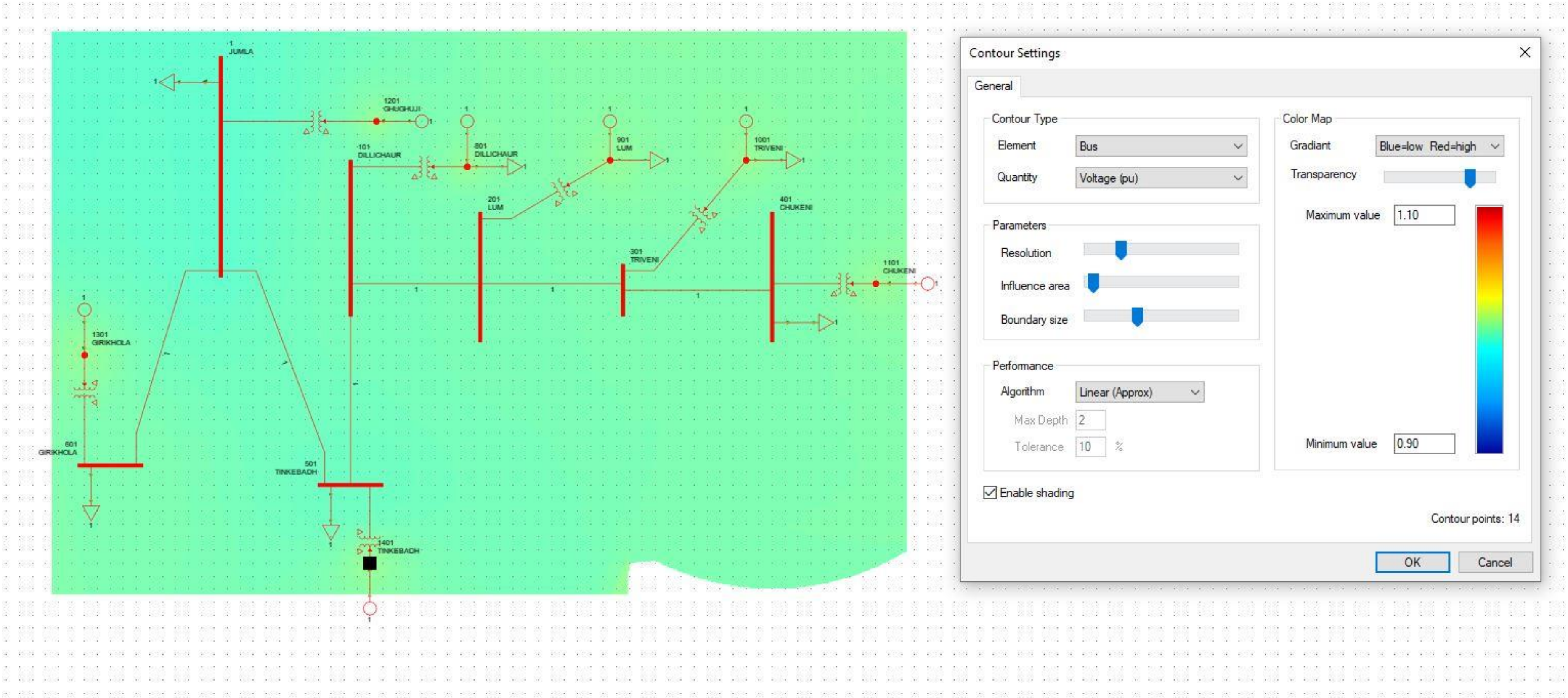


Figure 7-7: Voltage Profile for Isolated Mode - Wet Off Peak

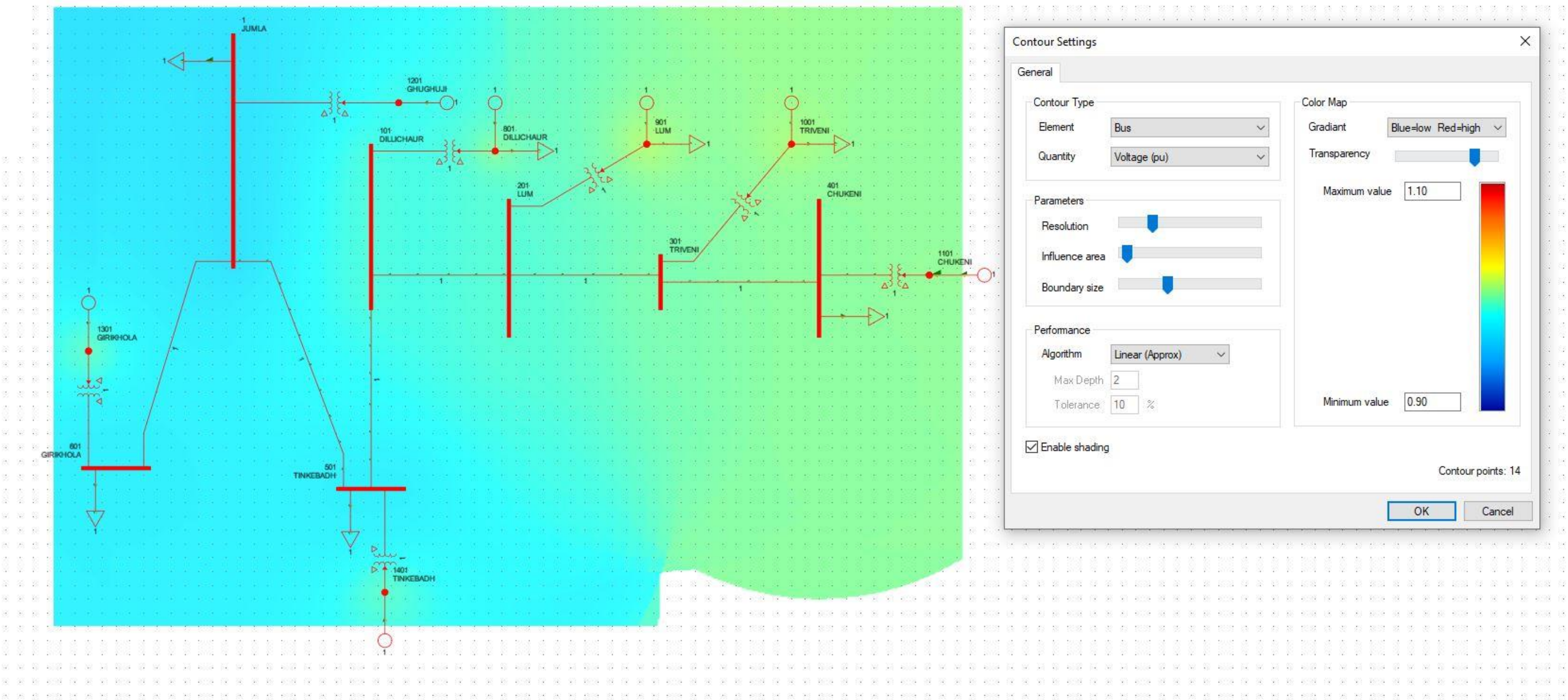


Figure 7-8: Voltage Profile for Isolated Mode - Wet Peak

7.4 **Load Flow Reports** for Isolated Minigrid Mode

7.4.1 **Wet Peak**

```
                              PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS(R)E     TUE, FEB 23 2021   9:42
                                                                                    %MVA FOR TRANSFORMERS
                                                                                    % I  FOR NON-TRANSFORMER BRANCHES

X--------- FROM BUS --------X AREA  VOLT           GEN    LOAD    SHUNT  X------------ TO BUS ------------X                       TRANSFORMER     RATING
  BUS#-SCT X-- NAME --X BASKV ZONE  PU/KV  ANGLE  KW/KVAR KW/KVAR KW/KVAR   BUS#-SCT X-- NAME --X BASKV AREA CKT    KW     KVAR    RATIO   ANGLE   %  SET 1

     1     JUMLA       11.000    1 0.9664  -7.1     0.0  1000.0     0.0 --------------------------------------------------------------------------------
                                 1 10.630           0.0   100.0    -0.0    501     TINKEBADH   11.000    1  1   -680.7    57.1
                                                                           601     GIRIKHOLA   11.000    1  1   -119.3   -70.3
                                                                          1201     GHUGHUJI    0.4000    1  1   -200.0   -86.8  1.000UN         87   250
   101     DILLICHAUR  11.000    1 0.9867  -5.8     0.0     0.0     0.0 --------------------------------------------------------------------------------
                                 1 10.854           0.0     0.0    -0.0    201     LUM         11.000    1  1   -651.3    94.5
                                                                           501     TINKEBADH   11.000    1  1    666.3   -80.8
                                                                           801     DILLICHAUR  0.4000    1  1    -15.0   -13.7  1.000UN         20   100
   201     LUM         11.000    1 0.9884  -5.6     0.0     0.0     0.0 --------------------------------------------------------------------------------
                                 1 10.872           0.0     0.0    -0.0    101     DILLICHAUR  11.000    1  1    652.8   -92.5
                                                                           301     TRIVENI     11.000    1  1   -643.5   107.3
                                                                           901     LUM         0.4000    1  1     -9.3   -14.8  1.000UN
   301     TRIVENI     11.000    1 0.9953  -4.8     0.0     0.0     0.0 --------------------------------------------------------------------------------
                                 1 10.948           0.0     0.0    -0.0    201     LUM         11.000    1  1    649.5  -101.8
                                                                           401     CHUKENI     11.000    1  1   -636.0   113.6
                                                                          1001     TRIVENI     0.4000    1  1    -13.5   -11.7  1.000UN         18   100
   401     CHUKENI     11.000    1 0.9986  -4.4     0.0   399.2     0.0 --------------------------------------------------------------------------------
```

			1 10.985		0.0	130.0	-0.0	301	TRIVENI	11.000	1 1	638.8	-111.0			
								1101	CHUKENI	0.4000	1 1	-1038.0	-19.0	1.000UN	80	1300
501	TINKEBADH	11.000	1 0.9730	-6.7	0.0	70.0	0.0	--------								
			1 10.703		0.0	10.0	-0.0	1	JUMLA	11.000	1 1	685.8	-53.2			
								101	DILLICHAUR	11.000	1 1	-655.8	86.8			
								1401	TINKEBADH	0.4000	1 1	-100.0	-43.6	1.000UN	109	100
601	GIRIKHOLA	11.000	1 0.9730	-7.1	0.0	80.0	0.0	--------								
			1 10.703		0.0	20.0	-0.0	1	JUMLA	11.000	1 1	120.0	67.0			
								1301	GIRIKHOLA	0.4000	1 1	-200.0	-87.0	1.000UN	87	250
801	DILLICHAUR	0.4000	1 0.9972	-5.2	50.0	35.0	0.0	--------								
			1 0.3989		24.0H	10.0	-0.0	101	DILLICHAUR	11.000	1 1	15.0	14.0	1.000LK	21	100
901	LUM	0.4000	1 1.0053	-5.0	31.0	21.7	0.0	--------								
			1 0.4021		0.0L	0.0	-0.0	201	LUM	11.000	1 1	9.3	15.2	1.000LK		
									M I S M A T C H			0.0	-15.2			
1001	TRIVENI	0.4000	1 1.0042	-4.2	45.0	31.5	0.0	--------								
			1 0.4017		0.0L	10.0	-0.0	301	TRIVENI	11.000	1 1	13.5	12.0	1.000LK	18	100
									M I S M A T C H			0.0	-22.0			
1101	CHUKENI	0.4000	1 1.0000	-2.3	1038.0	0.0	0.0	--------								
			1 0.4000		57.9R	0.0	-0.0	401	CHUKENI	11.000	1 1	1038.0	57.9	1.000LK	80	1300
1201	GHUGHUJI	0.4000	1 0.9833	-5.0	200.0	0.0	0.0	--------								
			1 0.3933		96.0H	0.0	-0.0	1	JUMLA	11.000	1 1	200.0	96.0	1.000LK	89	250
1301	GIRIKHOLA	0.4000	1 0.9897	-4.9	200.0	0.0	0.0	--------								
			1 0.3959		96.0H	0.0	-0.0	601	GIRIKHOLA	11.000	1 1	200.0	96.0	1.000LK	89	250
1401	TINKEBADH	0.4000	1 0.9891	-4.6	100.0	0.0	0.0	--------								

```
                                                 1 0.3957          48.0H     0.0    -0.0    501     TINKEBADH   11.000    1  1    100.0    48.0  1.000LK         111   100
```

