MICRO HYDRO INTERCONNECTED MINI GRID (MHIMG) FOR RURAL LIVELIHOOD

(A CASE STUDY OF URJA UPATYAKA MINI GRID OF BAGLUNG DISTRICT)

A Thesis

Submitted to:

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LETTER OF ACCEPTANCE

This is to certify that **Mr. Basanta Pathak**, MA Rural Development final year student at Tribhuvan University, Dhankuta Multiple Campus has carried out research title **"MICRO HYDRO INTERCONNECTED MINI GRID (MHIMG) FOR RURAL LIVELIHOOD"** under my supervision and guidance.

This research paper, therefore, has been accepted and forwarded for evaluation to the evaluation committee as a partial fulfillment for the Master's Degree of Rural Development.

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Date : Feb.15, 2017

APPROVAL LETTER

The thesis entitled **"MICRO HYDRO INTERCONNECTED MINI GRID (MHIMG) FOR RURAL LIVELIHOOD",** submitted by **Mr. Basanta Pathak** in partial fulfillment for the requirements of Master of Arts in Rural Development has been evaluated and approved by the evaluation committee.

EVALUATION COMMITTEE

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Nanda Kumar Neupane

Thesis Supervisor

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Ramesh Amatya

Head of the Department

Date: February 15, 2017

DECLARATION

I hereby declare that the work reported in this thesis entitled **“MICRO HYDRO INTERCONNECTED MINI GRID (MHIMG) FOR RURAL LIVELIHOOD”** submitted to Office of Dean, Faculty of Humanity and Social Sciences, Tribhuvan University is my original work done in the form of partial fulfillment of the requirement of Master of Rural Development (MA RD.) under the supervision of Mr. Nanda Neupane, Dhankkuta Multiple Campus, Dhankuta. I have not submitted it or any of its part to any other academic institutions for any degree.

…………………………

Date: February, 2017

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Basanta Pathak

Researcher

Abbreviations and Acronyms

AEPC	-	Alternative Energy Promotion Center
DDC	-	District Development Committee
DEECCO	-	District Environment, Energy and Climate Change Officer
DEECCS	-	District Environment, Energy and Climate Change Section
DEES	-	District Energy and Environment Section
DFID	-	Department for International Development
ESAP	-	Energy Sector Assistance Programme
FDG	-	Focus Group Discussion
HHs	-	Households
IMIREN	-	Interconnected Mini Grid for Intensive Rural Electrification
MG	-	Mini Grid
MHIMG	-	Micro Hydro Interconnected Mini Grid
MHEP	-	Micro Hydro Exhibition Project
MHFG	-	Micro Hydro Functional Group
MHIMG	-	Micro Hydro Interconnected Mini Grid
MHP	-	Micro Hydro Project
MHS	-	Micro Hydro Schemes
MHUG	-	Micro Hydro User Committee
NEA	-	Nepal Electricity Authority
REDP	-	Renewable Energy Development Programme
RERL	-	Renewable Energy for Rural Livelihood
SHS	-	Solar Home System
UNDP	-	United Nation Development Programme
UNSD	-	United Nation Sustainable Development
VDC	-	Village Development Committee

Abstract

Due to difficult geographic terrain from high hills to low plain of terai and vastly scattered settlements, the extension of national grid line is very sluggish in Nepal. To fulfil the electricity (especially lighting) needs of those far settled rural people, renewable energy technologies like MHS, SHS, gasifiers, etc. are in use through nodal government agency-AEPC and other agencies. In most cases, MHS are widely used as a source of electricity in rural areas. During initial stages, the electricity consumption was limited to lighting only with allocation of 100 to 200 watts per HHs. However, with increase in use of various electrical appliances, which now became essential parts of life like TV, mobile, computer, fridge, etc. for domestic use and agro processing mills, poultry farming, shops, etc. as productive end uses for commercial use, the electricity is demand is very high in those rural areas, too. But their supply is often limited to certain hours of the day when demand at its peak.Furthermore, stand-alone MHS are suffering more due low load factor, reliability, quality and availability, abandonment after national grid line extension, etc.

To address this constraint, AEPC/UNDP/REDP come up with testing a new approach to rural electrification connecting two or more plants in a locally-controlled distribution system, known as Micro Hydro Interconnected Mini Grid System. With the view that this decentralized network can improve the quality, reliability and availability of electricity produced by isolated plants and selling surplus energy, and buy deficit energy to/from the grid, to increase the income of MHS and entrepreneurs, sizable capacity to connect to national grid to avoid abandonment after national grid extension, further improving the living standard of rural people through job opportunities and reducing dependency on traditional energy sources, AEPC/UNDP/REDP has started a pilot project with cost of around two crore to connect 6 MHPs totaling 107 kW power in Baglung district through 8 km long 11 kV transmission line forming Mini Grid operated and managed by local community as Urja Upatyaka Mini Grid Co-operative.

As being a pilot project, there are several difficulties as technical, managerial, economic and social issues from construction phase to till date which now in defunct for running around one and a half year only. This research paper will explore all the benefits, issues, challenges, revival activities and future planning through techno-socio-economic study of this project so that it could pave way forward for its revival and replication of another such project in upcoming days

Chapter 1: Introduction

1.1 Background

Just above half of the Nepal's population has access to national electric grid, and it may be decades before the network reaches deep into remote, dispersed settlements of the northern hill and mountain regions. But owing to the terrain and water resources and human resources and institution with appropriated experiences to support such projects as well as cost effectiveness offers an alternative source of energy in the form of hydro power and other, that can be harnessed not only in super-sized constructions like China's 22,500 MW Three Gorges Dam, but also in comparatively miniscule, "run-off-river" turbines better suited to the needs of rural communities of Nepal (*Report, S Mallapaty*). About 15% of the population of Nepal has access to electricity through distributed renewable energy technologies such as MHPs and SHSs.

Till date over 2500 MHPs ranging from 1 kW to 100 kW has been constructed in Nepal, generating a total of 22 MW of electricity with 100 MW potential. A drizzle in the face of Nepal's estimated 43000 MW of commercially and technically viable hydropower potential, but these droplets provide electricity to over 200,000 people in remote areas. These stand-alone hydropower plants harness free flowing energy in streams and rivers to produce continuous, uninterrupted electricity with minimal environment impact. But their supply is often limited to certain hours of the day when demands as at its peak.

Improving energy access in Nepal is being pursued via grid extension by the state owned utility, the NEA, and via smaller distributed off-grid renewable energy technologies, administered through AEPC. Both approached have been their own pros and cons. Under current tariff arrangement, grid extension can provide electricity supply at a lower cost to consumers than alternative, provided that adequate generations and network capacity is available to supply the area. However, the access of national grid to rural areas is hindered due to unsuitable geography, vastly scattered settlements, resulting in low return on investment. In addition, the even in dense urban areas of Nepal, the grid is unreliable, with load shedding of 14-16 hours in the dry seasons due to inadequate generation capacity*(Report, B Shakya).*

The question often arises why interconnected mini grid? The obvious answer is load sharing. Besides this, it overcomes the hurdles and difficulties an individual micro hydro face such as low load factor (around 20%), unreliability, lack of integrated plan for rural electrification, expansion of national grid in micro hydro areas so that people switching from micro hydro to national grid, etc. Other shortcoming of isolated MHPs are: limited Capacity of Generation to meet the future load growth, less reliability to supply electricity during regular maintenance, low quality electricity, difficulty in providing round the clock supply for plants that share water for other important purposes like irrigation, drinking water, etc. *(EcoCoDE Nepal, 2013)*. Therefore, these MHPs often end up with dysfunction. To avoid this shortcoming, the first micro hydro interconnected mini grid has been constructed in Baglung district for in Nepal as a pilot project, where 6 micro hydros of Sarkuwa, Damek, Paiyuthanthap and Rangkhani VDCs ranging from 9 kW to 26 kW are connected to a local grid, forming a mini grid power system of 11 kV of 8 km transmission line with total power of 107 kW in 2010 (REDP report, 2010). The other example of such projects includes IMIREN Mini Grid of Gulmi where two MHPs are interconnected to generate 218 kW power supported by GIZ in 2015 and the Taplejung Mini Grid supported by the World Bank is underway. This report presents the techno-socio and economic aspect of mini-grid in all three phases of time: pre, during (synopsis of pre and during) and post-operation covering post operation in detail including revival activities.

1.2 Statement of the Problem

Being the first Micro Hydro Interconnected Mini Grid of Nepal, the project used to be one of the most successful project funded by UNDP. The positive changes are clearly visible with upgradation of technology (innovative), economic status and social bonding due to this project.

Though very successful in initial phases, the project remains defunct now. The acute causes of its non-operation in present time are still unanswered. Hence, this study unfolds and tries to address the following queries:

- ✓ What differences in technical, social and economic aspect does it create before, during and post-operation (post-operation, here, refers to the project after being stopped operation)
- ✓ What are the hidden reasons behind its non-operation?
- ✓ What are the revival efforts to bring it into operation?

1.3 Objectives of the Study

Though, the general objective of the study is to analyze the overall mini grid activities that contributed to the rural development, the specific objectives of this study can be listed as:

- ✓ To assess the technical, socio-economic aspects of the project to the beneficiaries before, during and post-operation with in-depth study of post-operation and its suitability in Nepal
- ✓ To ascertain underline causes of non-operation or defunct state
- ✓ Measures taken to revive the project
- ✓ Challenges forward to revive the mini-grid programs

1.4 Significance of the study

With the huge investment of the UNDP around 200,000 USD as a first pilot project of Nepal, people had hoped better techno-socio-economic boost from the project. Also, there's no undenying fact that a lot of crucial challenges and hurdles has been arisen during initial phases of implementation. However, the program has been lunched successfully with due effort and some signs of positive changes have been seen in the faces of beneficiaries. A lot of studies and research have been done about the project's pre and during operation which all seems to be in its 'nascent' stages but not about the post-operation after the operation has been halted. Thus this root-beneficiary based study unfolds the deep-rooted causes behind its defunct status that will be significantly helpful for the concerned authority to take appropriate actions to revive the projects as well as give a thorough synopsis on techno-socio-economic aspects of the project to those people who aspire to conduct in depth research in this area.

1.5 Focus of the Study

This study confirms the analysis of techno-socio-economic activities during MHIMG operation and explores the causes, efforts and challenges of post-operation (after the project stopped operation).

Here the researcher has focused the resource mainly to highlight the techno-socio-economic benefits that this project has brought about during operation to the true beneficiaries considering factors affected to halt the operation. It tries to present the true picture of mini grid with it technical synopsis to the socio-economic aspects at its most, which would assist other, mainly, to be sick projects for their survival and great learning for replication of such projects.

1.6 Limitations of the Study

The study has the following limitations:

- ✓ The study covers all 6 MHPs. However, depth study will be done in only few ones.
- ✓ The interview and focus group discussions will be conducted to the people who still reside there. But it excludes those who have migrated who once used to be a beneficiary of the project who might know much about it. Migration is rampant in the area.
- ✓ The study focuses on all three phases pre, during and post-operation but the emphasis would be given in post-operation phase in which it can be possible to be more influenced by present situation rather than the current situation.

1.7 Organization of the Study

The study will comprise following chapters.

In chapter - 1 (Introduction)

This chapter will include background of the study, statement of the problem, objectives, significances, focus, limitation and organization of the study itself.

In chapter - 2 (Review of Literature)

This chapter will include the conceptual framework and post research literatures on Micro hydro Interconnected Mini Grid and Rural Livelihood.

In chapter - 3 (Research Methodology)

This chapter will include research design, data collection, and method of analysis and research variables.

In chapter - 4 (Description of Study Area)

This chapter will include rationale for the selection of study area, study of research site, management study of mini grid, etc.

In chapter - 5 (Results and Discussions)

This chapter presents data processing, data analysis and interpretation of results with discussion including social, economic, technical analysis, benefits, issues and challenges.

In chapter - 6 (Summary, Conclusion and Recommendation)

This chapter will contain the findings of whole study after which major conclusion and recommendations are specified.

Chapter 2: Literature Review

2.1 Micro hydro Interconnected Mini Grid

2.1.1 Definition

Micro hydro connected mini grid is the local grid that connects more than one MHPs or generators to operate in parallel mode and sharing the load in equal proportion of its capacity. The rationale behind the opting of mini grid is that the individual MHPs have many shortcomings as: lower plant factor of around 25 %, because of lighting predominantly is the main requirement of rural people, limited Capacity of Generation to meet the future load growth, less reliability to supply electricity during regular maintenance, low quality electricity, difficulty in providing round the clock supply for plants that share water for other purposes like irrigation, drinking water etc.

Why Mini-Grid?

The obvious answer is load sharing. In addition to this, the urge for mini grid can be listed as:

- To overcome the shortcomings of individual MHPs
- Optimization of electricity generation from MHP
    - Balancing the surplus electricity of one or more MHPs with the deficit electricity of other one or more MHPs
    - Creating opportunity to establish bigger size end uses at a time requiring more electricity than quantity generated from normal MH of 10 to 30 kW.
    - Operating all plant at their full generation capacity round the clock without requiring of dumping of additional power into the ballast as in normal MHPs in order to keep frequency within acceptable range
    - Carrying out the vital maintenance activity in any or few plants with beneficiary households still getting electricity to meet their minimum households lighting requirement.
- Reduce the possibility of abandonment of MHP after grid in case of national grid comes in the area in the immediate future
- Interconnection into national grid

    - Offering sizable capacity to NEA for encouraging to connect the mini grid with the national grid
- ✓ Achievement of system sustainability
    - Increase the revenue for MHPs from the increased uses/sales of electricity
    - Shifting of power based tariff to energy based tariff system for disciplined use of electricity
    - Promoting better inter scheme coordination and sense of togetherness
    - Earning additional revenue from selling day time and night time excess electricity to national grid
    - Purchasing electricity form national grid in case of sever power shortages in the mini grid system especially in the dry month period

In short, mini-grid is a technology to join two or more micro hydros in order to share surplus power and continuous power supply if one MHP stops operating due to technical fault, with technical up gradation, economic boosting and social benefits.