7.4.2 Wet Off Peak

```
                                     PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS(R)E     TUE, FEB 23 2021   9:52
                                                                                  %MVA FOR TRANSFORMERS
                                                                                  % I  FOR NON-TRANSFORMER BRANCHES

X--------- FROM BUS --------X AREA  VOLT           GEN    LOAD    SHUNT  X------------ TO BUS ------------X                       TRANSFORMER     RATING
  BUS#-SCT X-- NAME --X BASKV ZONE  PU/KV  ANGLE  KW/KVAR KW/KVAR KW/KVAR   BUS#-SCT X-- NAME --X BASKV AREA CKT    KW     KVAR    RATIO   ANGLE   %  SET 1

     1     JUMLA       11.000    1 0.9898  -0.6     0.0   500.0     0.0 --------------------------------------------------------------------------------
                                 1 10.887           0.0   100.0    -0.0    501     TINKEBADH   11.000    1  1   -140.9   -43.3
                                                                           601     GIRIKHOLA   11.000    1  1   -159.1    -4.1
                                                                          1201     GHUGHUJI    0.4000    1  1   -200.0   -52.6  1.000UN          83   250
   101     DILLICHAUR  11.000    1 0.9941  -0.5     0.0     0.0     0.0 --------------------------------------------------------------------------------
                                 1 10.935           0.0     0.0    -0.0    201     LUM         11.000    1  1    -51.3   -20.1
                                                                           501     TINKEBADH   11.000    1  1     81.3    27.6
                                                                           801     DILLICHAUR  0.4000    1  1    -30.0    -7.5  1.000UN          31   100
   201     LUM         11.000    1 0.9944  -0.4     0.0     0.0     0.0 --------------------------------------------------------------------------------
                                 1 10.938           0.0     0.0    -0.0    101     DILLICHAUR  11.000    1  1     51.3    19.3
                                                                           301     TRIVENI     11.000    1  1    -30.3   -14.6
                                                                           901     LUM         0.4000    1  1    -21.0    -4.7  1.000UN
   301     TRIVENI     11.000    1 0.9950  -0.4     0.0     0.0     0.0 --------------------------------------------------------------------------------
                                 1 10.945           0.0     0.0    -0.0    201     LUM         11.000    1  1     30.3    12.2
                                                                           401     CHUKENI     11.000    1  1     -5.3    -5.8
                                                                          1001     TRIVENI     0.4000    1  1    -25.0    -6.4  1.000UN          26   100
   401     CHUKENI     11.000    1 0.9951  -0.4     0.0   200.0     0.0 --------------------------------------------------------------------------------
```

			1 10.946		0.0	130.0	-0.0	301	TRIVENI	11.000	1 1	5.3	4.5			
								1101	CHUKENI	0.4000	1 1	-205.3	-134.5	1.000UN	19	1300
501	TINKEBADH	11.000	1 0.9917	-0.5	0.0	40.0	0.0	--								
			1 10.908		0.0	10.0	-0.0	1	JUMLA	11.000	1 1	141.1	42.1			
								101	DILLICHAUR	11.000	1 1	-81.2	-30.0			
								1401	TINKEBADH	0.4000	1 1	-100.0	-22.1	1.000UN	102	100
601	GIRIKHOLA	11.000	1 0.9956	-0.3	0.0	40.0	0.0	--								
			1 10.952		0.0	20.0	-0.0	1	JUMLA	11.000	1 1	160.0	0.7			
								1301	GIRIKHOLA	0.4000	1 1	-200.0	-20.7	1.000UN	80	250
801	DILLICHAUR	0.4000	1 1.0000	0.8	50.0	20.0	0.0	--								
			1 0.4000		18.3R	10.0	-0.0	101	DILLICHAUR	11.000	1 1	30.0	8.3	1.000LK	31	100
901	LUM	0.4000	1 1.0000	0.9	31.0	10.0	0.0	--								
			1 0.4000		5.3R	0.0	-0.0	201	LUM	11.000	1 1	21.0	5.3	1.000LK		
1001	TRIVENI	0.4000	1 1.0000	0.7	45.0	20.0	0.0	--								
			1 0.4000		16.9R	10.0	-0.0	301	TRIVENI	11.000	1 1	25.0	6.9	1.000LK	26	100
1101	CHUKENI	0.4000	1 1.0000	0.0	205.3	0.0	0.0	--								
			1 0.4000		136.7R	0.0	-0.0	401	CHUKENI	11.000	1 1	205.3	136.7	1.000LK	19	1300
1201	GHUGHUJI	0.4000	1 1.0000	1.5	200.0	0.0	0.0	--								
			1 0.4000		60.5R	0.0	-0.0	1	JUMLA	11.000	1 1	200.0	60.5	1.000LK	84	250
1301	GIRIKHOLA	0.4000	1 1.0000	1.8	200.0	0.0	0.0	--								
			1 0.4000		28.1R	0.0	-0.0	601	GIRIKHOLA	11.000	1 1	200.0	28.1	1.000LK	81	250
1401	TINKEBADH	0.4000	1 1.0000	1.5	100.0	0.0	0.0	--								

```
                                      1 0.4000           25.8R     0.0    -0.0    501     TINKEBADH   11.000    1  1    100.0    25.8  1.000LK          103   100
```

7.4.3 Dry Peak

```
                                            PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS(R)E     TUE, FEB 23 2021  10:04
                                                                                                  %MVA FOR TRANSFORMERS
                                                                                                  % I  FOR NON-TRANSFORMER BRANCHES

 X--------- FROM BUS --------X AREA  VOLT            GEN    LOAD    SHUNT  X------------ TO BUS ------------X                       TRANSFORMER     RATING
   BUS#-SCT X-- NAME --X BASKV ZONE  PU/KV  ANGLE  KW/KVAR KW/KVAR KW/KVAR   BUS#-SCT X-- NAME --X BASKV AREA CKT    KW     KVAR    RATIO   ANGLE   %  SET 1

     1      JUMLA       11.000    1 0.9539  -6.3     0.0  1000.0     0.0 --------------------------------------------------------------------------------
                                  1 10.493           0.0   100.0    -0.0    501     TINKEBADH   11.000    1  1   -840.2    70.1
                                                                            601     GIRIKHOLA   11.000    1  1    -39.4   -76.6
                                                                           1201     GHUGHUJI    0.4000    1  1   -119.8   -93.5  1.000UN           61   250
                                                                                    M I S M A T C H                -0.5    -0.1
   101      DILLICHAUR  11.000    1 0.9806  -4.6     0.0     0.0     0.0 --------------------------------------------------------------------------------
                                  1 10.787           0.0     0.0    -0.0    201     LUM         11.000    1  1   -885.8   112.2
                                                                            501     TINKEBADH   11.000    1  1    876.4   -87.5
                                                                            801     DILLICHAUR  0.4000    1  1     10.0   -25.3  1.000UN           27   100
                                                                                    M I S M A T C H                -0.6     0.6
   201      LUM         11.000    1 0.9830  -4.3     0.0     0.0     0.0 --------------------------------------------------------------------------------
                                  1 10.813           0.0     0.0    -0.0    101     DILLICHAUR  11.000    1  1    888.7  -107.9
                                                                            301     TRIVENI     11.000    1  1   -888.6   122.9
                                                                            901     LUM         0.4000    1  1     -0.0   -14.8  1.000UN
   301      TRIVENI     11.000    1 0.9932  -3.2     0.0     0.0     0.0 --------------------------------------------------------------------------------
                                  1 10.925           0.0     0.0    -0.0    201     LUM         11.000    1  1    899.9  -110.1
                                                                            401     CHUKENI     11.000    1  1   -899.7   119.1
```

								1001	TRIVENI	0.4000	1	1	0.0	-9.0	1.000UN	9	100
401	CHUKENI	11.000	1 0.9983	-2.7	0.0	400.0	0.0	--------									
			1 10.981		0.0	130.0	-0.0	301	TRIVENI	11.000	1	1	905.4	-112.8			
								1101	CHUKENI	0.4000	1	1	-1305.0	-17.4	1.000UN	100	1300
501	TINKEBADH	11.000	1 0.9621	-5.7	0.0	70.0	0.0	--------									
			1 10.584		0.0	10.0	-0.0	1	JUMLA	11.000	1	1	848.2	-63.2			
								101	DILLICHAUR	11.000	1	1	-858.1	99.9			
								1401	TINKEBADH	0.4000	1	1	-59.9	-46.3	1.000UN	76	100
601	GIRIKHOLA	11.000	1 0.9578	-6.4	0.0	80.0	0.0	--------									
			1 10.535		0.0	20.0	-0.0	1	JUMLA	11.000	1	1	39.7	73.0			
								1301	GIRIKHOLA	0.4000	1	1	-119.8	-92.6	1.000UN	61	250
801	DILLICHAUR	0.4000	1 1.0000	-5.1	30.0	40.0	0.0	--------									
			1 0.4000		24.0H	10.0	-0.0	101	DILLICHAUR	11.000	1	1	-10.0	25.9	1.000LK	28	100
									M I S M A T C H				-0.0	-11.9			
901	LUM	0.4000	1 1.0000	-4.3	20.0	20.0	0.0	--------									
			1 0.4000		14.9H	0.0	-0.0	201	LUM	11.000	1	1	0.0	15.1	1.000LK		
1001	TRIVENI	0.4000	1 1.0000	-3.2	30.0	30.0	0.0	--------									
			1 0.4000		19.1R	10.0	-0.0	301	TRIVENI	11.000	1	1	-0.0	9.1	1.000LK	9	100
1101	CHUKENI	0.4000	1 1.0000	0.0	1305.0	0.0	0.0	--------									
			1 0.4000		78.9R	0.0	-0.0	401	CHUKENI	11.000	1	1	1305.0	78.9	1.000LK	101	1300
1201	GHUGHUJI	0.4000	1 0.9718	-5.0	120.0	0.0	0.0	--------									
			1 0.3887		96.0H	0.0	-0.0	1	JUMLA	11.000	1	1	119.8	98.0	1.000LK	62	250
									M I S M A T C H				0.2	-2.0			
1301	GIRIKHOLA	0.4000	1 0.9754	-5.1	120.0	0.0	0.0	--------									
			1 0.3902		96.0H	0.0	-0.0	601	GIRIKHOLA	11.000	1	1	119.8	97.1	1.000LK	62	250

```
                                                                                           M I S M A T C H                0.2    -1.1
  1401      TINKEBADH   0.4000     1 0.9790   -4.4    60.0       0.0      0.0 --------------------------------------------------------------------------------
                                   1 0.3916           48.0H      0.0     -0.0     501      TINKEBADH   11.000    1  1      59.9    48.4  1.000LK          77   100
```

7.4.4 Dry Off Peak

```
                                                                     PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS(R)E     TUE, FEB 23 2021   9:57
                                                                                              %MVA FOR TRANSFORMERS
                                                                                              % I  FOR NON-TRANSFORMER BRANCHES

X--------- FROM BUS --------X AREA  VOLT           GEN    LOAD    SHUNT  X------------ TO BUS ------------X                       TRANSFORMER     RATING
  BUS#-SCT X-- NAME --X BASKV ZONE  PU/KV  ANGLE  KW/KVAR KW/KVAR KW/KVAR   BUS#-SCT X-- NAME --X BASKV AREA CKT    KW     KVAR    RATIO   ANGLE   %  SET 1

     1      JUMLA       11.000     1 0.9853   -2.1     0.0     500.0      0.0 --------------------------------------------------------------------------------
                                   1 10.838            0.0     100.0     -0.0     501      TINKEBADH   11.000    1  1   -298.7    21.3
                                                                                  601      GIRIKHOLA   11.000    1  1    -80.5   -41.1
                                                                                 1201      GHUGHUJI    0.4000    1  1   -120.3   -79.3  1.000UN          58   250
                                                                                           M I S M A T C H               -0.4    -0.8
   101      DILLICHAUR  11.000     1 0.9937   -1.5     0.0       0.0      0.0 --------------------------------------------------------------------------------
                                   1 10.930            0.0       0.0     -0.0     201      LUM         11.000    1  1   -271.3    56.6
                                                                                  501      TINKEBADH   11.000    1  1    281.4   -47.1
                                                                                  801      DILLICHAUR  0.4000    1  1    -10.0    -8.3  1.000UN          13   100
                                                                                           M I S M A T C H               -0.1    -1.1
   201      LUM         11.000     1 0.9943   -1.4     0.0       0.0      0.0 --------------------------------------------------------------------------------
                                   1 10.937            0.0       0.0     -0.0     101      DILLICHAUR  11.000    1  1    271.5   -56.9
                                                                                  301      TRIVENI     11.000    1  1   -261.5    62.9
                                                                                  901      LUM         0.4000    1  1    -10.0    -5.0  1.000UN
```

```
                                                                   M I S M A T C H               -0.1    -1.0
  301     TRIVENI     11.000   1 0.9967  -1.1    0.0      0.0     0.0 --------------------------------------------------------------------------------
                               1 10.963          0.0      0.0    -0.0    201    LUM         11.000   1  1   262.5   -64.1
                                                                         401    CHUKENI     11.000   1  1  -252.5    69.7
                                                                        1001    TRIVENI     0.4000   1  1   -10.0    -4.4  1.000UN          11   100
                                                                   M I S M A T C H               -0.0    -1.3
  401     CHUKENI     11.000   1 0.9978  -0.9    0.0    200.0     0.0 --------------------------------------------------------------------------------
                               1 10.975          0.0    130.0    -0.0    301    TRIVENI     11.000   1  1   252.9   -70.4
                                                                        1101    CHUKENI     0.4000   1  1  -452.4   -58.5  1.000UN          35  1300
                                                                   M I S M A T C H               -0.5    -1.1
  501     TINKEBADH   11.000   1 0.9881  -1.9    0.0     40.0     0.0 --------------------------------------------------------------------------------
                               1 10.869          0.0     10.0    -0.0      1    JUMLA       11.000   1  1   299.7   -21.7
                                                                         101    DILLICHAUR  11.000   1  1  -279.5    46.2
                                                                        1401    TINKEBADH   0.4000   1  1   -60.1   -33.3  1.000UN          69   100
                                                                   M I S M A T C H               -0.1    -1.2
  601     GIRIKHOLA   11.000   1 0.9894  -2.0    0.0     40.0     0.0 --------------------------------------------------------------------------------
                               1 10.883          0.0     20.0    -0.0      1    JUMLA       11.000   1  1    80.8    37.3
                                                                        1301    GIRIKHOLA   0.4000   1  1  -120.5   -56.9  1.000UN          53   250
                                                                   M I S M A T C H               -0.4    -0.4
  801     DILLICHAUR  0.4000   1 1.0000  -1.1   30.0     20.0     0.0 --------------------------------------------------------------------------------
                               1 0.4000         18.5R    10.0    -0.0    101    DILLICHAUR  11.000   1  1    10.0     8.5  1.000LK          13   100

  901     LUM         0.4000   1 1.0000  -0.8   20.0     10.0     0.0 --------------------------------------------------------------------------------
                               1 0.4000          5.2R     0.0    -0.0    201    LUM         11.000   1  1    10.0     5.2  1.000LK

 1001     TRIVENI     0.4000   1 1.0000  -0.7   30.0     20.0     0.0 --------------------------------------------------------------------------------
                               1 0.4000         14.5R    10.0    -0.0    301    TRIVENI     11.000   1  1    10.0     4.5  1.000LK          11   100
```

```
  1101     CHUKENI     0.4000    1 1.0000    0.0   452.4      0.0      0.0 --------------------------------------------------------------------------------
                                 1 0.4000          66.0R      0.0     -0.0    401     CHUKENI     11.000    1  1    452.4    66.0  1.000LK          35  1300

  1201     GHUGHUJI    0.4000    1 1.0000   -0.8   120.0      0.0      0.0 --------------------------------------------------------------------------------
                                 1 0.4000          83.2R      0.0     -0.0      1     JUMLA       11.000    1  1    120.3    83.2  1.000LK          59   250

  1301     GIRIKHOLA   0.4000    1 1.0000   -0.8   120.0      0.0      0.0 --------------------------------------------------------------------------------
                                 1 0.4000          60.2R      0.0     -0.0    601     GIRIKHOLA   11.000    1  1    120.5    60.2  1.000LK          54   250

  1401     TINKEBADH   0.4000    1 1.0000   -0.7    60.0      0.0      0.0 --------------------------------------------------------------------------------
                                 1 0.4000          34.9R      0.0     -0.0    501     TINKEBADH   11.000    1  1     60.1    34.9  1.000LK          70   100
```

7.5 **Load Flo**w Reports for Grid Connected Mini Grid

7.5.1 Wet Peak

```
                                                          PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS(R)E     TUE, FEB 23 2021  11:43
                                                                                  %MVA FOR TRANSFORMERS
                                                                                  % I  FOR NON-TRANSFORMER BRANCHES
                                                        OUTPUT FOR OWNER 6 [            ]

X--------- FROM BUS --------X AREA  VOLT           GEN     LOAD    SHUNT  X------------ TO BUS ------------X                       TRANSFORMER     RATING
  BUS#-SCT X-- NAME --X BASKV ZONE  PU/KV  ANGLE  KW/KVAR KW/KVAR KW/KVAR   BUS#-SCT X-- NAME --X BASKV AREA CKT    KW     KVAR    RATIO   ANGLE   %  SET 1

     8     JUMLA       33.000    1 0.9517  -37.5     0.0      0.0      0.0 --------------------------------------------------------------------------------
                                 1 31.407            0.0      0.0     -0.0    307     JUMLA       11.000    1  1     36.1   -32.2  1.000LK           2  3000
                                                                              403     MANMA       33.000    1  1    -36.1    32.2
    14     GHUGHUJI    0.4000    1 0.9694  -35.3   200.0      0.0      0.0 --------------------------------------------------------------------------------
```

			1 0.3878		96.0H	0.0	-0.0	307	JUMLA	11.000	1	1	200.0	96.0	1.000UN	74	300
307	JUMLA	11.000	1 0.9523	-37.6	0.0	1000.0	0.0	---									
			1 10.475		0.0	330.0	-0.0	8	JUMLA	33.000	1	1	-36.1	32.2	1.000UN	2	3000
								14	GHUGHUJI	0.4000	1	1	-200.0	-86.6	1.000LK	73	300
								803	GIRIKHOLA	11.000	1	1	-119.3	-67.5			
								903	TINKEBADH	11.000	1	1	-644.6	-208.2			
402	CHUKENI	11.000	1 0.9936	-35.8	0.0	0.0	0.0	---									
			1 10.930		0.0	0.0	-0.0	504	TRIVENI	11.000	1	1	598.0	170.2			
								1001	CHUKENI	0.4000	1	1	-598.0	-170.2	1.000UN	48	1300
601	LUM	11.000	1 0.9763	-36.5	0.0	0.0	0.0	---									
			1 10.739		0.0	0.0	-0.0	504	TRIVENI	11.000	1	1	-602.7	-174.1			
								703	DILLICHAUR	11.000	1	1	611.7	178.9			
								1204	LUM	0.4000	1	1	-9.0	-4.8	1.000UN		
703	DILLICHAUR	11.000	1 0.9723	-36.7	0.0	0.0	0.0	---									
			1 10.695		0.0	0.0	-0.0	601	LUM	11.000	1	1	-609.8	-177.1			
								903	TINKEBADH	11.000	1	1	624.8	190.7			
								1301	DILLICHAUR	0.4000	1	1	-15.0	-13.7	1.000UN	20	100
803	GIRIKHOLA	11.000	1 0.9599	-37.4	0.0	0.0	0.0	---									
			1 10.559		0.0	0.0	-0.0	307	JUMLA	11.000	1	1	120.0	62.4			
								1501	GIRIKHOLA	0.4000	1	1	-120.0	-62.4	1.000UN	45	300
903	TINKEBADH	11.000	1 0.9600	-37.2	0.0	0.0	0.0	---									
			1 10.560		0.0	0.0	-0.0	307	JUMLA	11.000	1	1	648.6	212.2			
								703	DILLICHAUR	11.000	1	1	-618.6	-184.8			
								1401	TINKEBADH	0.4000	1	1	-30.0	-27.4	1.000UN	41	100
1001	CHUKENI	0.4000	1 1.0000	-34.5	998.0	400.0	0.0	---									
			1 0.4000		314.3R	130.0	-0.0	402	CHUKENI	11.000	1	1	598.0	184.3	1.000LK	48	1300

```
  1101     TRIVENI     0.4000    1 0.9966  -35.4     45.0      32.0      0.0 --------------------------------------------------------------------------------
                                 1 0.3986            21.6H     10.0     -0.0     504     TRIVENI     11.000    1  1     13.0    11.6  1.000LK          17   100

  1204     LUM         0.4000    1 0.9818  -35.9     31.0      22.0      0.0 --------------------------------------------------------------------------------
                                 1 0.3927            14.9H     10.0     -0.0     601     LUM         11.000    1  1      9.0     4.9  1.000LK

  1301     DILLICHAUR  0.4000    1 0.9829  -36.0     50.0      35.0      0.0 --------------------------------------------------------------------------------
                                 1 0.3932            24.0H     10.0     -0.0     703     DILLICHAUR  11.000    1  1     15.0    14.0  1.000LK          21   100

  1401     TINKEBADH   0.4000    1 0.9699  -36.6    100.0      70.0      0.0 --------------------------------------------------------------------------------
                                 1 0.3880            48.0H     20.0     -0.0     903     TINKEBADH   11.000    1  1     30.0    28.0  1.000LK          41   100
```