2.1.2 Origin of Micro Hydro Interconnected Mini Grid in Nepal

There was felt need of developing modality, both technical and managerial, to connect micro hydro (MH) with the grid, first to stop discarding MH due to the availability of grid electricity and next to generate additional revenue to community by selling MH electricity to grid (Nepal Electricity Authority- NEA).

Despite continuous follow-up and percussion of REDP and AEPC, NEA, though agreed in principal, never came forward to open the door for connecting MH with grid. The issue is not mush so with the technical reason, it is more of the negative "mind set" and the perceived managerial hassles from the unwanted initiatives.

Due to many shortcomings of individual MHPs, in 2001 the UNDP/REDP funded IOE, electrical department for R&D to testify feasibility connecting MHP with the national grid. After successfully connecting its MHs used for teaching purpose built in the lab with the national grid, the result was widely disseminated and hailed to the stakeholders with conclusion that MHP above 10 kW can be connected to national grid and the concept of interconnection of two or more MHPs of near vicinity came forward. With the overwhelming result of R&D and the objective of addressing such shortfall of isolated MHPs, in 2005, AEPC/REDP conceived an innovative idea of piloting micro hydro interconnected mini grid by synchronizing a number of similar nearby MHPs, for which a feasibility of grid connection of MHP was proposed. Accordingly, the MECC Consultancy (P) Ltd. was sub-contracted to conduct pre-feasibility study in three districts, viz. Kavre, Sindhupalchwok and Baglung. Amongst the three potential sites, the site in Baglung was found the most appropriate. Consequently, REDP undertook the "Detailed Feasibility Study for the Mini Grid Project in "Urja Upatyaka of Baglung" in September 2007.

In 2007, REDP contracted the MECC Consultancy(P) Ltd., Gongabu, Kathmandu for the "Detailed Feasibility Study for Mini Grid Development in Urja Upatyaka, Baglung" that has submitted the report in September 2007.

The Baglung Mini Grid was included in 2008 work plan and initiated the work. However the progress was slower than anticipated due to both technical issues and local conflicts. The activity is thus continued in 2009 too and started operation in 2011. It continued working till March 2013.

2.1.3 System Overview of Micro Hydro Interconnected Mini Grid of Baglung

Urja Upatyaka Mini Grid was established in the eastern-southern belt of Baglung District, a 12- hours walk on step dirty road from Baglung, the district headquarter. It includes 6 Micro Hydro plants (i.e. Upper Kalung Khola (12 kW), Kalung Khola (22 kW), Urja Khola I (26 kW), Urja Khola II (9kW), Urjakhola IV (14 kW) & Theulakhola MHP (24 kW), originated from same source of stream) located in Rangkhani, Paiyauthanthap, Sarkuwa and Dameak VDV having total power output of the system is 107 kW, interconnected by means of 8 kM long , 11 kV transmission line with 1198 households (HHs) as beneficiary. All of these plants were built in between 2056 to 2068 and are supported REDP. Microprocessor based grid synchronizable Electronic load Controller (ELC) is the core technology in mini grid project.

All of MHP and Mini Grid were operated in IPP model in which six MHP are treated as Independent Power producer (IPP). MHP sell the electricity to the Mini grid in fixed Power Purchase Agreement (PPA) rate and Grid sell the electricity to the consumer according to its tariff rate. Micro hydro functional group would be responsible for the generation of electricity and Mini Grid is responsible for the transmission and distribution of electricity. There are 2 operators in each MHP and manager as required. All the plants operate according to the operational schedule prepared by Mini Grid according to the loading status. Mini Grid is registered under the Co- Operative rules of Nepal government in Division Co-Operative office, Baglung. Mini Grid Co- operative management committee will be responsible for the operation of Mini Grid. It provides services to the consumer by establishment of office at center of grid. There are three staffs i.e. Technical manager, Accountant & Technician who performs the regular duty at office. Mini Grid is planned advance to the next phase of its development, in which it is planned to interconnect with the nearby 33kV national grid at Kushmi Sera bazaar. Besides Mini Grid, a number of Pico hydro provides service for many villages of this area.

Each of the generating unit generates power at distribution voltage i.e. 400 V and power station constitutes of turbine generator sets, frequency controlling unit, voltage regulating unit, synchronizing unit, measurement unit, switchgear and protection unit, bus bar arrangement & 11 kV line connecting 0.4/11 kV transformer unit. Six channels Microcontroller based digital ELC, having droop facility along with ballast heater regulates the frequency of the system. Automatic voltage regulator with droop facility suitable for parallel operation having panel mounting voltage adjustment facility controls the system voltage. Synchronizing unit facilitates the interconnection of MHP with other generator which can be done in both automatic and manual mode. Separate measurement system was provided for generation and local load measurement. Protection system consists of Relaying system i.e. Voltage restrained OC relay, Over / Under frequency relay, Phase unbalance relay, O/U voltage relay, Reverse power relay, Over current relay & Master trip relay. These relay protect the generator during abnormal condition of operation. Panel mounting bus bar arrangement facilitates power importing and exporting modes of operation through transformer with mini grid.

2.1.4 Status of Micro Hydro Interconnected Mini Grid of Nepal

Till date, 2 MHIMG: Urja Upatyaka Mini Grid, Baglung and the IMIREN Mini Grid, Gulmi, has been made with one in construction phase in Taplejung district as Kabeli Transmission and other 6 are under feasibility study. With the Urja Upatyaka Mini Grid, around 1200 beneficiaries have been benefitted and 52 micro-enterprises has been opened up. Similarly, IMIREN mini grid which connects two micro hydros of 83 kW and 135 kW generating total of 218 kW of power with total of 2273 beneficiary households and 36 number of micro, small and medium enterprises. Both projects have several positive impacts on all technological, economic and social aspects. The other possible MHIMG sites are attached in Annex II.

2.2 Rural Livelihood

2.2.1 Definition

"A livelihood is a means of making a living. It encompasses peoples' capabilities, assets, income and activities required to secure the necessities of life. A livelihood is sustainable when it enables people to cope with and recover from shocks and stresses (such as natural disasters and economic or social upheavals) and enhance their well-being and that of future generations without undermining the natural environment or resource base"- International Federation of Red Cross and Red crescent societies. [*Retrieved August 10, 2015 from https://www.ifrc.org/en/what-we-do/disaster-management/from-crisis-to-recovery/what-is-a-livelihood/*]

Robert chambers and G.R. Conway provided the first elaborated definition of sustainable livelihood which reads : "a livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to their livelihoods at the local and global levels and in the short and long term". *(Chambers and Conway, 1991) [Robert chambers and G.R. Conway (1991), Sustainable Rural Livelihoods: Practical Concepts for the 21st century*]. This definition tries to establish a relationship among different variables such as capabilities of the person/household, various forms of assets, and the type of activities required for living. Different forms of assets could be different alternatives for a livelihood. The notion of capabilities can be taken in terms of physical and mental and social capabilities for doing work. *(Dhakal, 2002)*

2.2.2 The Sustainable Livelihoods Approach

The Livelihoods approach has evolved from year of best practice in the development sector. This best practice has been distilled into a set of principles, which underpin Sustainable Livelihoods thinking:

People Centered: focusing on what matters t people, understanding differences between groups of people, understanding poverty from people's own perspective.

Responsive and Participatory: poor people are key actors in identifying and addressing livelihood practices.

Holistic: acknowledges that people adopt multiple strategies to secure their livelihoods. Applies livelihood analysis across sectors and social groups at different levels.

Dynamic: the dynamic nature of livelihoods is recognized. Interventions respond with flexibility to changes in people's situations.

Macro-micro links: the need for working at multiple levels is recognized. Micro level activity must inform policy. Macro level structures and processes must support people to build on their strengths.

Sustainable: economically, socially, institutionally and environmentally.

Build on Strengths: recognizes that people have strengths as opposed to just needs and is empowering and respectful.

Gender, equity and power relations are key cross cutting issues in the sustainable livelihoods approach. Thinking about these principles collectively is new. Using these principles, Sustainable Livelihoods thinking takes an integrated approach to poverty alleviation, trying to capture and provide a means of understanding of the vital causes and dimensions of poverty without focusing on individual factors. In essence, Sustainable Livelihoods thinking puts people at the center of development, thereby increasing the effectiveness of development assistance.

"Livelihood Comprises the assets (natural, physical, human, financial and social capital), the activities, and the access to these (mediated by institutions and social relations) that together determine the living gained by the individual or household *(Ellis, 2000)*". For *Ellis*, livelihood strategies have got activities that generate means of subsistence for the family unit and a singular person divided into activities based on natural resources, natural resources itself and non-based natural resources thus expressed: (a) activities based on natural resources : collect, nourishment cultivation, non-grazing; and (b) non-based on natural activities : rural products selling, inputs and goods, and another rural services like equipment maintenance, rural manufacture, formal jobs and income transference. *(IJEMS, 2011)*

A livelihood program should help the poor to gain better access to opportunities and may turn out to be substantially more cost effective for poverty reduction than attempting, artificially, to support particular sectors or sub-sectors of rural economic activity *(Ellis, 1998).*

2.2.3 MHIMG and Its Relation with Rural Livelihood and Rural Development

Evidences have found out that this project have a greater positive effect than the individual MHPs in rural livelihood. Increment of Productive End Use has boosted living standard of the community. The more revenue it generates, the more self-supportive and self-reliant the community becomes which the mini grid has capability to do. Continuous power supply not only benefitted directly to end uses like development of micro-enterprises such as saw-mills, chilling VATs, hollers, bakery, computer classes, mobile charging stations, soap manufacturing, etc. but also indirectly to act psychological self-sufficient and life standard of the community. Technological advancements like quality, availability and reliability of improved electricity, easier starting for motor and bigger load (which needs three times power: surge power), better safety and protection, increased plant factor especially doubled 20-30% (ECoCoDE Nepal, 2013). Financial benefits like increment of individual MHPs and their earnings, and the entrepreneurs as well as establishment of new enterprises. Similarly, social advantages includes behavioral change in electricity used (from mere use of electricity from lighting to productive end uses), sense of ownership and unity among community, decision on resource mobilization (*Annual Report*, *REDP, 2010*). To sum up, it has helped greatly to boost socio-economic status of rural people of that region.

The micro hydro project has great impact in Nepalese community where the settlements is sparsely dispersed with rough geographic terrain. Moreover, the expansion of National Grid lines has posed a great threat to the operation of micro hydros as the people obviously shift from micro hydros to National Grid on its reliability and readily availability where no maintenance, management, etc. from the community required. With MHIMG, the smaller micro hydros connected to a network where surplus energy can be sold to the non-electrified or needy community thereby increasing revenue. With increase in revenue and proper funding in community benefits, the community gets all the benefits like investing in infrastructure development viz, roads, schools, capacity development, etc. The fear of wiping out of individual plant can be prevented at its most. Empirical findings in India where mini grid implementation are rampant finds that benefits of MHIMG are increased financial capital, better education of children, self-supporting of individual micro hydro, increased productive end uses and increased social capital. Most of all, the dying of individual MHPs whatsoever reasons, which the community invested great effort during construction, can be prevented.

Chapter 3: Research Methodology

3.1 Research Design

The research will be based upon the survey data in particular describing the phenomenon about mini grid and its impacts. So, the research design used will be descriptive. The meaningful information is collected by using non-probability sampling purposively.

3.2 Nature and Source of data

The research paper will based on qualitative and quantitative information from the field. Both primary and secondary data is gathered from the field work.

The primary information is collected by using different data collection techniques such as structure and semi-structure questionnaire, key informant interview, observation and focus group discussion, and checklist.

The secondary data collection are from indirect or out sourcing i.e. from questionnaires and personal interview of concerned agencies and local bodies of government, internet, books, financial statements, other published journals from concerned persons and agencies, previous studies and reports, etc.

3.3 Universe, Population, Sample Size and Sampling Procedure

The universe consists of all beneficiaries of 6 MHPs connected to the mini grid. Among 1198 beneficiaries including 12 operators of 6 MHP and the mini grid co-operative and 104 numbers of functional group members. The selection is taken out from the operators and functional group members of individual MHPs and the Mini Grid Cooperatives as they falls under the category of having greater knowledge of both technical, managerial and socio-economic aspects of the MHIMG. Other 25 numbers of beneficiaries are also included

The purposive sampling techniques under non-probability sampling is used to select the appropriate sampling size. A total of 68 beneficiaries were taken as a sample where 6 beneficiaries from each of the 6 MHPs and one operator from each MHPs and the mini grid cooperatives and 25 number falls on common marginalized beneficiaries. Furthermore, the members of mini grid cooperatives are the members of each individual MHPs so that they need not be taken separately as they are included in the study priorly.

Moreover, in order to know the future plans for operation of halted mini grid, implementing agency AEPC/RERL and the local body as DDC/DEECCS are taken and the information gathered through one to one discussion.

3.4 Techniques and Tools of Data Collection

3.4.1 Desk Study

During this stage, various information of Micro Hydro Interconnected Mini Grid of Baglung regarding to technical, managerial, social and economic aspects were collected and studied. Checklist and questionnaires for communities, functional group, plant operator, and staff of cooperatives were made.

3.4.2 Field Study

During this stage, the detail study of following topic has been carried out

a) Technical Study
b) Managerial Study
c) Socio-Economic Study
with tools and techniques discussed below:

3.4.2.1 Focus Group Discussion

Focus group discussions were made in two of the 6 MHS regarding the previously made questionnaires where pre-testing of questionnaires occurred. A lot of discussion were done and the more precise questionnaires were prepared for the survey. The final questionnaires were attached in Annex I.

3.4.2.2 Survey

Structured questionnaire prepared were asked to the respondents to generate the realistic and actual data from the field. Some respondents filled up the form of questionnaires by themselves and for most respondents it was assisted.

3.4.2.3 Direct Observation

The study area was observed using checklist mostly involving technical matters as socio-economic aspects were included in questionnaires. The site was visited a number of times to gain real scenario.

3.4.2.4 Key Informant on Interview

One to one discussion, rather than mere interview, was carried out to gather information regarding MHIMG with the concerned agencies and the stakeholders in the district to assess primarily the future activities of mini grid operation. Information obtained from this will be useful to assert future planning of the project site.