7.5.2 Wet Off Peak

```
                                 PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS(R)E     TUE, FEB 23 2021  11:24

                                                                        %MVA FOR TRANSFORMERS
                                                                        % I  FOR NON-TRANSFORMER BRANCHES
                                          OUTPUT FOR OWNER 6 [            ]

 X--------- FROM BUS --------X AREA  VOLT           GEN    LOAD    SHUNT  X------------ TO BUS ------------X                        TRANSFORMER     RATING
   BUS#-SCT X-- NAME --X BASKV ZONE  PU/KV  ANGLE  KW/KVAR KW/KVAR KW/KVAR  BUS#-SCT X-- NAME --X BASKV AREA CKT    KW     KVAR    RATIO   ANGLE   %  SET 1

     8     JUMLA       33.000    1 0.9753  -31.8      0.0       0.0      0.0 --------------------------------------------------------------------------------
                                 1 32.185             0.0       0.0     -0.0     307     JUMLA       11.000    1  1   -807.6   123.9  1.000LK          27  3000
                                                                                 403     MANMA       33.000    1  1    807.7  -124.3
```

```
  14    GHUGHUJI    0.4000    1 0.9901  -28.8   200.0      0.0      0.0 --------------------------------------------------------------------------------
                              1 0.3960           96.0H     0.0     -0.0    307    JUMLA       11.000    1  1    200.0    96.0  1.000UN        74   300

 307    JUMLA       11.000    1 0.9733  -31.0     0.0    500.0      0.0 --------------------------------------------------------------------------------
                              1 10.706            0.0    164.0     -0.0      8    JUMLA       33.000    1  1    807.6  -112.2  1.000UN        27  3000
                                                                            14    GHUGHUJI    0.4000    1  1   -200.0   -86.9  1.000LK        73   300
                                                                           803    GIRIKHOLA   11.000    1  1   -169.0   -86.2
                                                                           903    TINKEBADH   11.000    1  1   -938.5   121.2
 402    CHUKENI     11.000    1 1.0046  -27.4     0.0      0.0      0.0 --------------------------------------------------------------------------------
                              1 11.050            0.0      0.0     -0.0    504    TRIVENI     11.000    1  1    798.6  -139.3
                                                                          1001    CHUKENI     0.4000    1  1   -797.9   138.8  1.000UN        62  1300
                                                                                  M I S M A T C H                  -0.7     0.5
 601    LUM         11.000    1 0.9919  -28.9     0.0      0.0      0.0 --------------------------------------------------------------------------------
                              1 10.911            0.0      0.0     -0.0    504    TRIVENI     11.000    1  1   -819.4   155.0
                                                                           703    DILLICHAUR  11.000    1  1    840.7  -149.1
                                                                          1204    LUM         0.4000    1  1    -21.0    -6.8  1.000UN
                                                                                  M I S M A T C H                  -0.3     0.9
 703    DILLICHAUR  11.000    1 0.9890  -29.2     0.0      0.0      0.0 --------------------------------------------------------------------------------
                              1 10.879            0.0      0.0     -0.0    601    LUM         11.000    1  1   -837.3   152.8
                                                                           903    TINKEBADH   11.000    1  1    877.5  -138.3
                                                                          1301    DILLICHAUR  0.4000    1  1    -40.0   -13.8  1.000UN        42   100
                                                                                  M I S M A T C H                  -0.2    -0.6
 803    GIRIKHOLA   11.000    1 0.9834  -30.7     0.0      0.0      0.0 --------------------------------------------------------------------------------
                              1 10.818            0.0      0.0     -0.0    307    JUMLA       11.000    1  1    170.3    81.6
                                                                          1501    GIRIKHOLA   0.4000    1  1   -169.8   -81.5  1.000UN        63   300
                                                                                  M I S M A T C H                  -0.5    -0.2
 903    TINKEBADH   11.000    1 0.9797  -30.3     0.0      0.0      0.0 --------------------------------------------------------------------------------
                              1 10.776            0.0      0.0     -0.0    307    JUMLA       11.000    1  1    946.0  -112.6
```

```
                                                                                             703     DILLICHAUR  11.000    1  1   -866.6   150.7
                                                                                            1401     TINKEBADH   0.4000    1  1    -80.0   -38.2  1.000UN          89   100
                                                                                                     M I S M A T C H                   0.5     0.1
  1001     CHUKENI     0.4000    1 1.0000  -25.8   998.0    200.0     0.0 -----------------------------------------------------------------------------------
                                 1 0.4000          -49.4R    66.0    -0.0    402     CHUKENI     11.000    1  1    797.9  -115.4  1.000LK          62  1300

  1101     TRIVENI     0.4000    1 1.0000  -26.4    45.0     10.0     0.0 -----------------------------------------------------------------------------------
                                 1 0.4000             2.9R    3.0    -0.0    504     TRIVENI     11.000    1  1     35.0    -0.1  1.000LK          35   100

  1204     LUM         0.4000    1 1.0000  -27.5    31.0     10.0     0.0 -----------------------------------------------------------------------------------
                                 1 0.4000             9.4R    2.0    -0.0    601     LUM         11.000    1  1     21.0     7.4  1.000LK

  1301     DILLICHAUR  0.4000    1 1.0000  -27.5    50.0     10.0     0.0 -----------------------------------------------------------------------------------
                                 1 0.4000            18.2R    3.0    -0.0    703     DILLICHAUR  11.000    1  1     40.0    15.2  1.000LK          43   100

  1401     TINKEBADH   0.4000    1 0.9936  -28.7   100.0     20.0     0.0 -----------------------------------------------------------------------------------
                                 1 0.3974            48.0H    7.0    -0.0    903     TINKEBADH   11.000    1  1     80.0    41.0  1.000LK          90   100
```

7.5.3 Dry Peak

```
                                        PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS(R)E     TUE, FEB 23 2021  11:27
                                                                                          %MVA FOR TRANSFORMERS
                                                                                          % I  FOR NON-TRANSFORMER BRANCHES
                                                          OUTPUT FOR OWNER 6 [            ]

X--------- FROM BUS --------X AREA  VOLT            GEN    LOAD    SHUNT  X------------ TO BUS ------------X                        TRANSFORMER     RATING
  BUS#-SCT X-- NAME --X BASKV ZONE  PU/KV  ANGLE  KW/KVAR KW/KVAR KW/KVAR   BUS#-SCT X-- NAME --X BASKV AREA CKT    KW     KVAR    RATIO   ANGLE   %  SET 1
```

8	JUMLA	33.000	1 0.9414	-41.6	0.0	0.0	0.0	--									
			1 31.066		0.0	0.0	-0.0	307	JUMLA	11.000	1	1	569.8	-252.8	1.000LK	21	3000
								403	MANMA	33.000	1	1	-569.8	252.8			
14	GHUGHUJI	0.4000	1 0.9636	-40.9	120.0	0.0	0.0	--									
			1 0.3854		96.0H	0.0	-0.0	307	JUMLA	11.000	1	1	120.0	96.0	1.000UN	51	300
307	JUMLA	11.000	1 0.9459	-42.3	0.0	1000.0	0.0	--									
			1 10.405		0.0	329.0	-0.0	8	JUMLA	33.000	1	1	-569.8	260.1	1.000UN	21	3000
								14	GHUGHUJI	0.4000	1	1	-120.0	-91.4	1.000LK	50	300
								803	GIRIKHOLA	11.000	1	1	-69.6	-83.2			
								903	TINKEBADH	11.000	1	1	-240.6	-414.6			
402	CHUKENI	11.000	1 0.9806	-42.5	0.0	0.0	0.0	--									
			1 10.787		0.0	0.0	-0.0	504	TRIVENI	11.000	1	1	200.0	342.1			
								1001	CHUKENI	0.4000	1	1	-200.0	-342.1	1.000UN	30	1300
601	LUM	11.000	1 0.9664	-42.4	0.0	0.0	0.0	--									
			1 10.631		0.0	0.0	-0.0	504	TRIVENI	11.000	1	1	-206.4	-355.3			
								703	DILLICHAUR	11.000	1	1	216.4	366.9			
								1204	LUM	0.4000	1	1	-10.0	-11.6	1.000UN		
703	DILLICHAUR	11.000	1 0.9631	-42.4	0.0	0.0	0.0	--									
			1 10.594		0.0	0.0	-0.0	601	LUM	11.000	1	1	-215.6	-366.5			
								903	TINKEBADH	11.000	1	1	225.6	383.2			
								1301	DILLICHAUR	0.4000	1	1	-10.0	-16.7	1.000UN	19	100
803	GIRIKHOLA	11.000	1 0.9525	-42.2	0.0	0.0	0.0	--									
			1 10.477		0.0	0.0	-0.0	307	JUMLA	11.000	1	1	70.0	77.8			
								1501	GIRIKHOLA	0.4000	1	1	-70.0	-77.8	1.000UN	35	300
903	TINKEBADH	11.000	1 0.9526	-42.3	0.0	0.0	0.0	--									
			1 10.479		0.0	0.0	-0.0	307	JUMLA	11.000	1	1	242.6	415.9			

```
                                                                  703     DILLICHAUR  11.000    1  1   -222.6  -381.5
                                                                 1401     TINKEBADH   0.4000    1  1    -20.0   -34.4  1.000UN          40   100
  1001     CHUKENI     0.4000    1 0.9932  -42.1   600.0    400.0     0.0 ---------------------------------------------------------------------------------
                                 1 0.3973          479.0H   131.0    -0.0   402     CHUKENI     11.000    1  1    200.0   348.0  1.000LK          31  1300

  1101     TRIVENI     0.4000    1 0.9871  -42.0    30.0     20.0     0.0 ---------------------------------------------------------------------------------
                                 1 0.3948           21.6H     7.0    -0.0   504     TRIVENI     11.000    1  1     10.0    14.6  1.000LK          18   100

  1204     LUM         0.4000    1 0.9800  -41.7    20.0     10.0     0.0 ---------------------------------------------------------------------------------
                                 1 0.3920           14.9H     3.0    -0.0   601     LUM         11.000    1  1     10.0    11.9  1.000LK

  1301     DILLICHAUR  0.4000    1 0.9761  -41.9    30.0     20.0     0.0 ---------------------------------------------------------------------------------
                                 1 0.3904           24.0H     7.0    -0.0   703     DILLICHAUR  11.000    1  1     10.0    17.0  1.000LK          20   100

  1401     TINKEBADH   0.4000    1 0.9651  -41.9    60.0     40.0     0.0 ---------------------------------------------------------------------------------
                                 1 0.3860           48.0H    13.0    -0.0   903     TINKEBADH   11.000    1  1     20.0    35.0  1.000LK          40   100
```

7.5.4 Dry Off Peak

```
                                       PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS(R)E     TUE, FEB 23 2021  11:25
                                                                                        %MVA FOR TRANSFORMERS
                                                                                        % I  FOR NON-TRANSFORMER BRANCHES
                                                         OUTPUT FOR OWNER 6 [            ]

X--------- FROM BUS --------X AREA  VOLT            GEN     LOAD    SHUNT  X------------ TO BUS ------------X                        TRANSFORMER     RATING
  BUS#-SCT X-- NAME --X BASKV ZONE  PU/KV   ANGLE  KW/KVAR KW/KVAR KW/KVAR   BUS#-SCT X-- NAME --X BASKV AREA CKT    KW     KVAR    RATIO   ANGLE   %  SET 1
```

8	JUMLA	33.000	1 0.9678	-36.3	0.0	0.0	0.0	------------								
			1 31.938		0.0	0.0	-0.0	307	JUMLA	11.000	1 1	-189.8	-162.3	1.000LK	8	3000
								403	MANMA	33.000	1 1	189.8	162.3			
14	GHUGHUJI	0.4000	1 0.9879	-34.8	120.0	0.0	0.0	------------								
			1 0.3951		96.0H	0.0	-0.0	307	JUMLA	11.000	1 1	120.0	96.0	1.000UN	51	300
307	JUMLA	11.000	1 0.9706	-36.1	0.0	500.0	0.0	------------								
			1 10.677		0.0	164.0	-0.0	8	JUMLA	33.000	1 1	189.8	163.4	1.000UN	8	3000
								14	GHUGHUJI	0.4000	1 1	-120.0	-91.6	1.000LK	50	300
								803	GIRIKHOLA	11.000	1 1	-89.4	-90.6			
								903	TINKEBADH	11.000	1 1	-480.4	-145.2			
402	CHUKENI	11.000	1 0.9974	-34.8	0.0	0.0	0.0	------------								
			1 10.971		0.0	0.0	-0.0	504	TRIVENI	11.000	1 1	400.0	70.2			
								1001	CHUKENI	0.4000	1 1	-400.0	-70.2	1.000UN	31	1300
601	LUM	11.000	1 0.9868	-35.3	0.0	0.0	0.0	------------								
			1 10.855		0.0	0.0	-0.0	504	TRIVENI	11.000	1 1	-416.4	-76.9			
								703	DILLICHAUR	11.000	1 1	426.4	88.4			
								1204	LUM	0.4000	1 1	-10.0	-11.5	1.000UN		
703	DILLICHAUR	11.000	1 0.9843	-35.5	0.0	0.0	0.0	------------								
			1 10.828		0.0	0.0	-0.0	601	LUM	11.000	1 1	-425.5	-88.0			
								903	TINKEBADH	11.000	1 1	445.5	108.4			
								1301	DILLICHAUR	0.4000	1 1	-20.0	-20.4	1.000UN	29	100
803	GIRIKHOLA	11.000	1 0.9781	-36.0	0.0	0.0	0.0	------------								
			1 10.759		0.0	0.0	-0.0	307	JUMLA	11.000	1 1	90.0	85.1			
								1501	GIRIKHOLA	0.4000	1 1	-90.0	-85.1	1.000UN	41	300
903	TINKEBADH	11.000	1 0.9762	-35.9	0.0	0.0	0.0	------------								
			1 10.738		0.0	0.0	-0.0	307	JUMLA	11.000	1 1	482.5	146.6			
								703	DILLICHAUR	11.000	1 1	-442.5	-106.8			

```
                                                               1401     TINKEBADH   0.4000    1  1    -40.0    -39.8  1.000UN          56   100
1001     CHUKENI     0.4000    1 1.0000  -34.0   600.0    200.0      0.0 ---------------------------------------------------------------------------------
                               1 0.4000          142.2R    66.0     -0.0    402     CHUKENI     11.000    1  1    400.0     76.2  1.000LK          31  1300

1101     TRIVENI     0.4000    1 1.0000  -34.1    30.0     10.0      0.0 ---------------------------------------------------------------------------------
                               1 0.4000           11.2R     3.0     -0.0    504     TRIVENI     11.000    1  1     20.0      8.2  1.000LK          22   100

1204     LUM         0.4000    1 1.0000  -34.7    20.0     10.0      0.0 ---------------------------------------------------------------------------------
                               1 0.4000           13.8R     2.0     -0.0    601     LUM         11.000    1  1     10.0     11.8  1.000LK

1301     DILLICHAUR  0.4000    1 1.0000  -34.6    30.0     10.0      0.0 ---------------------------------------------------------------------------------
                               1 0.4000           24.0H     3.0     -0.0    703     DILLICHAUR  11.000    1  1     20.0     21.0  1.000LK          29   100

1401     TINKEBADH   0.4000    1 0.9904  -35.1    60.0     20.0      0.0 ---------------------------------------------------------------------------------
                               1 0.3962           48.0H     7.0     -0.0    903     TINKEBADH   11.000    1  1     40.0     41.0  1.000LK          57   100
```

7.6 Cost Estimate of Grid Interconnection of MHPs

Table 7-1: Cost Estimate unit rates for MHP Grid Interconnection in Jumla

SN	Particular	Unit	CIP Price	Installation/Erection, Testing and Commissioning
			NPR	NPR
1	**Supply, Delivery, Installation of Synchronizing/Controller Panel with all digital relays**			
1.1	Supply, Delivery, Installation of Synchronizing/Controller Panel with all digital relays for ELC based MHP	Set	562,500.00	-
1.2	Supply, Delivery, Installation Synchronizing/Controller Panel with all digital relays with Governor Based Controller Suitable for Grid Interconnection	Set	687,500.00	-
2	**DC Supply System**			
1	**Supply, Delivery, Installation of Synchronizing/Controller Panel with all digital relays**			
1.1	Supply, Delivery, Installation of Synchronizing/Controller Panel with all digital relays for ELC based MHP	Set	562,500.00	-
1.2	Supply, Delivery, Installation Synchronizing/Controller Panel with all digital relays with Governor Based Controller Suitable for Grid Interconnection	Set	687,500.00	-

SN	Particular	Unit	CIP Price	Installation/Erection, Testing and Commissioning
			NPR	NPR
2	**DC Supply System**			
2.1	Supply, Delivery and Installation of Inverter cum Battery charger with 24-V Battery System, Input 230 V, Output 230V Sine Wave with accessories all complete	Set	100,000.00	-
3	**Switches, Disconnectors and Surge Arresters**			
3.1	Supply Delivery and Installation of Outdoor VCB with Over Current and Earth Fault Relay with essential accessories all complete	Set	907,536.00	41,443.20
3.2	Supply, Delivery, and Installation of Air Circuit Breaker of suitable rating with accessories and spare parts for operation for 2 years, all complete	set	250,000.00	-
3.3	Supply, Delivery, and Installation of 11 kV Pole Mounted Disconnecting Switch, with accessories and spare parts for operation for 2 years all complete	Set	50,000.00	-
3.4	Supply Delivery and Installation of MCCB with shunt Trip coil with essential accessories all complete	pcs	60,000.00	-
3.5	Supply Delivery and Installation of Drop Out Fuse, 11 kV with essential accessories all complete	Set	5,500.00	-

SN	Particular	Unit	CIP Price	Installation/Erection, Testing and Commissioning
			NPR	NPR
3.6	Supply Delivery and Installation of DO Operating Rod with essential accessories all complete	No.	4,000.00	-
3.7	Supply Delivery and Installation of MCB with boxes and essential accessories all complete	No.	345.00	-
3.8	Supply Delivery and Installation of Lighting Arrester at High Tension with essential accessories all complete	Set	5,500.00	-
3.9	Supply Delivery and Installation of Lighting Arrester at low Tension kV with essential accessories all complete	Set	3,000.00	-
4	**Metering and Synchronizing Equipment**			
4.1	Supply Delivery and Installation of Digital kW, kWh, PF, Frequency meter, ammeter & voltmeter with selector switch with essential accessories all complete	set	100,000.00	-
4.2	Supply Delivery and Installation of Synchronizer (synchronoscope, Dual frequency and voltmeter, dark lamp set, differential etc.) with Auto & Manual Selector Switch with essential accessories all complete	Set	80,000.00	-
4.3	Supply Delivery and Installation of 11 kV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	250,000.00	-

SN	Particular	Unit	CIP Price	Installation/Erection, Testing and Commissioning
			NPR	NPR
4.4	Supply Delivery and Installation of LV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	50,000.00	-
4	**Transformer**			
4.1	Supply Delivery and Installation of Transformer 11/0.4 kV, 50 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	382,543.62	60,480.25
4.2	Supply Delivery and Installation of Transformer 11/0.4 kV, 100 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	482,543.62	60,480.25
5	**Conductors**			
5.1	Supply, Delivery, Laying and Installation of PVC Insulated Cable all complete including cable lugs, and accessories	m	210.00	-
5.2	Supply, Delivery, Laying and Installation of 11 kV XLPE Armored 3 core Cable all complete including cable lugs, and accessories	m	1,100.00	-
5.3	Supply Delivery and Installation of up to 50 m line with a tap off Pole arrangement for Tapping, all complete	No.	86,657.03	33,388.79

SN	Particular	Unit	CIP Price	Installation/Erection, Testing and Commissioning
			NPR	NPR
6	**Installation, Testing and Commissioning, for complete work**	LS	-	180,000.00
7	**Transportation**	LS	-	120,000.00
3.1	Supply Delivery and Installation of Outdoor VCB with Over Current and Earth Fault Relay with essential accessories all complete	Set	907,536.00	41,443.20
3.2	Supply, Delivery, and Installation of Air Circuit Breaker of suitable rating with accessories and spare parts for operation for 2 years, all complete	set	250,000.00	-
3.3	Supply, Delivery, and Installation of 11 kV Pole Mounted Disconnecting Switch, with accessories and spare parts for operation for 2 years all complete	Set	50,000.00	-
3.4	Supply Delivery and Installation of MCCB with shunt Trip coil with essential accessories all complete	pcs	60,000.00	-
3.5	Supply Delivery and Installation of Drop Out Fuse, 11 kV with essential accessories all complete	Set	5,500.00	-
3.6	Supply Delivery and Installation of DO Operating Rod with essential accessories all complete	No.	4,000.00	-

SN	Particular	Unit	CIP Price	Installation/Erection, Testing and Commissioning
			NPR	NPR
3.7	Supply Delivery and Installation of MCB with boxes and essential accessories all complete	No.	345.00	-
3.8	Supply Delivery and Installation of Lighting Arrester at High Tension with essential accessories all complete	Set	5,500.00	-
3.9	Supply Delivery and Installation of Lighting Arrester at low Tension kV with essential accessories all complete	Set	3,000.00	-
4	**Metering and Synchronizing Equipment**			
4.1	Supply Delivery and Installation of Digital kW, kWh, PF, Frequency meter, ammeter & voltmeter with selector switch with essential accessories all complete	set	100,000.00	-
4.2	Supply Delivery and Installation of Synchronizer (synchronoscope, Dual frequency and voltmeter, dark lamp set, differential etc.) with Auto & Manual Selector Switch with essential accessories all complete	Set	80,000.00	-
4.3	Supply Delivery and Installation of 11 kV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	250,000.00	-

SN	Particular	Unit	CIP Price	Installation/Erection, Testing and Commissioning
			NPR	NPR
4.4	Supply Delivery and Installation of LV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	50,000.00	-
4	**Transformer**			
4.1	Supply Delivery and Installation of Transformer 11/0.4 kV, 50 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	382,543.62	60,480.25
4.2	Supply Delivery and Installation of Transformer 11/0.4 kV, 100 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	482,543.62	60,480.25
5	**Conductors**			
5.1	Supply, Delivery, Laying and Installation of PVC Insulated Cable all complete including cable lugs, and accessories	m	210.00	-
5.2	Supply, Delivery, Laying and Installation of 11 kV XLPE Armored 3 core Cable all complete including cable lugs, and accessories	m	1,100.00	-
5.3	Supply Delivery and Installation of up to 50 m line with a tap off Pole arrangement for Tapping, all complete	No.	86,657.03	33,388.79

SN	Particular	Unit	CIP Price	Installation/Erection, Testing and Commissioning
			NPR	NPR
6	**Installation, Testing and Commissioning, for complete work**	LS	-	180,000.00
7	**Transportation**	LS	-	120,000.00
8	Supply Delivery and Installation of System Setup (Workstation Setup - Ts Computers, Furnitures and Control Station for Mini grid) with essential accessories all complete	LS	250,000.00	25,000.00

Table 7-2:Cost Estimate for Grid Interconnection of Giri Khola MHP

S. No	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Remarks
				NPR	NPR	NPR	NPR	
1	**Supply, Delivery, Installation Synchronizing/Controller Panel with all digital relays with Governor Based Controller Suitable for Grid Interconnection**	Set	1	137,500.00	-	137,500.00	137,500.00	Only synchro check and Dual Frequency and Voltmeter required, They are included in 4.2., The cost is for any missing items (20% of rate)
a	Governor Based Controller Suitable for Grid Interconnection							

S. No	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Remarks
				NPR	NPR	NPR	NPR	
g	Voltage Restrained Over-current Relay, VR O/C R							
h	Phase -Imbalance Relay, PUR							
i	Over-Current Relay, O/C R							
k	Main Fail Relay							
l	Rate of Change of Frequency and Voltage Vector Shift Relay							
m	Turbine Shut Down Relay							
2	**DC Supply System**							
3	**Switches, Disconnectors and Surge Arresters**							
3.2	Supply, Delivery, and Installation of Air Circuit Breaker of suitable rating with accessories and spare parts for operation for 2 years, all complete	set	1	250,000.00	-	250,000.00	250,000.00	
3.3	Supply, Delivery, and Installation of 11 kV Pole Mounted Disconnecting Switch, with accessories and spare parts for operation for 2 years all complete	Set	1	50,000.00	-	50,000.00	50,000.00	
3.4	Supply Delivery and Installation of MCCB with shunt Trip coil with essential accessories all complete	pcs	1	60,000.00	-	60,000.00	60,000.00	
3.5	Supply Delivery and Installation of Drop Out Fuse, 11 kV with essential accessories all complete	Set	0	5,500.00	-	5,500.00	-	Not Required with Isolator