3.4.3 Data Analysis

After the completion of the collection of data, the data was analyzed into 2 ways. First is qualitative analysis and second is quantitative analysis. In qualitative analysis, qualitative data (text, words, opinions, etc.) are analyzed are put into quantitative (numbers) wherever possible. The data was presented and interpreted by using different statistical tools. The data obtained from the field work was reviewed to avoid the problems of duplications and ambiguities.

The information which are relevant only be presented in the report to be more specific and consistent with the objective of this study. The data which are collected from the primary and secondary data were presented into various graphical ways for example bar diagram, pie-chart, sub-bar diagram, scatter diagram etc. They were categorized and tabulated according to the objective of the research by using computer applications such as MS-Excel, Word & Spreadsheets.

Chapter 4: Description of Study Area

4.1 Rationale for the Selection of study area

As the Urja Upatyaka mini grid is the first piloted mini grid implemented with huge investment of UNDP through AEPC, its successful operation for around two and a half year is lauded from all over the globe. Similarly, its non-operation after operating for two and a half year only is a big issue that greatly affects on replication of such projects to other places. The replications of such projects has been widely discussed in several diverse forums with its core technical, social and economic benefits. But its stalled operation after successful operation stunned the world. Thus this study helps to identify the problems, challenges and techno-socio-economic benefits during its operation and the hidden issues behind its halted operation that could be helpful to other ongoing replicated projects and the people who are pursuing to have R&D in this area.

4.2 A short Glimpse of Baglung District

Baglung District, a part of Dhawalagiri Zone, is one of the seventy-five districts of Nepal lies in the western region of Nepal. The district, with Baglung as its district headquarters, covers an area of 1,784 km^2, total households, 61,482 and has a population of 268,613(Male-117,997 & Female-150,616). Baglung (28.27 N, 83.60 E, elev. 1020 m.) lies in the mid hills of Nepal, 275 km West of Kathmandu. With 59 VDCs and one Municipality, it has many rivers and streams and so, many suspension bridges. Baglung is also known as the district of suspension bridges because of the large number of bridges. The district has been declared as model district of decentralized rural energy system “URJA JILLA” by 12th District Council in 2004 (24th Baisakh 2061). Baglung is the district headquarters of Baglung District and is also the zonal headquarters of Dhaulagiri Zone. Baglung is also diverse in religion, culture,

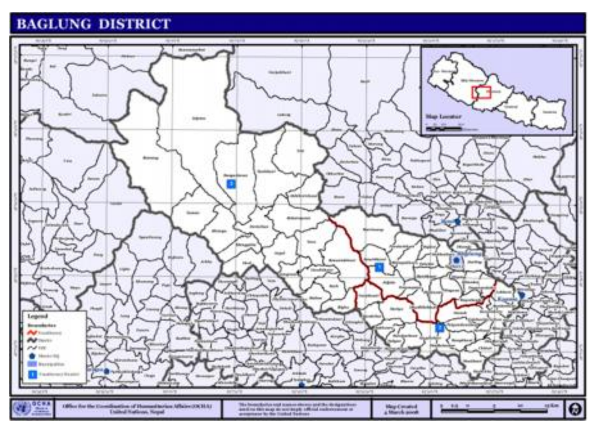


Fig 1: Baglung District

ethnicity, altitude, temperature etc. Hinduism and Buddhism are the major religions. Pun, Thapa, Rana, Chhantyal, Magar, Chhetri, Brahmin, Newar, Gurung, and Thakali are the main ethnic groups living in the district. Highest temperature in the lowest altitude of Baglung rises up to about 37.5 degrees Celsius in summer and the lowest temperature at Dhorpatan fall up to about −15 degrees Celsius in winter. It has more than 99 MHS generating 2.29 MW of electricity with more than 100 peltric sets. So nowadays this district is also known by the name of "*Microhydro Jilla*".

4.3 District Energy Situation Report (DESR) of Baglung District

Being known as "Urja Jilla" or "Micro Hydro Jilla", Baglung has 99 number of MHPs generating 2.92 MW of electricity with 27,349 households benefitted. Moreover, there are more than 100 peltric sets (below 5 kW) and IWM electrification that are lighting small community households. Around 55% households have access to national grid. Most MHP are in the state of defunct as the beneficiaries are diverted towards national grid and nowadays the trend is very rampant. Toilet Attached Biogas, TAB, is also common source of renewable energy for cooking purposes. The Metallic and Mud Improved Cooking Stoves contained households are enormous and their purchase during the border obstruction from India was overwhelmingly enormous where it is hard to track the exact numbers. Most of the schools and FM stations are equipped with institutional solar. The simplicity of using renewable energy technologies is harness by the subsidy policy on renewable energy by Government of Nepal through Alternative Energy Promotion Center facilitated by District Environment, Energy and Climate Change Section under District Development Committee of Nepal. The district renewable energy status is presented below.

Table 1: Renewable Energy Status of Baglung District

S.N.	Description	Quantity	Power/ Size	Beneficiaries HHS	Remarks
1	**Renewable Energy Technology**				
1.1	Completed Micro-Hydro(MHDS/MHVEP/MHP/MHS)	86	2,478 kW	23,485	Completed
1.2	Under- Construction Micro-Hydro(MHDS/MHVEP/MHP/MHS)	12	1802 kW	6216	Under constrn
1.3	Peltric Set	36	49kW	580	Completed
1.4	Solar Home System(SHS)	4324		4324	Completed
1.5	Institutional SHS	80	35kW		
1.6	Improved Cooking Stove(ICS)-Mud	22325		22325	Completed
1.7	Metallic ICS	4000		4000	Completed
1.7	Institutional ICS	14		14	Completed
2	**Productive End use(PEU) Promotion**	502		23425	Completed

Source: DEECCS 2015

4.4 Description of Study Sites

The service area of Mini Grid covers the area of 4 VDCs, viz. Rangkhani, Paiyauthanthap, Sarkuwa and Damek VDC of Baglung district. The approximate population of this area is about 9000 and about 1400 no of households. Among them around 1200 households are electrified through the micro hydros of mini grid and approx. 200 households do not have excess of electricity till now. Some of them use small Peltric sets only for lighting purposes, some use national grid line which surrounds the whole service area of Mini Grid. The shifting of MHPs consumers to national grid line is seen in notable numbers. Average monthly income of the households is about Rs.11,590 Rupees. Agriculture is the main occupation of the people. Besides this governmental jobs, teachers, employment in private /public organization and especially abroad employments (army for India, British, Singapore, Malaysia and workers in gulf countries) are the main source of income. The literacy level is about same percentage as that of National scenario. There is complex community composition consisting of *Brahman, Chhetri, Magar, Damai, Kami, Sarki*, and small numbers of *Gurung* (in Local language) and Hinduism is the main religion. Political rife is high in this area.

A numbers of social organizations provide services in this area. There are three Higher secondary schools (From 1 to class 12), one secondary school, one lower secondary school and a numbers of Primary and lower primary schools contributing for education growth of that area. Private boarding schools do not play any significant role in this area and there is only one private Boarding schools provide primary level of education. Children occupy almost 33% of total population. All of these have access of education. Higher secondary schools use computers for their practical course subjects. The trends of using the computers, printers are going to be increasing from Secondary to Primary schools from last years. For Bachelor and above level of education, students are used to move Kushmi Sera, Baglung, Pokhara, Kathmandu and other cities of Nepal. A number of community owned Co-Operative has been established in the last years. Three health posts and some private medical clinic are providing health service for public. A steep dirty road of 35 Km long provides the access to the Kushmisera and Baglung Bazzar only in dry seasons. The communities are still out of scope of Internet and Banking service for which they must travel up to Kushmi Sera. Almost all HHs uses mobile phones (Nepal Telecom/N- Cell/Smart- Cell/CDMA/Sky phones) for communication and post office as required. All the HHs use at least one mobile phone for communication. Police station at Kushmi Sera and Barang oversees the overall security status of this area. Two cable industries provide television service in this area.

Women are given priority for the social activities and their contribution in social organization, local politics, education, decision making process, etc. seems to be quite appreciable. A members of women managed Groups like *AMA SAMUHA*, Community based agriculture groups, active involvement in the dispute settlement of local groups etc. are gaining more and more reputation in this area. A numbers of NGOs and INGO'S have been launching various programs for women empowerment and motivating them for income generating activities. The single biggest and the new project of this area seems to be the Micro Hydro Interconnected Mini Grid till date.

4.5 Socio-Economic information of sample population

Among the 68 number of respondents, 27 are females and 68 are males in which most male and female are of age between 31 and 40 (Fig 2). Similarly, more than half percentages have 5 to 8 members in a family (Fig 3).

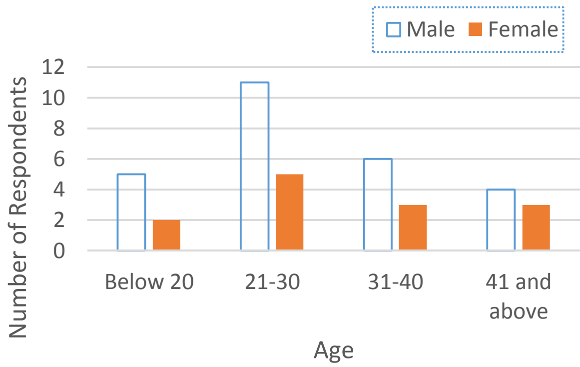
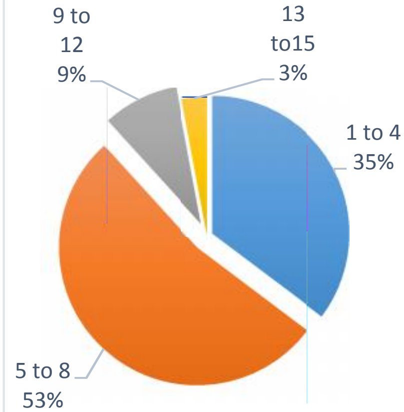


Fig 2: Age and Sex Composition of Respondents

Fig 3:Percentage of Respondents' family size



In the same vein, the respondents mostly comprises of Kshetri and the Magar community with 38% and 31% respectively. The Newar respondents share the lowest part (Fig 4). Furthermore, the majority of respondents are generally literate who can just read and write Nepal whereas 34% of respondents are illiterate. The more respondents with high education and SLC passed are of 10% and 18% respectively.

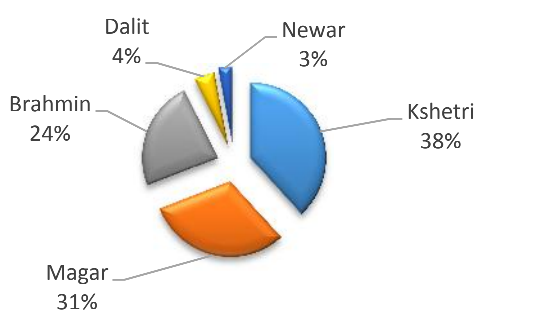
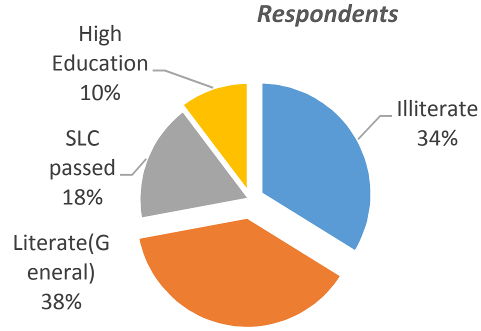


Fig 4 :Percentage of Caste of Respondent

Fig 5 : Educational Status of Respondents



Similarly, agriculture is the primary occupation of majority of respondents (56%) followed by foreign employment, and job (GO, NGO) as in Fig 6.

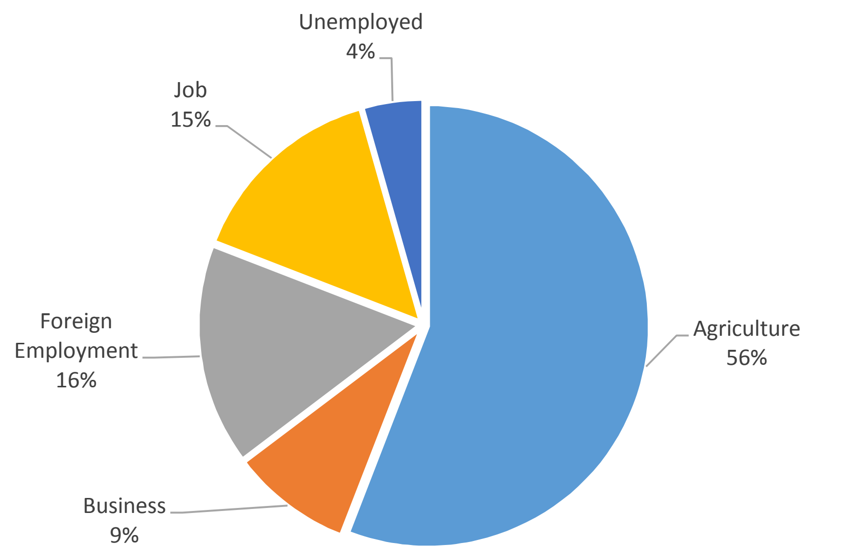


Fig 6: Occupation of respondents

4.6 Management Study of Micro Hydro Interconnected Mini Grid

4.6.1 Overall Management

The Mini Grid is not a single entity but an arrangement of multiple networks and multiple power generation units with multiple operators employing varying levels of communication and coordination, most of which is manually controlled. Management system of mini-grid will be more complicated than the existing standalone operation. Management and technical aspect is the significant and vital aspect for enhanced operation of the Mini Grid which is entirely new practice in the segment. For a mini-grid power system to sustain and run smoothly, it is significant to determine who invests, develops, owns and operates the system. More importantly, the issue of ownership becomes decisive. The working modality for mini-grid under rural circumstances is specifically dealt with three options. These are: *[reference RERL: report]*

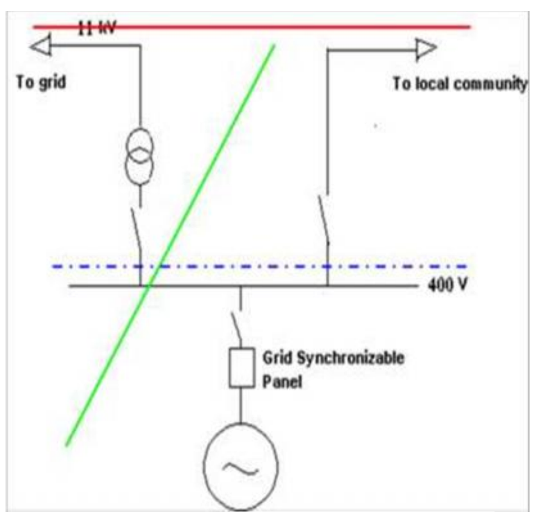


Fig 7 Mini Grid System

- ✓ Option A: The whole system, including generation and distribution, is managed by single entity.
- ✓ Option B: The "business as usual" situation, where the Mini Grid operator will be receiving surplus power only but it coordinates among the seven MHPs.
- ✓ Option C: The Independent Power Producer (IPP) model where each MHP will be responsible for the generation only and load management and dispatching will be controlled by the Mini-grid operator.

The mini grid at Baglung District, Nepal is funded 90% of the total investment with remaining by kind contribution by the beneficiaries. Thus, Urja Upatyaka Mini Grid Cooperative was formed from the representative of each individual MHP functional group with member proportional to capacity of the MHPs. Rules, regulations and other legal documentation such as *Arthik Niyamawali, Bidhut Bitaran Niyamawali, Biniyamawali, Karmachari sewa Niyamawali* & Power purchase agreement were developed. This model enhances the communal responsibility among the members or the beneficiary households for the project sustainability. Cooperative will be responsible for operating and maintaining the Mini Grid, distribution and consumer services, and individual Micro Hydro Functional Group (MHFG) were restricted to independent power producers (IPP). The trading arrangement were made in such a way that Cooperative will buy electricity from respective IPP and sell it to consumers that were previously supplied by individual MHFG and new consumer were added by expanding distribution system as well. This executive body of the co-operative has the decisive power for operation, maintenance, expansion of transmission and distribution lines, fixing power purchase agreement (PPA) rate, tariff structure, office management, hiring the staffs and all other related issues. The main objectives of Urja Upatyaka Mini Grid Co-operative are:

To purchase electrical energy generated by the 6 MHPs situated within the Kalung Khola valley and distribute (sell) the same to consumers.

To raise financial resources from shareholders to carry out activities for long run sustainability of the organization.

To promote and assist cooperatives movement in the project area.

4.6.2 Duties, Responsibilities and Authorities of Mini Grid Co- Operative

The following activities are duties, authority and responsibility Mini Grid Co-operative :

- ✓ To make an agreement (PPA) with all 6 micro hydropower plants for the purchase of electricity.
- ✓ To involve plants in the distribution system of the mini-grid.
- ✓ To assist plants in their operations and maintenance.
- ✓ To assist in load dispatch and management.
- ✓ To supervise, monitor and repair all distribution lines
- ✓ To conduct training programs on electrical systems and its uses.
- ✓ Authority to disconnect the electricity line if consumer does not follow the rules and regulation set by Mini Grid.
- ✓ To provide financial resources (loans) to shareholders and consumers as and when required provided the financial condition of the organization is favorable.
- ✓ To cooperate and coordinate with other organizations.
- ✓ To make every effort to interlink and connect Mini Grid to NEA's national grid.

4.6.3 Duties and Responsibility of Micro Hydro Functional Group

Each of the Micro Hydro functional Groups is responsible for the following activities:

- ✓ Generation of electrical power and provide it for Mini Grid according to its requirement.
- ✓ Operating the plant according to the operational schedule prepare by Mini Grid.
- ✓ Collect the revenue from the sale of electricity to the Mini Grid in accordance to the fixed PPA rate.

- ✓ To assist the Mini Grid for fixing tariff rate, addition of new consumer, distribution and consumer service, fault finding in distribution line and other social works.
- ✓ Making Power Purchase Agreements with Mini Grid.
- ✓ To assist the Mini Grid for the maintenance of transmission and distribut ion lines.

4.6.4 Distribution and Consumer Service

In order to fulfill the enlisted objective and to provide better service to the consumer, Co- Operative management committee established an office at the center part of the Mini Grid (at Rumta) from where all the activities of the Mini Grids are being conducted. There are three regular staffs at the office. One is technical Manager having intermediate degree in Electrical Engineering from CTEVT. Technical manager is responsible for all the technical works of Mini Grid. Preparation of operation schedule for plants, help plant operators for maintenance of control panel, controlling and monitoring of all plant, to assist the management committee for deciding the future work plan, keeping the technical record of the system e.g. log book, load curve, energy consumption and generation record etc., to identify, mobilize, create close relationship with support organization, supervise and support to the other staffs, calling for the meetings as required are the major responsibilities of the technical manager. Accountant of the Co-Operative is responsible for keeping overall financial record of the Co-Operative, collection of tariff from the consumer, keeping the record of fee, dues and other charges from consumer, keeping the data record of energy meter reading, paying to the plant for the price of electricity that Mini Grid purchases, suggest for management committee and manager about financial status of Mini Grid and support for office management are major duties of Accountant. Another regular staff is the technician, whose main responsibility is to perform the meter reading, line maintenance, providing service for the consumer e. g. replacement of energy meters, maintenance of wiring, other consumer service, helping to operators for maintenance activities and support for the office management etc.

Regular customers service have been providing through the Co-Operative office, for this office opens from 10 AM to 4 PM from Sunday to Saturday except those days of meter reading, during which all the staffs are in the process of metering and collecting tariff from consumer so office remains closed during these days. Metering process is running for each month from 1st to 10th of every month. Billing is done by the meter reader. For the consumers who are missing to pay for tariff at specified places are given a chance to pay from 11th to 15th of that month without any extra charges at office time in Cooperative office. Those consumers who miss such opportunity are charged Re 1 per day plus Rest 15 for first 15 day of the month. Mini Grid provides the charge for that energy to plant operator or manager or chairperson of that plant at the time of regular meeting which held approximately at mid time of each month.

For Mini Grid, domestic households act as consumer and for each plant, Mini Grid acts as consumer. Separate tariff structures were formed for both consumers. Mini Grid sells the electricity to the domestic consumer at specified tariff structure and purchases the electricity from plants in fixed Power Purchase Agreement rate. Regular expenses and maintenance cost of Mini Grid is achieved from the margin between these two rates.

Tariff: Each of the domestic consumers was installed single phase energy meter to measure the amount of electricity consumed. The load specified to these single phase consumer is 6 Amp. Due to the various difficulties for purchasing NEA recommended energy meter some of the consumers do not have meters till now. Following table summarizes such consumers.

Table 2: Meter connected HHs of Mini Grid

S.No.	Name of feeder	Total no of active HHs	No of HHs (having Meter)	No of HHs (not meter)	Remarks
1.	Upper Kalung Khola	114	111	3	Un available
2.	Kalung Khola	232	232	0	
3.	Urja Khola I	267	265	1	Un available
4.	Urja Khola II	165	165	0	
5.	Urja Khola IV	124	124	0	
6.	Theule Khola	282	275	7	Un available

Tariff for the domestic consumers is fixed from the discussion with the consumers & Micro hydro functional groups. There are major two difficulties for fixing the tariff rate. If we go for higher tariff structure it is very difficult to convince for local people. Also high rate compels the consumer to decrease the use of electricity which ultimately reduces the energy consumption of households thus reducing the net revenue. On the other hand if we go for low tariff rate to increase the consumption of electricity, then it becomes necessary to go for load shedding which creates negative impact towards Mini Grid. So compromise is made to fix the tariff structure. The current tariff rate is Rs 75 for minimum of 12 units and Rs 7 for each additional unit.

All the consumers follow the rules of Co- Operative. Consumer who do not pay the tariff at specified time, are fined at certain rate. Since there is some socio-political problems in the Theulekhola plants, three consumers (all three are local political leaders) do not pay for tariff till now.

Table 3: Tariff structure of Mini Grid for Three Phase consumer

S.No.	Name of feeder	No of 3 phase consumer	Tariff structure	Remarks
1.	Upper Kalung Khola (Mill)	3	1150	
2.	Kalung Khola (Mill)	5	1300	
3.	Urja Khola I (Mill)	3	800	
	Urja Khola I (N-Cell)	1	10000	
	Urja Khola II (Mill)	2	1000	
4.	Urja Khola IV(Mill)		500 min+7/ unit	Meter Installed
	Urja Khola IV(Mill)	1	800	
5.	Theula Khola(Mill)	4	1000	

There is no large debt. Although Co-Operative has authority to disconnect line of consumer who does not follow the rules and regulation, such consumer are not punished by the Co-Operative. Till now energy based tariff system is not adopted for the three phase consumers. Depending upon the amount of energy consumption and hours of operation per day, three phase consumers are charges at separate rates as:

4.6.5 Power Purchase Agreement (PPA)

Each of the generating stations sells the energy to the Mini Grid at specified PPA rate. Since there is no such prior experience, it was fixed by the negotiation with the Micro Hydro Functional Group. Along with some preliminary calculation, PPA rate is fixed as Rs 4 per unit and is implemented from Ashadh of 2069 for the first time. When this agreement was applied, it was observed that the income statement of larger plant (having capacity greater than 15 kW) increased but that of plants of capacity less than 15 kW was reduced such that, income from the energy sell in not sufficient to meet the salary of two operator. Especially such problem was occurring for Urja II MHP (9 kW Capacity). In order to solve such problem PPA Rate was modified to Rs 4.5 per Unit from 2069 Mangsir and was implemented from the same time along with modified operational schedule for plants.

4.6.6 Grid Operation

Despite of long unanticipated delays and uncertainty, the project was finally completed at the mid of 2068. Immediately the project was entered into the testing phase and after preparation for office management and Energy meter installation, Mini grid was operated in IPP model from beginning of 2069. According to the Mini Grid manager, from the beginning of grid operation a lot of methods were practiced to optimize the generation, minimize the outage rate and making economic load dispatching. These could be summarized as:

Operational schedule: To cope with the load variation, during light load period (night and day time) some of the plants are shut down and as the load grows additional plants are brought into operation. The operational schedule of plants is prepared by Co-Operative in close co-ordination with operator, accounting the Generation and loading condition at that season. Operating time of plants vary according to the requirement. Separate schedule for three phase agro-processing mills is applied to restrict them from unnecessary load burden at the same time to Mini Grid.

Black Start Mechanism: When the system collapses due to some reason, firstly larger plants i.e. either Kalung Khola or Urja Khola I or Theula Khola station charges the gird and the other plants successively come into synchronism. According to the operator the normal black start time is about 2 minutes and it takes long time in certain instances.

Complete and partial Grid shutdown: Mini Grid system is not operated in complete shutdown mode. If there are problems in the Grid transmission line each of plants are operated in isolated mode providing supply to the local load feeder. The partial system break down will occur in the following conditions;

If there is fault in the Grid transmission line. If the fault clearance time is expected to be long then Grid section is broken into two sections which permits to operate the Grid in partial break down mode in respective sections.

While fault or carrying out maintenance activities in any feeder of distribution lines.

Due to the negligence of the operator i.e. violence of time schedule.

If there are some problems in the generating stations.

- ✓ **Communication Mechanism:** Mobile phones call and messaging are the major means of communication mechanism in the Mini Grid system. Meeting, Visiting and message through someone are also the means of communication.
- ✓ **Component failure rate of control panel:** After the testing and commissioning various equipment of the control panel have failed due to abnormal operating condition and failure of semiconductor chips. Mostly equipment of the control panels are semiconductor based digital ICs the failure rate of which seems to be high. During the field visit it is experienced that, repair and maintenance rate is almost negligible. The operation of the plants in such condition seems to be very danger. According to the operators, we can say that Battery Charger controller cards, Relays, Electronic Load monitors, Automatic synchronizers are among frequently falling components. Dual frequency meter, AVR and ELC are comparatively less damaged.

Chapter 5: Results and Discussion

5.1 Impact of Micro Hydro Interconnected Mini Grid

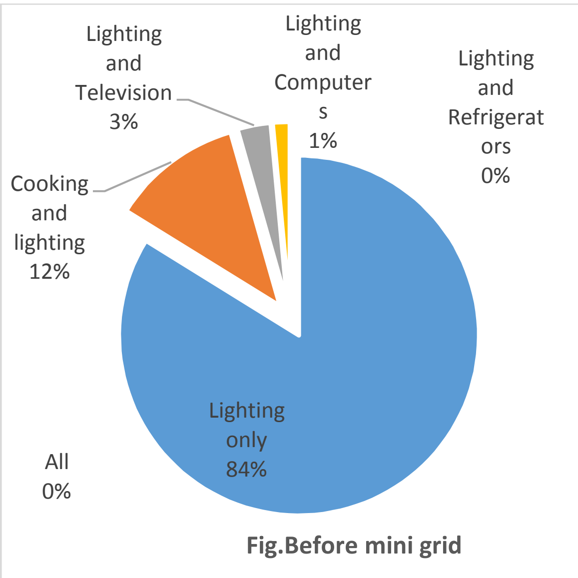
Among the 68 respondents, majority gave a view on technologically higher benefits side of the project as beneficiary get continuous reliable electricity from the mini grid.

Following result is observed about the mini grid technology:

Description	Technologically good	Medium	Unanswered
No of Respondents	58	4	6

Table 4: Response for mini grid technology

Similarly, when asked about what applications you use energy before and during mini grid, the result can be shown in pie-chart comparatively as:



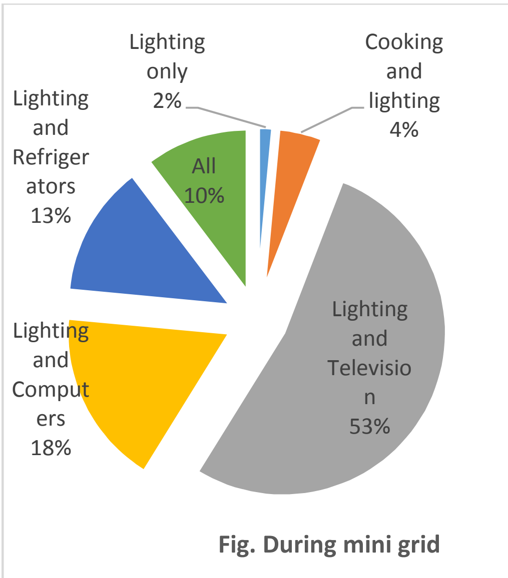


Fig 8: Domestic use of energy before and during mini grid operation

Before mini grid, the energy distribution is discontinuous and there's large voltage drop and overload so that much amount of energy was used up in lighting purpose only whereas during mini grid operation, combined lighting and television took a major part of energy with the consumption of energy in computers and refrigerators has started which were devoid of before mini grid operation.