S. No	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Remarks
				NPR	NPR	NPR	NPR	
3.6	Supply Delivery and Installation of DO Operating Rod with essential accessories all complete	No.	0	4,000.00	-	4,000.00	-	Not Required with Isolator
3.7	Supply Delivery and Installation of MCB with boxes and essential accessories all complete	No.	2	345.00	-	345.00	690.00	
5.1	Supply Delivery and Installation of Lighting Arrester at High Tension with essential accessories all complete	Set	1	5,500.00	-	5,500.00	5,500.00	
5.1	Supply Delivery and Installation of Lighting Arrester at low Tension kV with essential accessories all complete	Set	1	3,000.00	-	3,000.00	3,000.00	
4	**Metering and Synchronizing Equipment**					-		
4.1	Supply Delivery and Installation of Digital kW, kWh, PF, Frequency meter, ammeter & voltmeter with selector switch with essential accessories all complete	set	0	100,000.00	-	100,000.00	-	Available on Generator side
4.2	Supply Delivery and Installation of Synchronizer (synchronoscope, Dual frequency and voltmeter, dark lamp set, differential etc.) with Auto & Manual Selector Switch with essential accessories all complete	Set	1	80,000.00	-	80,000.00	80,000.00	Should be available. Has to be confirmed later with the Contractor
4.3	Supply Delivery and Installation of 11 kV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	1	250,000.00	-	250,000.00	250,000.00	
4.4	Supply Delivery and Installation of LV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	0	50,000.00	-	50,000.00	-	Metering at HT side
4	**Transformer**							
4.1	Supply Delivery and Installation of Transformer 11/0.4 kV, 50 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	0	382,543.62	60,480.25	443,023.87	-	Transformer available

S. No	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Remarks
				NPR	NPR	NPR	NPR	
4.2	Supply Delivery and Installation of Transformer 11/0.4 kV, 100 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	0	482,543.62	60,480.25	543,023.87	-	-
5	**Conductors**					-		
5.2	Supply, Delivery, Laying and Installation of PVC Insulated Cable all complete including cable lugs, and accessories	m	0	210.00	-	210.00	-	Available
5.3	Supply, Delivery, Laying and Installation of 11 kV XLPE Armored 3 core Cable all complete including cable lugs, and accessories	m	0	1,100.00	-	1,100.00	-	Available
5.4	Supply Delivery and Installation of up to 50 m line with a tap off Pole arrangement for Tapping, all complete	set	1	86,657.03	33,388.79	120,045.82	120,045.82	
6	**Installation, Testing and Commissioning, for complete work**	LS	1	-	108,000.00	108,000.00	108,000.00	Transformer Already Commissioned
7	**Transportation**	LS	1	-	48,000.00	48,000.00	48,000.00	Transformer Transportation not required
Total (NPR)				1,112,735.82				
VAT Amount 13				144,655.66				
Grand Total including VAT				1,257,391.47				
Grand Total amount including VAT and Contingency				**1,320,261.05**				

Table 7-3:Cost Estimate for Grid Interconnection of Ghughuti MHP

S. No	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
1	**Supply, Delivery, Installation Synchronizing/Controller Panel with all digital relays with Governor Based Controller Suitable for Grid Interconnection**	Set	1	137,500.00	-	137,500.00	137,500.00	Only synchro check and Dual Frequency and Voltmeter required, They are included in 4.2., The cost is for any missing items (20% of rate)
a	Governor Based Controller Suitable for Grid Interconnection							
b	Automatic Voltage Regulator, AVR							
c	Automatic Power Factor Regulator, APFR							
d	Over/Under Frequency Relay, O/U FR							
e	Over/Under-Voltage Relay, O/U VR							
f	Reverse Power Relay, RPR							
g	Voltage Restrained Over-current Relay, VR O/C R							
h	Phase -Imbalance Relay, PUR							
i	Over-Current Relay, O/C R							
j	Generator-Earth Fault Relay, EFR							
k	Main Fail Relay							
l	Rate of Change of Frequency and Voltage Vector Shift Relay							
m	Turbine Shut Down Relay							
2	**DC Supply System**							
2.1	Supply, Delivery and Installation of Inverter cum Battery charger with 24-V Battery System, Input 230 V, Output 230V Sine Wave with accessories all complete	Set	0	100,000.00	-	100,000.00	-	Available
3	**Switches, Disconnectors and Surge Arresters**							

S. No	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
3.1	Supply Delivery and Installation of Outdoor VCB with Over Current and Earth Fault Relay with essential accessories all complete	Set	0	907,536.00	41,443.20	948,979.20	-	In Scope of Chukehi HEP Interconnection
3.2	Supply, Delivery, and Installation of Air Circuit Breaker of suitable rating with accessories and spare parts for operation for 2 years, all complete	set	0	250,000.00	-	250,000.00	-	
3.3	Supply, Delivery, and Installation of 11 kV Pole Mounted Disconnecting Switch, with accessories and spare parts for operation for 2 years all complete	Set	0	50,000.00	-	50,000.00	-	
3.4	Supply Delivery and Installation of MCCB with shunt Trip coil with essential accessories all complete	pcs	0	60,000.00	-	60,000.00	-	
3.5	Supply Delivery and Installation of Drop Out Fuse, 11 kV with essential accessories all complete	Set	0	5,500.00	-	5,500.00	-	
3.6	Supply Delivery and Installation of DO Operating Rod with essential accessories all complete	No.	0	4,000.00	-	4,000.00	-	
3.7	Supply Delivery and Installation of MCB with boxes and essential accessories all complete	No.	0	345.00	-	345.00	-	
5.1	Supply Delivery and Installation of Lighting Arrester at High Tension with essential accessories all complete	Set	0	5,500.00	-	5,500.00	-	
5.1	Supply Delivery and Installation of Lighting Arrester at low Tension kV with essential accessories all complete	Set	0	3,000.00	-	3,000.00	-	
4	**Metering and Synchronizing Equipment**					-		
4.1	Supply Delivery and Installation of Digital kW, kWh, PF, Frequency meter, ammeter & voltmeter with selector switch with essential accessories all complete	set	0	100,000.00	-	100,000.00	-	Available

S. No	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
4.2	Supply Delivery and Installation of Synchronizer (synchronoscope, Dual frequency and voltmeter, dark lamp set, differential etc.) with Auto & Manual Selector Switch with essential accessories all complete	Set	0	80,000.00	-	80,000.00	-	In Scope of Chukehi HEP Interconnection
4.3	Supply Delivery and Installation of 11 kV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	1	250,000.00	-	250,000.00	250,000.00	It may be required
4.4	Supply Delivery and Installation of LV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	0	50,000.00	-	50,000.00	-	-
4	**Transformer**							
4.1	Supply Delivery and Installation of Transformer 11/0.4 kV, 50 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	0	382,543.62	60,480.25	443,023.87	-	Transformer already available
4.2	Supply Delivery and Installation of Transformer 11/0.4 kV, 100 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	0	482,543.62	60,480.25	543,023.87	-	-
5	**Conductors**					-		
5.2	Supply, Delivery, Laying and Installation of PVC Insulated Cable all complete including cable lugs, and accessories	m	0	210.00	-	210.00	-	-
5.3	Supply, Delivery, Laying and Installation of 11 kV XLPE Armored 3 core Cable all complete including cable lugs, and accessories	m	0	1,100.00	-	1,100.00	-	-
5.4	Supply Delivery and Installation of up to 50 m line with a tap off Pole arrangement for Tapping, all complete	No.	0	86,657.03	33,388.79	120,045.82	-	-
6	**Installation, Testing and Commissioning, for complete work**	LS	0	-	180,000.00	180,000.00	-	In Scope of Chukehi HEP Interconnection
7	**Transportation**	LS	1	-	12,000.00	12,000.00	12,000.00	Only minimal costs for few items

S. No	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
5	Supply Delivery and Installation of System Setup (Workstation Setup - Two Computers, Furnitures and Control Station for Mini grid) with essential accessories all complete	LS	1	250,000.00	25,000.00	275,000.00	275,000.00	Required for Control Room
Total (NPR)							674,500.00	
VAT Amount				13			87,685.00	
Grand Total including VAT							762,185.00	
Contingency				5			38,109.25	
Grand Total amount including VAT and Contingency							**800,294.25**	

Table 7-4:Cost Estimate for Grid Interconnection of Thinke Badh MHP

S. No	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
1	**Supply, Delivery, Installation of Synchronizing/Controller Panel with all digital relays**							
1	**Supply, Delivery, Installation of Synchronizing/Controller Panel with all digital relays for ELC based MHP**	Set	1	562,500.00	-	562,500.00	562,500.00	
a	Electronic Load Controller compatible for grid interconnection of MHP, ELC							
b	Automatic Voltage Regulator, AVR							
c	Automatic Power Factor Regulator, APFR							
d	Over/Under Frequency Relay, O/U FR							
e	Over/Under-Voltage Relay, O/U VR							
f	Reverse Power Relay, RPR							
g	Voltage Restrained Over-current Relay, VR O/C R							
h	Phase -Imbalance Relay, PUR							
i	Over-Current Relay, O/C R							
j	Generator-Earth Fault Relay, EFR							
k	Main Fail Relay							
l	Rate of Change of Frequency and Voltage Vector Shift Relay							
m	Turbine Shut Down Relay							
2	**DC Supply System**							
2.1	Supply, Delivery and Installation of Inverter cum Battery charger with 24-V Battery System, Input 230 V, Output 230V Sine Wave with accessories all complete	Set	1	100,000.00	-	100,000.00	100,000.00	
3	**Switches, Disconnectors and Surge Arresters**							

S. No	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
3.1	Supply Delivery and Installation of Outdoor VCB with Over Current and Earth Fault Relay with essential accessories all complete	Set	1	907,536.00	41,443.20	948,979.20	948,979.20	
3.2	Supply, Delivery, and Installation of Air Circuit Breaker of suitable rating with accessories and spare parts for operation for 2 years, all complete	set	1	250,000.00	-	250,000.00	250,000.00	
3.3	Supply, Delivery, and Installation of 11 kV Pole Mounted Disconnecting Switch, with accessories and spare parts for operation for 2 years all complete	Set	1	50,000.00	-	50,000.00	50,000.00	
3.4	Supply Delivery and Installation of MCCB with shunt Trip coil with essential accessories all complete	pcs	1	60,000.00	-	60,000.00	60,000.00	
3.5	Supply Delivery and Installation of Drop Out Fuse, 11 kV with essential accessories all complete	Set	0	5,500.00	-	5,500.00	-	Not Required with Disconnecting Switch
3.6	Supply Delivery and Installation of DO Operating Rod with essential accessories all complete	No.	0	4,000.00	-	4,000.00	-	
3.7	Supply Delivery and Installation of MCB with boxes and essential accessories all complete	No.	2	345.00	-	345.00	690.00	238,050.00
5.1	Supply Delivery and Installation of Lighting Arrester at High Tension with essential accessories all complete	Set	1	5,500.00	-	5,500.00	5,500.00	30,250,000.00
5.1	Supply Delivery and Installation of Lighting Arrester at low Tension kV with essential accessories all complete	Set	1	3,000.00	-	3,000.00	3,000.00	9,000,000.00
4	**Metering and Synchronizing Equipment**					-		
4.1	Supply Delivery and Installation of Digital kW, kWh, PF, Frequency meter, ammeter & voltmeter with selector switch with essential accessories all complete	set	1	100,000.00	-	100,000.00	100,000.00	
4.2	Supply Delivery and Installation of Synchronizer (synchronoscope, Dual frequency and voltmeter, dark lamp set, differential etc.) with Auto & Manual Selector Switch with essential accessories all complete	Set	1	80,000.00	-	80,000.00	80,000.00	