In case of productive end uses question, does the mini-grid operation useful in end use promotion? Around 85% of the respondents responded that the electricity was 'Very Useful' in operating productive end uses like agro-processing (*kutani*, *pisani*, etc.), saw mills, poultry farming, photo-studio, electronic shop, internet cyber, etc. and one-tenth of the respondents respond just 'Useful' with none respondents replied 'Not Useful'.

Table 5: MHIMG's importance for PEU

Description	Very Useful	Useful	So-so	Not Useful	Unanswered
No. of Respondents	58	8	1	0	1
% of respondents	85.3	11.7	1.5	0	1.5

The above tabulated data can be shown in pie-chart below:

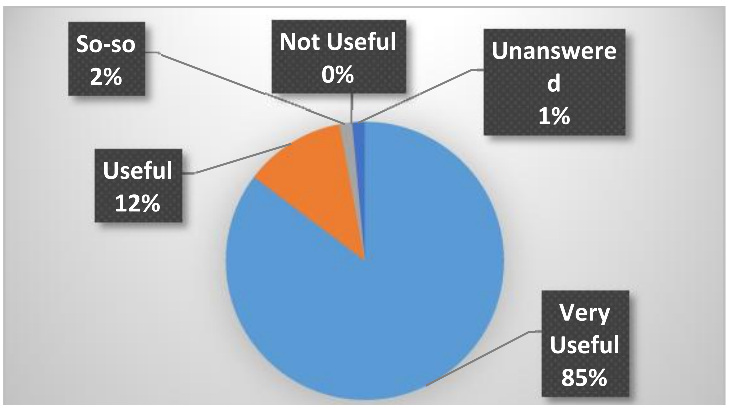


Fig 9: MHIMG importance in PEU

When enquired about the tariff structure of MHIMG, 49 respondents replied with 'Medium' , 18 went for 'Cheap' and only one respondents as 'Expensive' which can be shown in bar diagram as below:

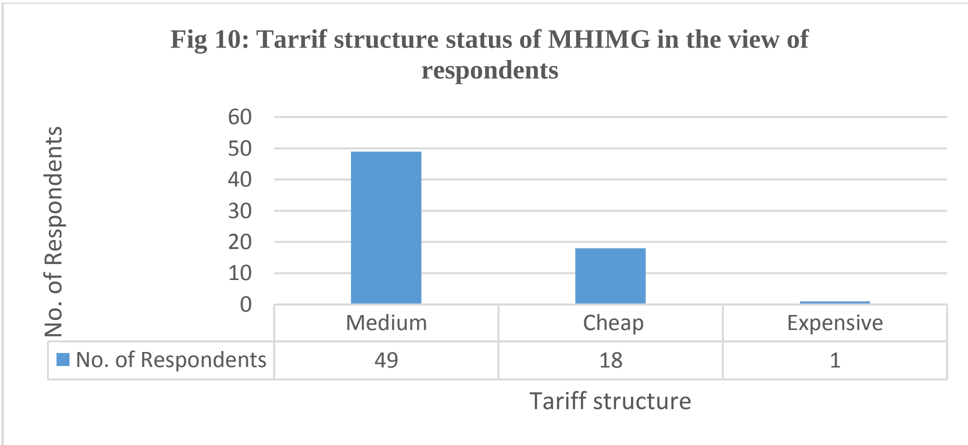


Fig 10: Tarrif structure status of MHIMG in the view of respondents

Satisfaction level over quality and reliability of electricity from MHIMG and Management Model of MHIMG can be shown through respondents' eyes as in pie-charts below. Almost all respondents were satisfied with quality and reliability of electricity from MHIMG system. In contrast, above half of the respondents were not in favor of existing management model (IPP) of MHIMG as large micro hydro collect huge revenues as the revenue distributed proportionately with the size of micro hydro.

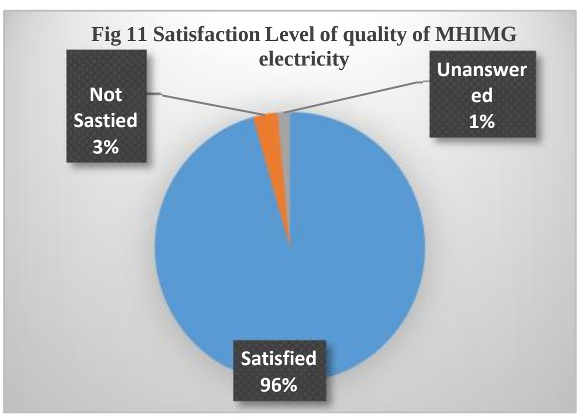


Fig 11 Satisfaction Level of quality of MHIMG electricity

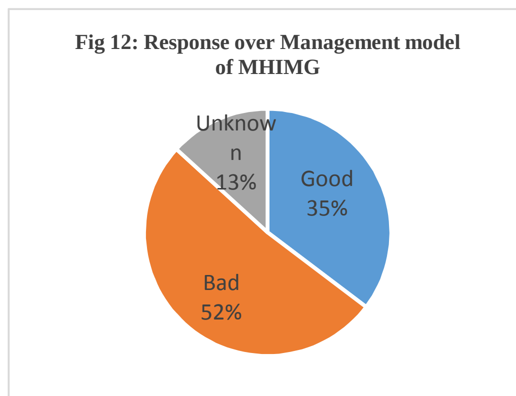


Fig 12: Response over Management model of MHIMG

Similarly, when asked about the wisely use culture of electricity during MHIMG operation, almost 100 per cent respondents says yes. It was found so as the energy meter was installed in each household and the consumer had to pay according to the bills of energy meter in which previously they had to pay fixed amount in watt basis (minimum NPR 75 for each bulb). Moreover, almost 76 percent households of the respondents has their meter installed which can be tabulated as:

Description	Yes	No
No. of Respondents	52	16
% of Respondents	76.5	23.5

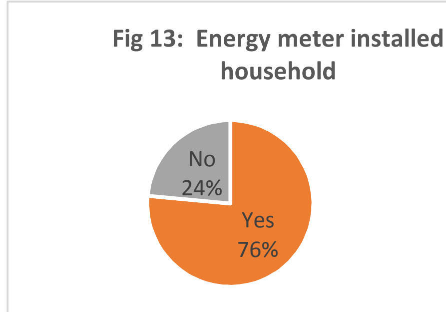
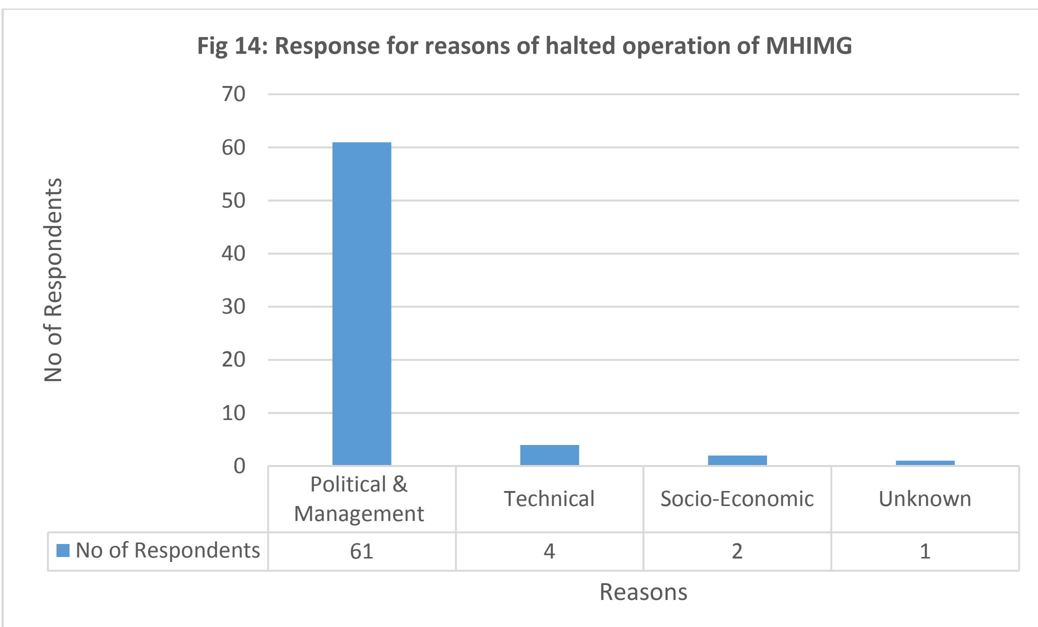


Table 6 & Figure 13: Meter installed HHs of respondents

For the question, if MHIMG is very useful, what are the main reasons for its dysfunction? The result was astonishing as the major reasons for halted operation is political and management of cooperative as IPP model. The project was running continuously for around one and an half year through good management. But after that, the project seemed politicized and the people with vested interest gave a continuous pressure to change the management committee of MHIMG and finally it was changed. That was the turning point for the project to be in halted position as the construction committee who once were also the first management committee of cooperative didn't support the new management committee.



In the same way, when asked, "Does expansion of national grid line which is near mini grid site wipe out the operation of each individual MHP of Mini Grid?" The result can be summarized in table as:

Table 7: Response of National Grid line extension wipe out individual MHP from the site

Description	Yes	No	Unknown
No. of Respondents	65	2	1
% of respondents	95.58	2.941	1.47

5.2 Economic Analysis:

Here we consider the source of income for individual plant is only the sale of energy to the grid (local and mini grid). Some of the plants have small amount of income from the interest of deposit fund which is excluded here. Also some dues of Cooperatives is excluded here. The detail of economic analysis of MG operation in 3 phases viz. before, during and after(now) has been presented in Annex with necessary calculations but the individual economic sub-headings has been discussed in following paragraphs.

5.2.1 Income, Expenditure and Savings:

The monthly average income, expenditure and savings of each individual MHP and the Mini Grid Cooperative can be summarized in table below as:

Table 8: Monthly Income Vs. Saving

S.N.	MHS	Income			Saving		
		Before	During	now	Before	During	now
1	Theula Khola (24 kW)	24000	35000	30000	-5000	20000	5000
2	Urja Khola IV (14 kW)	0	14000	16000	0	2000	3000
3	Urja Khola II (9 kW)	13000	9000	20000	3000	-8000	2000
4	Urja Khola I (26 kW)	14000	28000	30000	2000	4000	5000
5	Kalung Khola (22 kW)	18000	30000	25000	2000	12000	1000
6	Upper Kalung Khola (12 kW)	8000	10000	13000	-2000	-1000	-3000
	Total	**77000**	**126000**	**134000**	**0**	**29000**	**13000**
7	Minigrid Co-operative	0	167000	0	0	41000	0

As a whole, the revenue of all MHP has increased except Urja II MHP with large MHP has higer income during mini grid operation as they share large power in mini grid whereas for small MHP the revenue is low as governed by IPP model. The revenue is above forty thousand per month for co-operative.

5.2.2 Salary of Operator:

The salary of operators has been increased during mini grid operation and the trend has been continuing till date. The salary of operator now seems big, but it's been almost 3 years and the operator has to cope with the expensiveness for their livelihood. If the amount becomes deficit, they get salary only after collecting from the beneficiaries as extra amount.

Table 9: Salary level of Operator of each MH plant before, during and after MG operation

S.N.	MHS	Monthly Salary of Operators, NPR		
		Before	During	Now
1	Theula Khola (24 kW)	4500	7000	10000
2	Urja Khola IV (14 kW)	0	6000	7000
3	Urja Khola II (9 kW)	3500	7000	7000
4	Urja Khola I (26 kW)	3500	8000	10000
5	Kalung Khola (22 kW)	6000	7000	11000
6	Upper Kalung Khola (12 kW)	3000	5000	5000

5.2.3 Operation Hours:

Before MG, the operation hours for productive end uses like agro-processing, saw mills, photo studio, electronic shop, poultry farming, etc. was just 2 to 3 hours due to deficit of electricity and they had to be run during off peak times that continues in recent time too. But during MG operation, the time of running end uses increased from 2 to 3 hours to 8 to 10 hours also somehow in peak times too. Further, the entrepreneurs had accessed to 3-phase power to run 3-phase equipment yielding more income.

Table 10 : Productive End Use running hours

	Before,Hr	During, Hr	After, Hr
Time	2 to 3	8 to 10	2 to 3

5.2.4 Number of Micro-enterprises:

The number of micro-enterprises has increased noticeably during short period of mini grid operation which can be summarized as:

Table 11: Number of Micro-enterprises (Productive end uses)

S.N.	MHS	Productive End Uses numbers		
		Before	During	After
1	Theula Khola (24 kW)	6	13	10
2	Urja Khola IV (14 kW)	0	5	7
3	Urja Khola II (9 kW)	2	4	4
4	Urja Khola I (26 kW)	7	13	17
5	Kalung Khola (22 kW)	5	14	10
6	Upper Kalung Khola (12 kW)	0	4	4

5.2.5 Financial benefits of MHIMG:

The financial benefits can be discussed in bulleted points from the focus group discussion and respondents' view as:

- Income of power houses has increased and so has the salary of individual MH operators. Basically power houses of capacity greater than 15 kW has increased their annual income by NPR 50000 to 70000 while power houses with capacity less than 15 kW increased their annual income by NPR 15000 to NPR 30000 per annum. In above financial calculation lower plants Upper Kalung, Urja Khola II and Urja Khola IV seem to be financially unfeasible, the main reason behind this are increased salary of operator, maintenance of Panel equipment and low power consumption in MG in return low revenue.
- It creates more than 55 job opportunity for local people through the establishment of Agro processing mills, Poultry farming, Computer Institute, Photo studio, electronic shop etc. People in this area are very motivated towards the establishment of small and medium sizes enterprises i.e. vision of small industries comes forward after establishment of Mini Grid.
- Individual earns a lot of money through small poultry farm, small saw mills, electronic shop, photo studio etc. Due to freedom from limited electricity use, small carpentry using electric grinder becomes important source of income for disadvantageous people.
- The income of Entrepreneurs has increased as they can use electricity any time of day and night as their requirement. Moreover, entrepreneurs can operate their

enterprises continuously even if there are some problem in respective plants, in the case of forced outage and regular maintenance period.

- Many possibilities of financial strengthening of the micro hydro and Mini Grid seem to be possible by the establishment of medium sized industries, supply to communication tower, tone crushing plant, slate processing plants.

In short, the financial benefits can be bulleted as:

- Increment of MHPs income by 20% to 60%
- Increment of operator salary by 17% to 129%
- Income of entrepreneurs increased by 5% to 30%
- New enterprises established (22 to 53)

5.3 Social Analysis:

There has been a greater impact of MG in society. There has been a sense of togetherness through meetings, discussions and exposure to international society during mini grid operation. The data has been presented above in impact assessment. Moreover, the social impact of mini grid can be presenter through questions and answer from the respondents as:

Changes brought by the mini grid in society?

- 24 hour reliable electricity availability
- Wise use of electricity as use of energy meter governed this
- Greater role in education(electricity line in schools), health (continuous electricity in health post) and communication sector(mobile charging, supply electricity to mobile tower)
- Exposure to national and international communities
- Training facility (computer, *muda bunne, nanglo banaune, dhup-batti banaune,* etc.)
- Create hope of joining this project to national grid line and its sustainability

Changes brought about in individual/family lifestyle

- Longer hour of study for children
- Convenience in domestic works

- Build social relation through frequent meetings and discussions
- Better lifestyle through higher income from productive end uses
- Job opportunities for local people

  In detail, the social benefits can be described as:

- **End Use promotion:** Mini Grid plays important role for the end use promotion. A large numbers of existing end users are presented in the fact sheet of generating stations. Agro- processing mills, Furniture industries, Computer institute, Poultry firm, Electronic shop, Individual carpentry, Photo studio, etc. are the existing end uses. Various trainings, seminars, capacity building activities organized by the AEPC/RERL become the key source of motivation for the end use promotion. Local people are quite motivated towards the income generating activities through the establishment of small size enterprises. Communities are ready to maximize the use of rural energy. All the existing end use are presented in the data sheer of individual plants.
- **Concept towards the use of electricity has been changed:** Before Mini people thought that electricity is only for the lighting purpose but now they use electricity for various household purposes and productive end uses
- **People know about saving the electricity:** Power based tariff structure was used before Mini Grid concept, so consumers made large misuse of electricity. After using energy based tariff structure, people know the price of electricity and are shelf motivated for saving of electricity.
- Confidence of the community has increased to construct, own & manage bigger projects.
- Community mentality has changed and they are confident that micro hydro connected to mini grid can be the permanent source of electricity if utilized properly.
- Mini-grid unites the six different communities socially as well. That protects the MHPs from vanishing, even if the grid has already covered the area. Inter community Coordination seen due to the establishment of Cooperative in the Mini Grid society. Seven different community groups merge into one huge community and became members of common institution.

- It is easy for the educational institution for providing computer education and internet facility to the students because of availability of quality, reliable and continuous energy from Mini Grid.

5.4 Technical Analysis:

The MHIMG of Baglung includes 6 Micro Hydro plants (i.e. Upper Kalung Khola (12 kW), Kalung Khola (22 kW), Urja Khola I (26 kW), Urja Khola II (9 kW), Urja khola IV (14 kW) & Theule khola MHP (24 kW), originated from same source of stream) located in Rangkhani, Paiyauthanthap, Sarkuwa and Dameak VDC having total power output of the system is 107 kW, interconnected by means of 8 km long , 11 kV transmission line with 1178 households (HHs) as beneficiary. All of these plants were built in between 2056 to 2068 and are supported REDP. Microprocessor based grid synchronizable Electronic load Controller (ELC) is the core technology used in mini grid project.

For the Power transfer and network formation, 8 Km long 3 phase 11 KV single circuit transmission line has been constructed. 7 sets of isolators and D.O. fuse for isolating the 11 KV line from each MHP are used. The transmission line runs along Urja Khola River, which are tapped at seven different places to connect each MHP. Double pole mounted outdoor transformer along with Lighting Arrester, Isolating switch and drop out fuse are use in all tapped lines. The whole length of transmission line can be broken into three different sections by means of two sets of series drop out fuse, the purpose of which are to make the fault finding process easy, to minimizing the fault clearance time and to operate the Mini Grid in partial breakdown mode in case of longer duration problems. A numbers of Lighting Arresters are used to protect line and equipment from lighting over voltages. 11 kV Grid transmission line corridor of Mini Grid and connection scheme of each plant to Grid is shown in single line diagram attached in Annex.

5.4.1 P-F Control system

Electronic load controller is the central part of this system. It is an electronic device that maintains constant load to the generator despite of the variation of the load in the village.

Microcontroller based programmable digital electronic load controller is used in this system which functions differently in isolated and grid connected modes. In isolated mode, ELC operates so as to make the system frequency at the constant value, while at the interconnected mode, power sharing takes place through droop mechanism, thereby frequency is allowed to vary with in certain limit (2% in this case). Another importance of frequency droop is that there is proportional sharing of added load to the system. Suppose two generator having capacity 100 & 40 kVA having droop setting of 2%, both of them operating at no load. If a load of 25 kW is switch on then, first generator will share 17.85kW and second generator will share 7.15 kW of load.

GENERATING POWER = MAIN LOAD POWER + BALLAST LOAD POWER

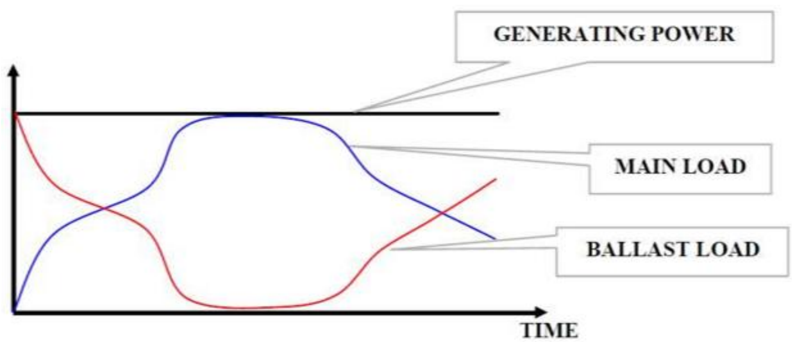


Figure 15: Principle of Electronic Load Controller (ELC)

The ELC unit consists of ELC block, gate driving unit & ELM. The i/p signals are associated with the voltage values at the generator terminals, voltage values of grid and other signals from the switching units. The input signals are processed by the ELC unit and the control signals are generated to feed circuit driving unit (Drive Card) and ELM unit. The main function of the drive card is to provide the gate signals to Thyristors, so that the frequency of the output voltage would be maintained at the desired value. It also helps to suppress the spikes while chopping the ac cycles. Apart from the ELC block and drive card, there are other components used with ELC system, such as voltage transformers and IC units. When proper signals are produced from the ELC system, the Thyristors would feed ballast load, thereby balancing the load and regulating the frequency.

5.4.2 Q-V Control system

Automatic Voltage Regulator (AVR) along with Automatic Power Factor Regulator (APFR) play very important role to control Reactive power and Voltage of the system. Voltage variation is related to reactive power sharing and vice versa. Since consumers have varying unpredictable reactive power demand which is very difficult to predict so there is always mismatch between reactive power generation with consumption which is the main cause of voltage variation and flow of circulating current. AVR is a device that provides the necessary dc current to the field windings of the generator to provide the constant magnetic flux in the air gap so that the generator produce required voltage. In spite of using the AVR we can configure generators in shelf excited mode in which external excitation system is not required. Generator first builds up some voltage from the residual magnetization which is picked by AVR & builds rated voltage at rated speed. The main function of the AVR is to sense the generator voltage & control the excitation so as to obtain desired output voltage. It operates in two different modes, in isolated and the Mini Grid modes. In isolated mode it regulates the terminal voltage at the constant value, while in the MG connected mode, voltage regulation is performed by droop regulation techniques.

5.4.3 Switchgear and Protection system

Protection system is the primary requirement of the power system. For the protection of power system equipment and personal, various protection equipment are provided in our control panel.

They are fuses, MCBs, MCCBs, contactors, relaying system and emergency switches.

5.4.4 Fuse, MCB, MCCB & Contactor

Fuses are much conventional type of protection elements. They are placed in series with the element that has to be protected. Small Cartridge fuses are provided in all equipment, such as AVR, ELC, and diver card. High Rupturing (HRC) Fuses of various capacities are provided for the protection of ballast heater and Battery charging units. For the protection against overload and short circuit inside the equipment of control panel a numbers of MCBs are provided. MCBs are superior protection element than fuse. They can be operated manually or automatically during over current. The control panel uses 8 MCBs to provide protection from over current to the different circuit branches. Two MCCBs have been used in control panel, one MCCB for village load feeder and the other is for grid feeder inside panel. They can be operated manually or automatically by providing 24 V supplies to its shunt trip coil. Both village & grid MCCBs are operated by the action of master trip relay depending upon the nature of fault. Both MCCBs can also be operated manually. In case of contactors, DC and AC contactors are used in the control panel. The DC contactor requires 24V DC supply to operate and it acts as switch for dc system, whereas AC contactor requires 220V AC supply to energize. It provides protection to the generator and blocks the generator power supply to Grid and Village load.

5.4.5 Relay System

It is used to sense abnormal condition in the circuit and gives the tripping signal for the MCCB and Contactor. Relaying system consists of a number of sensors to sense abnormal condition in the circuit and giving the tripping signal for the MCCB and Contactor. These relays operate in three modes: scan mode (gets activated for searching of faults), set mod (setting the value of tripping parameters), and value mode (shows the instantaneous values of the parameter). The main relaying functions include:

a) Over-under frequency relay
b) Over under voltage relay
c) Over current rely
d) Phase unbalance relay
e) Voltage restrained over current relay
f) Reverse power relay
g) Earth fault relay
h) Master trip relay

The objective of these relays is to protect the generator and consumer load from abnormal condition of faults and any other disturbances. Relays give the signal to Master trip relay which will trip the ac contactor and MCCBs. All above relays are used to protect Generator except Earth fault relay which is used to sense the Transformer earth fault, and is remains in operative in present situation.

There are six auxiliary relays used in the control panel which provides both ac and dc supply for various equipment at suitable instant and are energized by 24 v dc supply. All relays have 11 terminals.

5.4.6 Emergency case Handling

The emergency tripping unit is the most important unit in the control panel. It allows the operator to disconnect the generator and village load from grid if he\she so desired. If the operator feels any abnormal condition inside power house or village distribution system or grid transmission system, he can operate mushroom type emergency key which prevent the generator to supply to village & grid. It also trips the both MCCBs so grid connection to village can also be stopped.

5.4.7 Measurement & Instrumentation System

Measurement of various electrical parameters & variables of the system play important role to provide the idea of what is going on inside the system and what sort of actions need to be applied for corrective action, if any. The measurement system includes, acquiring data of generation, consumption and other at the different places. Separate units are provided for Generation (After ballast) measurement, local load measurement, Excitation measurement and other miscellaneous measurement and Indication system.

5.4.8 Generation Measurement System

It includes monitoring values of voltage at generator output terminal and output current injected by generator after the ballast load. For current measurement, three current transformers are installed in between generator and contactor in vertical bus bar; while for voltage, it is directly tapped through the bus bar. It shows the instantaneous values of Generating line voltages, Line current, Generator Power factor, Generator kW load and total unit of Generation. Frequency of generating voltage is shown by the Digital frequency meter.

5.4.9 DC System

For the operation of protective switchgear, Switching application, Indicating equipment and operation of other equipment DC system is used. It consists of two 12 V DC battery having capacity 17 Ah (In General) connected in series to provide 24 V DC system. 0-36 V, 2 Amp step down transformer is use to charge the Batteries. Two 12-0-12 V transformer are used to supply the battery card. Automated battery charge controller along with adjustable charging current and voltage. Combination of diode and Thyristors forms semi controlled bridge rectifier in which gating signal for Thyristors are provided by Controller card. DC supply is used in the following equipment:

- ✓ 12 V for Driver card.
- ✓ 24 V for main relays.
- ✓ 24 V for auxiliary relays.
- ✓ 24V for ELC during synchronization.
- ✓ 24 V for Electronic hooter.
- ✓ 24 V for Automatic synchronizer during synchronization.
- ✓ 24 V for semaphore indicator etc.

5.4.10 Synchronization

The process of connecting an alternator in parallel with another generator or with infinite bus bars to which a numbers of alternators are connected is called synchronizing. Before synchronizing, the incoming generator should necessarily meet certain conditions, which are:

- ➢ The terminal voltage of the incoming generator must be exactly equal to that of the grid
- ➢ Bus bar voltage connecting the other generators.
- ➢ The speed of the incoming generator must be such that its frequency (being equal to the
- ➢ P*Ns/120) equals grid Bus bar frequency.
- ➢ The phase of the incoming generator voltage must be same as that of the Bus-Bar voltage relative to the load.
- ➢ Phase sequence of the incoming generator must be same as that of the Bus-Bars.

Synchronization is done in both auto and manual mode. The diagram is attached in Annex.

5.4.11 Technical Benefits of MHIMG

After the formation of the Mini Grid, there are a lot of technical up gradation in the control system, protection, safety, measurement, Instrumentation and in other field. There are technical up-gradations in all MHPs after the introduction of MG Technology, because the older control technologies were designed for the isolated mode and could not be compatible with MG operation. These technology and equipment has resulted stable voltage & frequency, reliable service due to effective relaying. Further, Fault detection process is made easier and faster by using indicators, Alarming facility & relays based protection system in the control system.