S. No	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
4.3	Supply Delivery and Installation of 11 kV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	1	250,000.00	-	250,000.00	250,000.00	
4.4	Supply Delivery and Installation of LV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	0	50,000.00	-	50,000.00	-	Metering on HT side
4	**Transformer**							
4.1	Supply Delivery and Installation of Transformer 11/0.4 kV, 150 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	1	495,162.08	60,480.25	555,642.33	555,642.33	> 100 kVA transformer required, However, Pole structure available
5	**Conductors**					-		
5.2	Supply, Delivery, Laying and Installation of PVC Insulated Cable all complete including cable lugs, and accessories	m	10	210.00	-	210.00	2,100.00	441,000.00
5.3	Supply, Delivery, Laying and Installation of 11 kV XLPE Armored 3 core Cable all complete including cable lugs, and accessories	m	0	1,100.00	-	1,100.00	-	Available
5.4	Supply Delivery and Installation of up to 50 m line with a tap off Pole arrangement for Tapping, all complete	No.	0	86,657.03	33,388.79	120,045.82	-	Available
6	**Installation, Testing and Commissioning, for complete work**	LS	1	-	180,000.00	180,000.00	180,000.00	-
7	**Transportation**	LS	1	-	120,000.00	120,000.00	120,000.00	-
Total (NPR)							3,268,411.53	39,929,050.00
VAT Amount				13			424,893.50	-
Grand Total including VAT							3,693,305.03	39,929,050.00
Contingency				5			184,665.25	-
Grand Total amount including VAT and Contingency							**3,877,970.28**	**39,929,050.00**

Table 7-5:Cost Estimate for Grid Interconnection of Triveni MHP

S. No	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
1	**Supply, Delivery, Installation of Synchronizing/Controller Panel with all digital relays**							
1	**Supply, Delivery, Installation of Synchronizing/Controller Panel with all digital relays for ELC based MHP**	Set	1	562,500.00	-	562,500.00	562,500.00	
a	Electronic Load Controller compatible for grid interconnection of MHP, ELC							
b	Automatic Voltage Regulator, AVR							
c	Automatic Power Factor Regulator, APFR							
d	Over/Under Frequency Relay, O/U FR							
e	Over/Under-Voltage Relay, O/U VR							
f	Reverse Power Relay, RPR							
g	Voltage Restrained Over-current Relay, VR O/C R							
h	Phase -Imbalance Relay, PUR							
i	Over-Current Relay, O/C R							
j	Generator-Earth Fault Relay, EFR							
k	Main Fail Relay							
l	Rate of Change of Frequency and Voltage Vector Shift Relay							
m	Turbine Shut Down Relay							
2	**DC Supply System**							
2.1	Supply, Delivery and Installation of Inverter cum Battery charger with 24-V Battery System, Input 230 V, Output 230V Sine Wave with accessories all complete	Set	1	100,000.00	-	100,000.00	100,000.00	
3	**Switches, Disconnectors and Surge Arresters**							

S. No	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
3.1	Supply Delivery and Installation of Outdoor VCB with Over Current and Earth Fault Relay with essential accessories all complete	Set	0	907,536.00	41,443.20	948,979.20	-	No VCB required
3.2	Supply, Delivery, and Installation of Air Circuit Breaker of suitable rating with accessories and spare parts for operation for 2 years, all complete	set	1	250,000.00	-	250,000.00	250,000.00	
3.3	Supply, Delivery, and Installation of 11 kV Pole Mounted Disconnecting Switch, with accessories and spare parts for operation for 2 years all complete	Set	0	50,000.00	-	50,000.00	-	DO Fuse used
3.4	Supply Delivery and Installation of MCCB with shunt Trip coil with essential accessories all complete	pcs	1	60,000.00	-	60,000.00	60,000.00	
3.5	Supply Delivery and Installation of Drop Out Fuse, 11 kV with essential accessories all complete	Set	1	5,500.00	-	5,500.00	5,500.00	
3.6	Supply Delivery and Installation of DO Operating Rod with essential accessories all complete	No.	1	4,000.00	-	4,000.00	4,000.00	
3.7	Supply Delivery and Installation of MCB with boxes and essential accessories all complete	No.	2	345.00	-	345.00	690.00	
5.1	Supply Delivery and Installation of Lighting Arrester at High Tension with essential accessories all complete	Set	1	5,500.00	-	5,500.00	5,500.00	
5.1	Supply Delivery and Installation of Lighting Arrester at low Tension kV with essential accessories all complete	Set	1	3,000.00	-	3,000.00	3,000.00	
4	**Metering and Synchronizing Equipment**					-		
4.1	Supply Delivery and Installation of Digital kW, kWh, PF, Frequency meter, ammeter & voltmeter with selector switch with essential accessories all complete	set	1	100,000.00	-	100,000.00	100,000.00	
4.2	Supply Delivery and Installation of Synchronizer (synchronoscope, Dual frequency and voltmeter, dark lamp set, differential etc.) with Auto & Manual Selector Switch with essential accessories all complete	Set	1	80,000.00	-	80,000.00	80,000.00	
4.3	Supply Delivery and Installation of 11 kV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	0	250,000.00	-	250,000.00	-	Metering at LT side

S. No	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
4.4	Supply Delivery and Installation of LV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	1	50,000.00	-	50,000.00	50,000.00	
4	**Transformer**							
4.1	Supply Delivery and Installation of Transformer 11/0.4 kV, 50 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	0	382,543.62	60,480.25	443,023.87	-	
4.2	Supply Delivery and Installation of Transformer 11/0.4 kV, 100 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	1	482,543.62	60,480.25	543,023.87	543,023.87	45 kW plant
5	**Conductors**					-		
5.2	Supply, Delivery, Laying and Installation of PVC Insulated Cable all complete including cable lugs, and accessories	m	30	210.00	-	210.00	6,300.00	
5.3	Supply, Delivery, Laying and Installation of 11 kV XLPE Armored 3 core Cable all complete including cable lugs, and accessories	m	30	1,100.00	-	1,100.00	33,000.00	
5.4	Supply Delivery and Installation of up to 50 m line with a tap off Pole arrangement for Tapping, all complete	No.	1	43,328.52	33,388.79	76,717.30	76,717.30	Pole available, Tapping arrangement only required
6	**Installation, Testing and Commissioning, for complete work**	LS	1	-	180,000.00	180,000.00	180,000.00	
7	**Transportation**	LS	1	-	120,000.00	120,000.00	120,000.00	
Total (NPR)							2,180,231.17	
VAT Amount				13			283,430.05	
Grand Total including VAT							2,463,661.22	
Contingency				5			123,183.06	
Grand Total amount including VAT and Contingency							**2,586,844.29**	

Table 7-6:Cost Estimate for Grid Interconnection of Lum MHP

SN	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
1	**Supply, Delivery, Installation of Synchronizing/Controller Panel with all digital relays**							
1	**Supply, Delivery, Installation of Synchronizing/Controller Panel with all digital relays for ELC based MHP**	Set	1	562,500.00	-	562,500.00	562,500.00	
a	Electronic Load Controller compatible for grid interconnection of MHP, ELC							
b	Automatic Voltage Regulator, AVR							
c	Automatic Power Factor Regulator, APFR							
d	Over/Under Frequency Relay, O/U FR							
e	Over/Under-Voltage Relay, O/U VR							
f	Reverse Power Relay, RPR							
g	Voltage Restrained Over-current Relay, VR O/C R							
h	Phase -Imbalance Relay, PUR							
i	Over-Current Relay, O/C R							
j	Generator-Earth Fault Relay, EFR							
k	Main Fail Relay							
l	Rate of Change of Frequency and Voltage Vector Shift Relay							
m	Turbine Shut Down Relay							
2	**DC Supply System**							
2.1	Supply, Delivery and Installation of Inverter cum Battery charger with 24-V Battery System, Input 230 V, Output 230V Sine Wave with accessories all complete	Set	1	100,000.00	-	100,000.00	100,000.00	
3	**Switches, Disconnectors and Surge Arresters**							

SN	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
3.1	Supply Delivery and Installation of Outdoor VCB with Over Current and Earth Fault Relay with essential accessories all complete	Set	0	907,536.00	41,443.20	948,979.20	-	No VCB required
3.2	Supply, Delivery, and Installation of Air Circuit Breaker of suitable rating with accessories and spare parts for operation for 2 years, all complete	set	1	250,000.00	-	250,000.00	250,000.00	
3.3	Supply, Delivery, and Installation of 11 kV Pole Mounted Disconnecting Switch, with accessories and spare parts for operation for 2 years all complete	Set	0	50,000.00	-	50,000.00	-	DO Fuse used
3.4	Supply Delivery and Installation of MCCB with shunt Trip coil with essential accessories all complete	pcs	1	60,000.00	-	60,000.00	60,000.00	
3.5	Supply Delivery and Installation of Drop Out Fuse, 11 kV with essential accessories all complete	Set	1	5,500.00	-	5,500.00	5,500.00	
3.6	Supply Delivery and Installation of DO Operating Rod with essential accessories all complete	No.	1	4,000.00	-	4,000.00	4,000.00	
3.7	Supply Delivery and Installation of MCB with boxes and essential accessories all complete	No.	2	345.00	-	345.00	690.00	
5.1	Supply Delivery and Installation of Lighting Arrester at High Tension with essential accessories all complete	Set	1	5,500.00	-	5,500.00	5,500.00	
5.1	Supply Delivery and Installation of Lighting Arrester at low Tension kV with essential accessories all complete	Set	1	3,000.00	-	3,000.00	3,000.00	
4	**Metering and Synchronizing Equipment**					-		
4.1	Supply Delivery and Installation of Digital kW, kWh, PF, Frequency meter, ammeter & voltmeter with selector switch with essential accessories all complete	set	1	100,000.00	-	100,000.00	100,000.00	
4.2	Supply Delivery and Installation of Synchronizer (synchronoscope, Dual frequency and voltmeter, dark lamp set, differential etc.) with Auto & Manual Selector Switch with essential accessories all complete	Set	1	80,000.00	-	80,000.00	80,000.00	

SN	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
4.3	Supply Delivery and Installation of 11 kV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	0	250,000.00	-	250,000.00	-	Metering at LT side
4.4	Supply Delivery and Installation of LV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	1	50,000.00	-	50,000.00	50,000.00	
4	**Transformer**							
4.1	Supply Delivery and Installation of Transformer 11/0.4 kV, 50 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	1	382,543.62	60,480.25	443,023.87	443,023.87	
4.2	Supply Delivery and Installation of Transformer 11/0.4 kV, 100 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	0	482,543.62	60,480.25	543,023.87	-	31 kW only
5	**Conductors**					-		
5.2	Supply, Delivery, Laying and Installation of PVC Insulated Cable all complete including cable lugs, and accessories	m	30	210.00	-	210.00	6,300.00	
5.3	Supply, Delivery, Laying and Installation of 11 kV XLPE Armored 3 core Cable all complete including cable lugs, and accessories	m	30	1,100.00	-	1,100.00	33,000.00	
5.4	Supply Delivery and Installation of up to 50 m line with a tap off Pole arrangement for Tapping, all complete	No.	1	43,328.52	33,388.79	76,717.30	76,717.30	Pole available, Tapping arrangement only required
6	**Installation, Testing and Commissioning, for complete work**	LS	1	-	180,000.00	180,000.00	180,000.00	
7	**Transportation**	LS	1	-	120,000.00	120,000.00	120,000.00	
Total (NPR)							2,080,231.17	
VAT Amount				13			270,430.05	
Grand Total including VAT							2,350,661.22	
Contingency				5			117,533.06	
Grand Total amount including VAT and Contingency							**2,468,194.29**	