- **Quality of the Electricity:** The quality of the supply is mainly governed by its voltage and frequency. Because of system interconnection and paralleling of generators, voltage deviation and frequency variation range is drastically reduced then isolated mode. Also adjustable voltage control facility in the new control panel helps to boost up the terminal voltage at the feeder end point. According to local people, same bulb used for lighting glows more brightly after the formation of Mini Grid, proving that quality of electricity has been drastically increased.
- **Reliability of Electricity supply:** One of the major objectives of the Local grid formation is to increase the reliability of electricity supply. In case of isolated plant the supply to the local consumer would be interrupted if any problem (caused by forced condition) occurs in any structures from intake to tailrace i.e. penstock, Turbine system, Drive system, Generator and control system. Also the same case would happen during the period of regular maintenance. In all above condition local consumer receive electricity from Mini Grid. Moreover during regular shut down period of each day, consumers do not feel the sense of load shedding. So we can say that Mini Grid increases the reliability of electricity.
- **Introduction to energy based tariff structure from power based tariff system:** Before the formation of Mini Grid consumers paid the charge of electricity according to the amount of power they used. Such system has various disadvantages. Now each consumer has installed energy meter to measure amount of energy they used. Consumer using less energy pays less charge and one who uses more pays more which helps to balance deficit power of one house by surplus electricity of other house. Also deficit amount of electricity of one plant is balanced by surplus electricity of other plant. This is due to the load sharing between

Generators. For example Theule Khola station has its own local load greater than its capacity, which is fulfilling by importing power from grid. Kalung Khola and Urja Khola IV station have excess of electricity. Energy based tariff structure and load haring help to reduce the overloading of Generators.

- **Better operating condition of Generator:** The temperature and sound of Generator becomes better when operating in parallel which also extends its operating life. According to operators it is very easy to start Induction motors used for domestic and Industrial Purpose.
- **Starting and processing speed of agro-processing and saw mill:** According to the entrepreneurs of these enterprises, it is very difficult to start their Induction motor when plant is running in isolated mode. It is very easy to start those motors also the processing speed of these motors largely increases, they can easily increase load without any drought. Especially in case of small plant of capacity less than 15 kW such problem troubles them frequently.
- **Future planning for using large surplus power**: Large scale end use application like 40 kW stone crusher, line to N-Cell tower, etc. on the cards.
- **Mini Grid is becoming a research place**: Different organizations in energy field are interested to replicate the technology and management model in other parts as well. Such visit was made by team from Ministry of Rural and Reconstruction from Afghanistan. Several students from various Universities are currently engaged for their thesis work in Graduate and post Graduate Programs related to technical, social and environmental issues of Mini Grid.
- **Better safety for personnel and equipment:** Due to the adaptation of relaying based protection system, it is very easy to find the condition of abnormal operating condition and can easily be cleared which provides safety for both personal & equipment. The fault indicating alarm Annunciator, electronic hooter and Emergency switch helps to rapid clearance of fault preventing the further damage and destruction due to fault.

- **Advanced metering system:** Microcontroller based digital frequency counter, Digital Electronic Load monitor and other appropriate metering systems provide sufficient technical information about the system which play important role to provide the idea of what is going on inside the system and what sort of actions need to be applied for corrective action, if any.
- **Easiness of plant operation:** Due to the automatic control and protection it is very easy for operators to operate the plant. According to them they do not take care of over / under voltage, Current, over / under frequency etc. In any abnormal condition of fault, protection system automatically isolates the generator from fault and hooter calls them to take necessary action. Also sudden increase or decrease of load is easily balanced by the system especially while starting and stopping large motors.
- **Infrastructure Development of Connection of Mini Grid with National Grid:** It offers sizeable capacity (Both load and Generation) to NEA for encouraging to connect the Min- Grid with the national grid.

5.5 Issues and reasons behind halted operation of Mini Grid operation

5.5.1 Social Issues:

Social issues are the main reason for halted operation of mini grid which can be listed through focus group discussion, stakeholder's views and respondents' response as:

- Local political interference in Mini Grid Cooperative: One of the major reasons for dysfunction of mini grid. The people in the committee of both functional group and the Cooperative have high influence in politics and the member selection also was a part of politics so that the highly qualified people are devoid in the committee. Moreover, the operation of Mini Grid runs with the politics so that there was conflict in decision making in crucial matters.
- Difficulty in community mobilization
- Lack of ownership feelings
- Lack of unity/biasness

5.5.2 Financial Issues:

The financial issues of mini grid can be bulleted from the eyes of respondents as:

- Low electricity consumption rate of domestic consumer.
- Higher repair, maintenance and replacement cost of control equipment.
  Older structures of the plants lead to more maintenance costs of civil, electrical and mechanical components.
- Lack of deposit fund with the Mini Grid and plants: It makes difficult for the replacement of equipment requiring huge costs such as to Transformer, Generator, damaging of transmission and distribution system.
- Expensive human resource cost for operation, management staffs, maintenance and person causes the additional financial burden over both business groups
- Difficulties for end use promotion in the Mini Grid area due to adverse geology condition, bad structure of access road, individual biasness of community, lack of human resource etc. are the main barriers for the end use promotion.

5.5.3 Technical Issues:

Although there are many technical advantages of Mini Grid, there are some technical difficulties or issues which obstruct the smooth operation of Mini Grid. Since Mini Grid is the piloting project which is implemented for the first time in Nepal there is no such prior experience for us, so there is possibility of occurring new and new technical issues and problems in the Mini Grid technology. These are based on operator's response, implementing agencie's views and the response of the respondents.

Lack of central control and monitoring unit: For maintaining power quality, active and reactive power balance must be maintained within the system. Mini Grid operator should be able to choose the mode of operation. Similarly, generation, supply and storage of energy must be suitably planned with respect to load demand on the system. So Grid operator should know continuously about Generation and loading condition of the system.

- **Lack of convenient communication mechanism:** Mobile communication is only the means of communication between Grid operators and Plant operator and operator to operator. It is very difficult to take continuous information and giving instruction to the operator from phone call. Also it is more expensive. There are lots of cases in which due to the problem on the communication network, many sensitive loads have to be stopped for longer time period. On the other hand there is a confusion who will communicate if there are some general problems.

- **Issues on the active power sharing:** In the Mini Grid system the active power sharing is proportional to the capacity of the ballast load. So the power sharing is affected by the ballast size. When, any plant is operating at lower capacity than its rated capacity or size of ballast is high than its usual size, in such condition there may be possibility of back feeding by grid to the ballast of that plant, making reverse rotation of generator Energy meter.

- **Lack of spare parts, Expensive technology and maintenance problems:** Mini Grid technology was imported from India and is more expensive than older system. Since there is no local supplier of panel equipment's it is very difficult to buy the new equipment. Also maintenance of defected equipment cannot be done by local technician, high cost and longer shut down period, lack of timely maintenance even for minor problems. For example Urja IV plant was found operating without ELC for more than one month. Lack of appropriate spare parts is also the major cause of plant shut down.

- **Difficulties in dry season load management:** All the plants within Mini Grid, uses same source of water and operate in cascade mode, especially in the driest months Falgun, Chaitra, Baishak and Jestha, when water is diverted for irrigation operation of Mini Grid is totally affected causing frequency instability. Lack of load control authority and mechanism with Co-Operative, lack of synchronism check and large local load of each plant are other causes of frequency instability.

- **Older structures of the plants:** Almost all plants were established 10 years ago, so the condition and efficiency of generators, turbines, earthing systems become very poor which needs higher maintenance costs. In case of Theulakhola plant, although efficient AVR system is used voltage regulation is very poor. This plant cannot start induction motors in isolated mode. Contactor gets frequently tripped while starting induction motors

- **Lack of skilled manpower for O/M:** As the technology is new and from India, no skilled manpower has been produced for maintenance and dependent on technical person from Y-tek Controls.
- **Lack of sufficient knowledge for MHP operator:** As the operator are from non-technical background and there's frequent changes of operator, it's difficult for them to operate the mini grid which needs highly technical person.

5.5.4 Management Issue:

Followings are the noticeable issues of the current management model (IPP Model) through respondents' eyes:

- **Gap creation between Micro Hydro functional Group and Co-Operative:** In straight forward way both of these are two separate business groups so both of them tries to generate more revenue from the common source of income i.e. electricity. This creates dispute between them. Micro Hydro functional group tries to make higher PPA rate and lower tariff structure for consumer which is not in favor of Mini Grid. The hidden fact is that, staffs within both groups are internally jealous to each other regarding to scope of work, facilities etc. which affects the management of Mini Grid.
- **Delay in problem solving:** Micro Hydro functional groups do not have authority over the distribution system up to consumer energy meter. If there are some problems in distribution line and consumer connection, due to large coverage area, limited staffs and long procedures it will be very much delayed to solve even for the simple problems.
- **High financial burden over the Mini Grid:** Especially according to this IPP Model distribution line is under the Mini Grid which is old and it needs high cost for repair & maintenance. More over to operate whole distribution system Co-Operative either has to hair additional staff or use plant operators by paying extra charge. Due

to this difficulty all the distribution lines are looked after by the Micro Hydro functional group till now in Mini Grid system.

- If any generating plant is shut down for long time due to some reason then the income of that plant is very low which may create financial problems for MHFG

5.6 Efforts and Measures taken to revive the project

This can be described in three levels of implementation of the project as:

5.6.1 Central Level:

At central level, AEPC/RERL has disbursed budget approximately NPR 10 lakh to DDC: DEECCS account in 2014/15 for carrying out operation and maintenance as well as repair the faulty parts. Frequent field visits, monitoring and guidance and triggering the committee and the community are other tasks done from central level. Furthermore, it has played a pivotal role to have agreement with Y-Tek Controls Company (the installer of mini grid) for repair and maintenance work. Also, they are collecting deficit fund of around 35 lakhs where 30 lakhs has previously been disbursed to connect mini grid to the national grid. For repair and maintenance, there is an agreement between Spectrum Consult and Research Center Pvt. Ltd., Lalitpur and Urja Upatyaka Mini Grid Co-operative coordinated by AEPC/RERL. This would be helpful in repairing the faulty parts as early as possible and with very low cost as previously equipment and trained manpower are imported from India with very higher cost. The work done from central level can be listed as;

Financial support:

- Support for office establishment
- Support for establishment of communication center
- Support for establishment of Chilling Vat
- Planning to support for the establishment of Cold store & Crusher Industry
- Planning to support for providing spare parts.

Capacity building & skills enhancement trainings:

- Field visit of mini grid working committee to India
- Seminar for fixing the operating modality of Mini Grid

- Basic Technical training for operators through technology provider
- Technical training (Operational and maintenance) for the technical manager, selected operators and local electronic maintenance entrepreneurs through technology provider
- Line man training to the technical person of Mini Grid
- Orientation for consumers about IPP Modality
- Accounting system training for Accountant
- Co-operative management & accounting system training for management committee and staffs
- Rural electrification training for MHP functional group and Co-operative.
- Management training for plant manager.
- Seminar for designing the 1 year business plan and 5 year strategic plan.

Income generation Activities (IGA):

- Business promoting training for local entrepreneurs.
- Poultry farming and computer training
- Dairy product and chilling vat operation training
- *Kaulo* to *Agarbati* manufacturing training
- *Lapsi ko achar, morubba* and candle processing training
- Bamboo and its product manufacturing training

5.6.2 Local Level:

At local level, DDC: DEECCS, Baglung in coordination with mini grid cooperative has conducted repair and maintenance of all MHPs and minigrid lines. With the supply of equipment done in 2014 through the agreement between cooperative and the Y-Tek Controls, India with the fund provided by AEPC/RERL. In 2015, the same company with their skilled manpower conducted the repair and maintenance of individual MHPs and the mini grid lines favorable to operate mini grid. The following work has been done:

- Replace and carry out repair and maintenance of faulty equipment like thyristor, relays, meters, driver card, power and current transformer, etc.
- Change the faulty DO fuse and pin insulator

- Clear out the 11 kV mini grid lines
- Conduct various meetings regarding revival of mini grid

5.6.3 Management and Beneficiary Level:

At this level, each individual plant operator and functional group helped in assessing and replacing faulty equipments with the coordination of Indian engineers who were involve for O/M and DDC: DEECCS engineer for proper functioning of MHS. The current management (Mini Grid Co-operative) vows to step down to pave the way for the benefit of mini grid and in process of selection of new committee through General Assembly. The first Cooperative Committee who were also the mini grid construction committee is helping to handover financial transparent matters during their working period which didn’t happen previously.

5.7 Challenges forward to revive the project

- Change of Management of mini grid Cooperative through general assembly
- Handover from first committee to second committee successively to the new forming committee as there's a big issue of transparency of first committee and till date no financial handover to second committee from first committee is happened.
- Easy access of spare parts (as of now imported from Y-tek Control, India)
- Availability of trained manpower both operator and O/M personnel
- Capacity development of operator, as most of them are from non-technical background
- Fund and technology to connect mini grid to national grid line: Around 65 lakhs needed for this purpose

Chapter 6: Summary, Conclusion and Discussions

6.1 Summary

MHIMG has larger positive techno-socio-economic impacts in rural livelihood. It somehow directly and indirectly cause greater impact in developing different infrastructure of development like health, education, communication, etc. Moreover, formation of the Mini Grid Network through the interconnection of nearby isolated Micro Hydro Plant can be the best method of solving the various issues of standalone MHP. Affordable and reliable supply to the rural communities of Nepal can be given through the construction of such local grids. Implementation of Baglung Mini grid opens the floor for the construction of such community managed projects. In a given context, such projects require suitable choice of technologies and implementation strategies right from the design stage. It has collected accolades of praises all around the world with much positive impact regarding technical, economic and social aspects to the localities in the short period of implementation. These benefits are summarized in following table, grouped into technical, financial and social categories.