Table 7-7:Cost Estimate for Grid Interconnection of Dillichaur MHP

SN	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
1	**Supply, Delivery, Installation of Synchronizing/Controller Panel with all digital relays**							
1	**Supply, Delivery, Installation of Synchronizing/Controller Panel with all digital relays for ELC based MHP**	Set	1	562,500.00	-	562,500.00	562,500.00	
a	Electronic Load Controller compatible for grid interconnection of MHP, ELC							
b	Automatic Voltage Regulator, AVR							
c	Automatic Power Factor Regulator, APFR							
d	Over/Under Frequency Relay, O/U FR							
e	Over/Under-Voltage Relay, O/U VR							
f	Reverse Power Relay, RPR							
g	Voltage Restrained Over-current Relay, VR O/C R							
h	Phase -Imbalance Relay, PUR							
i	Over-Current Relay, O/C R							
j	Generator-Earth Fault Relay, EFR							
k	Main Fail Relay							
l	Rate of Change of Frequency and Voltage Vector Shift Relay							
m	Turbine Shut Down Relay							
2	**DC Supply System**							
2.1	Supply, Delivery and Installation of Inverter cum Battery charger with 24-V Battery System, Input 230 V, Output 230V Sine Wave with accessories all complete	Set	1	100,000.00	-	100,000.00	100,000.00	
3	**Switches, Disconnectors and Surge Arresters**							

SN	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
3.1	Supply Delivery and Installation of Outdoor VCB with Over Current and Earth Fault Relay with essential accessories all complete	Set	0	907,536.00	41,443.20	948,979.20	-	No VCB required
3.2	Supply, Delivery, and Installation of Air Circuit Breaker of suitable rating with accessories and spare parts for operation for 2 years, all complete	set	1	250,000.00	-	250,000.00	250,000.00	
3.3	Supply, Delivery, and Installation of 11 kV Pole Mounted Disconnecting Switch, with accessories and spare parts for operation for 2 years all complete	Set	0	50,000.00	-	50,000.00	-	DO Fuse used
3.4	Supply Delivery and Installation of MCCB with shunt Trip coil with essential accessories all complete	pcs	1	60,000.00	-	60,000.00	60,000.00	
3.5	Supply Delivery and Installation of Drop Out Fuse, 11 kV with essential accessories all complete	Set	1	5,500.00	-	5,500.00	5,500.00	
3.6	Supply Delivery and Installation of DO Operating Rod with essential accessories all complete	No.	1	4,000.00	-	4,000.00	4,000.00	
3.7	Supply Delivery and Installation of MCB with boxes and essential accessories all complete	No.	2	345.00	-	345.00	690.00	
5.1	Supply Delivery and Installation of Lighting Arrester at High Tension with essential accessories all complete	Set	1	5,500.00	-	5,500.00	5,500.00	
5.1	Supply Delivery and Installation of Lighting Arrester at low Tension kV with essential accessories all complete	Set	1	3,000.00	-	3,000.00	3,000.00	
4	**Metering and Synchronizing Equipment**					-		
4.1	Supply Delivery and Installation of Digital kW, kWh, PF, Frequency meter, ammeter & voltmeter with selector switch with essential accessories all complete	set	1	100,000.00	-	100,000.00	100,000.00	
4.2	Supply Delivery and Installation of Synchronizer (synchronoscope, Dual frequency and voltmeter, dark lamp set, differential etc.) with Auto & Manual Selector Switch with essential accessories all complete	Set	1	80,000.00	-	80,000.00	80,000.00	

SN	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
4.3	Supply Delivery and Installation of 11 kV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	0	250,000.00	-	250,000.00	-	Metering at LT side
4.4	Supply Delivery and Installation of LV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	1	50,000.00	-	50,000.00	50,000.00	
4	**Transformer**							
4.1	Supply Delivery and Installation of Transformer 11/0.4 kV, 50 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	0	382,543.62	60,480.25	443,023.87	-	
4.2	Supply Delivery and Installation of Transformer 11/0.4 kV, 100 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	1	482,543.62	60,480.25	543,023.87	543,023.87	50 kW plant
5	**Conductors**					-		
5.2	Supply, Delivery, Laying and Installation of PVC Insulated Cable all complete including cable lugs, and accessories	m	30	210.00	-	210.00	6,300.00	
5.3	Supply, Delivery, Laying and Installation of 11 kV XLPE Armored 3 core Cable all complete including cable lugs, and accessories	m	30	1,100.00	-	1,100.00	33,000.00	
5.4	Supply Delivery and Installation of up to 50 m line with a tap off Pole arrangement for Tapping, all complete	No.	1	43,328.52	33,388.79	76,717.30	76,717.30	Pole available, Tapping arrangement only required
6	**Installation, Testing and Commissioning, for complete work**	LS	1	-	180,000.00	180,000.00	180,000.00	
7	**Transportation**	LS	1	-	120,000.00	120,000.00	120,000.00	
Total (NPR)							2,180,231.17	
VAT Amount				13			283,430.05	
Grand Total including VAT							2,463,661.22	
Contingency				5			123,183.06	
Grand Total amount including VAT and Contingency							**2,586,844.29**	

Table 7-8:Cost Estimate for Grid Interconnection of Juged MHP

SN	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
1	**Supply, Delivery, Installation of Synchronizing/Controller Panel with all digital relays**							
1	**Supply, Delivery, Installation of Synchronizing/Controller Panel with all digital relays for ELC based MHP**	Set	1	562,500.00	-	562,500.00	562,500.00	
a	Electronic Load Controller compatible for grid interconnection of MHP, ELC							
b	Automatic Voltage Regulator, AVR							
c	Automatic Power Factor Regulator, APFR							
d	Over/Under Frequency Relay, O/U FR							
e	Over/Under-Voltage Relay, O/U VR							
f	Reverse Power Relay, RPR							
g	Voltage Restrained Over-current Relay, VR O/C R							
h	Phase -Imbalance Relay, PUR							
i	Over-Current Relay, O/C R							
j	Generator-Earth Fault Relay, EFR							
k	Main Fail Relay							
l	Rate of Change of Frequency and Voltage Vector Shift Relay							
m	Turbine Shut Down Relay							
2	**DC Supply System**							
2.1	Supply, Delivery and Installation of Inverter cum Battery charger with 24-V Battery System, Input 230 V, Output 230V Sine Wave with accessories all complete	Set	1	100,000.00	-	100,000.00	100,000.00	
3	**Switches, Disconnectors and Surge Arresters**							

SN	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
3.1	Supply Delivery and Installation of Outdoor VCB with Over Current and Earth Fault Relay with essential accessories all complete	Set	0	907,536.00	41,443.20	948,979.20	-	No VCB required
3.2	Supply, Delivery, and Installation of Air Circuit Breaker of suitable rating with accessories and spare parts for operation for 2 years, all complete	set	1	250,000.00	-	250,000.00	250,000.00	
3.3	Supply, Delivery, and Installation of 11 kV Pole Mounted Disconnecting Switch, with accessories and spare parts for operation for 2 years all complete	Set	0	50,000.00	-	50,000.00	-	DO Fuse used
3.4	Supply Delivery and Installation of MCCB with shunt Trip coil with essential accessories all complete	pcs	1	60,000.00	-	60,000.00	60,000.00	
3.5	Supply Delivery and Installation of Drop Out Fuse, 11 kV with essential accessories all complete	Set	1	5,500.00	-	5,500.00	5,500.00	
3.6	Supply Delivery and Installation of DO Operating Rod with essential accessories all complete	No.	1	4,000.00	-	4,000.00	4,000.00	
3.7	Supply Delivery and Installation of MCB with boxes and essential accessories all complete	No.	2	345.00	-	345.00	690.00	
5.1	Supply Delivery and Installation of Lighting Arrester at High Tension with essential accessories all complete	Set	1	5,500.00	-	5,500.00	5,500.00	
5.1	Supply Delivery and Installation of Lighting Arrester at low Tension kV with essential accessories all complete	Set	1	3,000.00	-	3,000.00	3,000.00	
4	**Metering and Synchronizing Equipment**					-		
4.1	Supply Delivery and Installation of Digital kW, kWh, PF, Frequency meter, ammeter & voltmeter with selector switch with essential accessories all complete	set	1	100,000.00	-	100,000.00	100,000.00	
4.2	Supply Delivery and Installation of Synchronizer (synchronoscope, Dual frequency and voltmeter, dark lamp set, differential etc.) with Auto & Manual Selector Switch with essential accessories all complete	Set	1	80,000.00	-	80,000.00	80,000.00	

SN	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
4.3	Supply Delivery and Installation of 11 kV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	0	250,000.00	-	250,000.00	-	Metering at LT side
4.4	Supply Delivery and Installation of LV Time of Day Smart Metering Unit with CT/PT with essential accessories all complete	Set	1	50,000.00	-	50,000.00	50,000.00	
4	**Transformer**							
4.1	Supply Delivery and Installation of Transformer 11/0.4 kV, 50 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	0	382,543.62	60,480.25	443,023.87	-	
4.2	Supply Delivery and Installation of Transformer 11/0.4 kV, 100 kVA, 3 ph. 50 Hz, earthing arrangement with essential accessories all complete	No.	0	482,543.62	60,480.25	543,023.87	-	58 kW plant, transformer existing
5	**Conductors**					-		
5.2	Supply, Delivery, Laying and Installation of PVC Insulated Cable all complete including cable lugs, and accessories	m	30	210.00	-	210.00	6,300.00	
5.3	Supply, Delivery, Laying and Installation of 11 kV XLPE Armored 3 core Cable all complete including cable lugs, and accessories	m	0	1,100.00	-	1,100.00	-	Available
5.4	Supply Delivery and Installation of up to 50 m line with a tap off Pole arrangement for Tapping, all complete	No.	0	86,657.03	33,388.79	120,045.82	-	Available
6	**Installation, Testing and Commissioning, for complete work**	LS	1	-	108,000.00	108,000.00	108,000.00	Transformer Already Commissioned
7	**Transportation**	LS	1	-	48,000.00	48,000.00	48,000.00	Transformer Transportation not required
5	Supply Delivery and Installation of System Setup (Workstation Setup - Two Computers, Furnitures and Control Station for Mini grid) with essential accessories all complete	LS	1	250,000.00	25,000.00	275,000.00	275,000.00	
Total (NPR)							1,658,490.00	
VAT Amount				13			215,603.70	

SN	Particular	Unit	Quantity	Supply CIP Price	Construction and Installation Works	Unit Rate	Amount	Amount
				NPR	NPR	NPR	NPR	NPR
Grand Total including VAT							1,874,093.70	
Contingency				5			93,704.69	
Grand Total amount including VAT and Contingency							**1,967,798.39**	

7.7 Assumed Parameters For Transient Analysis

Model GENSAL Model 801 '1 '

Model CONS | Model ICONS | Model VARS

	Con Value	Con Description
1	5.0000	T'do (> 0)
2	0.0500	T''do (> 0)
3	0.1000	T''qo (> 0)
4	2.0000	Inertia H
5	0.0000	Speed Damping D
6	0.6300	Xd
7	0.4500	Xq
8	0.2500	X'd
9	0.1300	X''d = X''q
10	0.1167	X1
11	0.0900	S(1.0)
12	0.2900	S(1.2)

Figure 7-9 Parameters of Synchronous Generator

Model CONS | Model ICONS | Model VARS

	Con Value	Con Description
1	0.1000	TA/TB
2	10.0000	TB (> 0)
3	100.0000	K
4	0.1000	TE
5	0.0000	EMIN
6	4.0000	EMAX

Figure 7-10 Parameters of Excitation System

Model HYGOV Model 1101 '1 '

Model CONS | Model ICONS | Model VARS

	Con Value	Con Description
1	0.0500	R, Permanent Droop
2	0.4000	r, Temporary Droop
3	7.0000	Tr (> 0) Governor Time Constant
4	0.0500	Tf (> 0) Filter Time Constant
5	0.5000	Tg (> 0) Servo Time Constant
6	0.1000	VELM, Gate Velocity Limit
7	1.0000	GMAX, Maximum Gate Limit
8	0.0000	GMIN, Minimum Gate Limit
9	1.0000	TW (> 0) Water Time Constant
10	1.0000	At, Turbine Gain
11	0.0000	Dturb, Turbine Damping
12	0.1000	qNL, No Load Flow

Figure 7-11 Parameters of Hydro Governor