Table 12: Summary of Benefits of MHIMG

Technical	Financial	Social
✓ Reliability, quality and availability of electricity enhanced ✓ Capacity factor increased ✓ Overall safety and safety to operator during operation enhanced ✓ Possibilities to operate large load ✓ Facilitates interconnection with central grid ✓ Operational performance of MH generators and commercial equipment increased ✓ MHMG's operator's capacity enhanced ✓ Computer education, internet service became possible ✓ Running of 3-phase equipments ✓ Introduction of power based tariff to energy based tariff in MH plant ✓ Prevent wipe out of the individual MHS.	✓ Increase in income of individual MHMGs ✓ Increase in income of entrepreneurs due to availability of electricity ✓ Increase in number of commercial loads ✓ New job creation ✓ Increased salary of operators ✓ Long hours operation of productive end uses	✓ Community perspective towards electricity use changed ✓ Community confidence increased through operation of complex system ✓ Increased ownership of electrical appliances ✓ Unite the community ✓ Capacity development of beneficiaries ✓ Exposure visits to international community

Similarly, the issues and reasons behind the closure of the projects can be summarized as:

Table 13: Issues and Reasons behind closure of the MHIMG project

Technical	Financial
✓ Lack of central control and monitoring Unit ✓ Improper IPP model for active power sharing as small MHPs income becomes low ✓ Lack of trained manpower for opera ration and maintenance ✓ Low knowledge on operator and their frequent changes ✓ Lack of spare parts and their accessibility are low as the technology is fully dependent on India(Y-tek company) ✓ Lack of Operating and Maintenance guidelines ✓ Difficulty in dry season load management ✓ Older structure of plants ✓ Lack of convenient communication	✓ Lack of transparency in management committee (Mini Grid Cooperative) ✓ Smaller MHS getting less money, consequently becoming hard to sustain ✓ High O/M cost ✓ Difficulty in End Use promotion due to adverse geology condition, individual baseness of community, lack of human resource and knowledge ✓ Big burden for co-operative if the plant stop operation during for long time needing maintenance ✓ Low electricity consumption rate of domestic consumer ✓ Lack of deposit fund with the mini grid cooperative and the individual plant ✓ Expensive human resource cost for O/M as they need to be hire from India
Social	**Management**
✓ Local political interference ✓ Difficulty in community mobilization ✓ Lack of ownership feelings ✓ Lack of unity/biasness	✓ Lack of transparency in income and expenditure of MG cooperative ✓ Politically biased management committee ✓ Cooperative run in its own way disregarding problem faced by individual MHS ✓ Issues of income sharing between cooperative and the individual MHS ✓ Urja I took income from electricity consumed by NCELL tower which is not with the spirit of IPP model creating havoc between cooperative and the Urja I MHS

Besides benefits and issues, there are ample of opportunities too, to revive the project. And a lot of efforts has been taken in the past to re-operate the project mostly from central level-AEPC/RERL and local level-DDC: DEECCS. The opportunities and threats can be summarized as:

Table 14: Opportunities and Threats

Opportunities	Threats
➢ Proper use of International fund and make good relation with donor agency ➢ High chance to be the first project to connect to the national grid ➢ Skill development of people of catchment area ➢ High chance of other internationally funding projects if it get success	If left defunct, ➢ Low chance of implementation of other international funding project in the current project catchment area ➢ Division of community over the project ➢ As national grid line has reached, beneficiary of individual MHP shift towards it and these individual MHPs will be wipe out

6.2 Conclusion:

As discussed in above chapters, the technical and socio-economic benefits of MHIMG heavily surpassed that of the individual MHPs such as upgradation of technology, automatic control and high protection, higher income for MHS and entrepreneurs, favorable environment for connection with the national grid, etc. to name a few. Compared to large hydropower plant, micro hydro plant especially MHIMG plant has as much techno-socio-economic benefits in difficult terrain of rural areas where large hydropower is inaccessible. Electricity supplied by MHIMG enhances income generation (agro-processing, and small service business such as mills and shops) and enables inhabitants to make savings on expenses on kerosene, gasoline, candles, and batteries. Income increase and savings enhance better livelihood of the beneficiaries Moreover, women's and children's work load decreases, since they spend less time on energy related household tasks such as the collection of fire wood. Furthermore, women and children have more productive time which can be used for studying and thus education is improved. Electricity supply allows lighting at night and give inhabitants the chance to study during evening hours. Furthermore, telecommunication is enhanced so that people get more aware of the outside world which gives them more knowledge. It further strengthens the community' health situation, since it decreases indoor air pollution and the risk of fire.

There is a growing interest in interconnecting MHS systems in Nepal to overcome limitations such as low capacity factor, poor reliability and inability to serve larger commercial loads. MHIMG can certainly have positive impacts, as outlined in above chapter. Having said that, a number of issues with MHIMG have been identified in the relevant literature. Some of the major issues include the limited benefit of MHIMG over MHS, the potentially high costs of construction, system complexity in terms of technology and management, and lack of skilled labor to operate the system.

For cases where a collection of MHS are located too far from the central grid to be considered for connection, and when combining the generation of individual MH would result in better overall power reliability for a planned MHIMG, interconnecting the MHS to create an MHIMG is appropriate. The potential success of an MHIMG is site specific. Its success depends on a number of factors, including distances between MHMGs, possibilities to inter system energy transfers between MH schemes during high and low demand periods, community involvement, integrated planning approaches for capital and operational cost reduction, and methods for maximizing operating revenue, such as identifying potential market, favorable support policy and capacity assessment and enhancement ensure the success of MHIMG.

At this time, two MHIMGs are in operation. However, impact studies have largely focused only on Urja Upatyaka MHIMG and it is likely still too early to draw firm conclusions. Further experience and analysis will be required to assess whether interconnected MHMGs are an appropriate solution to be used at scale to overcome the limitations faced by the large numbers of isolated MHS in Nepal. Mini Grid is found to be technically feasible, financial viable depending on different factors (capacity, plant factor, distance, etc.). It could be the permanent source of electricity supply in areas far away from national grid and could be connected with grid if it is nearby. Capacity building and coordination, understanding among community is major step for sustainable operation. Baglung Mini Grid is becoming a research place and has built confidence for replication.

Locals have already started to take advantage of the benefits afforded by the system. In the past, electricity was rationed to a few hours of lighting in the mornings and evenings, and households were allotted two-hour slots to run their rice mills. But the electricity available to use was limited. Before they had no control, but today, with 24-hour access and meters installed in almost every houses, locals have the freedom to choose when and how much electricity to consume. And the price is more affordable and there's an increase in consumption from 100 kilowatts to 200 or 300 kilowatts every month due to increase use of various domestic appliances. The new system is transforming livelihoods. More people are using rice cookers, small saw mills and rice mills. Schools now offer early morning classes for eleventh and twelfth graders and many can now run computers. Some locals have invested in poultry farming that requires lighting through the night.

There are other long-term advantages to mini-grid development that have yet to be realized by locals in Baglung. By pooling electricity into larger units, communities can sell their electricity to the grid, if and when the infrastructure develops. At the moment, when areas are finally connected to the central grid, existing micro-hydro plants are forced to shut down because consumers choose to switch to the cheaper alternative and the Nepal Electricity Authority (NEA), the country's sole grid operator, is reluctant to purchase electricity from small plants. If it is connected with the national grid line, Baglung could be the first community-based input to the grid, selling only electricity generated in excess of local needs. Mini-grids could lead to a reversal of the transfer of power and money, to ultimately benefit the village.

As the trend shows that most of the micro hydros were being shut down where national grid line are reached and many more are waiting for the similar fate. But before this can happen, a few issues raised by the project in Baglung need to be addressed. Local research and development (R&D) needs to mature to reduce dependency on technology and know-how from India; lack of expertise and difficulty transporting equipment through customs delayed the project in Baglung. But the real challenges are social rather than technical: the bottlenecks for the sustainable success of mini-grids are not the technologies, but financing, management, business models, maintenance, sustainable operations, and socio-economic conditions.

In last but the not the least, social issues are the major part for the success of any project which can be learned from this mini grid project. The implementing agencies including AEPC/RERL, DDC: DEECCS, and other concerned stakeholders should take utmost efforts to revive the project and take part in the replication of similar project, hoping to cash in on the new technology.

6.3 Recommendations:

Regarding its benefits outnumber other aspects, this project has to be revived anyway and should be connected to national grid as a first project and replicated to other places considering every aspects, through eagle eyes, such as managerial, social, economic and technical with following recommendations made through this study for the revival of the project:

- **Think beyond political:**
  The piloted project is not only the pride of the Baglung district, or just say 4 implemented VDCs, but, also the pride of nation. The project need not see through political eyes, but rather broader aspect considering its huge benefits. The selection of effective management committee in mini grid cooperative irrespective of political reservation could harness the revival activities.

- **Easily accessible equipments and manpower:**
  As the technology is imported from India, every time, a major fault comes, there is an urge to bring equipments and skilled manpower from there which seems much more costly. Producing trained manpower through MHS Installer Company and the manufacturing of equipments, in case possible, are better ways for the operation of the project.

- **Reorganization of MG cooperative committee:**
  The MG cooperative should be reorganized through general assembly where the good, honest and skilled person from each MHS should be introduced to the cooperative committee. Enhanced transparency would be vital for the proper execution of project.

- **Changing of IPP management model:**
  This model where the income of each MHS proportionate with the capacity of plant should be revised as the smaller MHS has got problem to sustain through low income. Other appropriate models need to be implemented which can be useful unanimously. The best possible model could be 'business as usual' situation, where the Mini Grid Cooperative will charge only for receiving surplus power coordinating

among the six MHPs and the individual MHP generate, operate, charge the local grid and the mini grid. The Cooperatives will be responsible only for the mini grid devoid of local grid.

- **Capacity development of Operator**

  There seems urgent need of training to the operators as the technology is very new. Only after that they would easily operate mini grid with proper care thereby heavily decreasing the O/M cost that benefit the whole system.

- **Improve the load factor:**

  Operating the system in steady state over time create economical means with improved load factor. The barrage of PEU like agro-processing, shops, etc. during peak load could easily harness good load factor. These high power consuming equipment's need to be run in off-peak times.

- **Diversity of generation mix and supply security:**

  Interconnection of system that use different technologies and/or fuels to generate electricity provide greater security in the event that one kind of generation becomes limited, for e.g. water falls short during dry season. Hybrid energy system would improve reliability and better performance.

- **Adding up new MHS to the mini grid**

  At times, where electrical appliances use were less, the energy was just sufficient at peak times. But now, where most households use TV, fridges, mixture, cable, etc. the power seems largely dearth of. In that case, a new MHS setup and connection to the mini grid would help in effective load management and frequency stability that eventually boost the confidence level over mini grid operation.

- **Coordination/incentives among operators, mini grid cooperatives, functional group of individual MHS:**

  Proper communication among operators to release lines in mini grid at favorable is a most. To achieve this, there should be provision of incentives like allocating some amount for mobile charging, exposure visit, etc. Also, there need to be frequent and timely inter and intra meetings of cooperatives and functional groups, if possible some incentives at the meeting should be allocated for convenience.

- **Set up fund:**

  As the technology is new, there could be sudden major equipment fault. For prompt recovery, the implementing agency like AEPC/RERL, DDC, VDC, functional group and the cooperative should set aside some fund that would greatly help in continuous operation of mini grid.

- **Awareness campaign to the beneficiaries:**

  As the operation of mini grid is short and now halted, the beneficiaries should make aware of its importance where that behavioural change would be milestone to revive the project as early as possible.

- **Replication:**

  For replication in other places, following points, as explained in World Bank, 2015 report, need to be considering carefully:

  - Distance between individual MHS
  - Market for excess energy
  - Potential for inter-system power transfer
  - Distance from central grid
  - Community engagement
  - Favorable support policy
  - Capacity assessment
  - Appropriate management model
  - Availability of technology and manpower

Only through proper coordination, collaboration, facilitation and engagement, this project can be revived. Every concerned people and the stakeholders have to play respective roles to provide mini grid service to the rural people through its revival afterwards full-fledged service. Only after revival, the good message about this innovative energy technology can be widespread throughout the world. Let the world known through mini grid technology.

Annex I A: *General Questionnaires*

I am a student of M. A. Rural Development at TU/Dhankuta Multiple Campus, Dhankuta, Nepal. I am carrying out research entitled "Micro Hydro Interconnected Mini Grid (MHIMG) for Rural Livelihood" for partial fulfillment of the requirement for my M.A.Degree. All information mentioned in this questionnaire will be confidential. So, I humbly request you to mention your own reality in this questionnaire with full confidence that will be a vital part in my whole educational career. Please feel free to express your personnel opinion and those will not be disclosed to other.

Date of Interview: **Interview No.:**

A. General Information of the respondent

Name: **Address:**

Age: **Sex:**

Occupation: **Education:**

Name of related MHP:

B. Questionnaires

1. Do you know about Micro Hydro Interconnected Mini Grid (MHIMG)?

   a) Yes b) No

2. Who were the contributors of MHIMG?

   a) Beneficiary only b) RERL through UNDP

   c) Local GOs like DDC, VDC d) all

3. For what application did you use minigrid energy?

   a) Cooking b) Lighting

   c) Heating d) Watching TV

   If other, specify…

4. What other end uses applications minigrid energy was used?

   a) Poultry Farming b) Agro-processing like Hollors, cold storage,etc.)

   c) Saw Mill d) Poultry Farming

   If other, specify…

5. Which among the following changes were brought about by the minigrid?

   a) 24-hour quality electricity b) Use of electricity wisely

   c) Greater role in education, health & communication sector d) No difference

   If other, specify…

6. What changes had minigrid brought in your/family lifestyle?

   a) Longer hour study for children b) Convenience in domestic work

   c) Productive energy use d) Creative

7. In what aspects, did minigrid help for social upliftment?

   a) Build social relation through frequent meetings, discussions

   b) Exposure to national & international communities

   c) Training facility for capacity development

   d) Togetherness through Income generation activities like productive end uses

   If others, specify….

8. Which mode of electricity generation is good in your view and why?

   a) Microhydro interconnected mini grid b) Isolated Microhydro

   c) National Grid d) Solar

   If others, specify….

9. What do you think about MHIMG for rural development?

   a) Very Useful b) Useful

   c) Not useful d) No idea

10. How long did you use electricity for various domestic purposes; before, during and after minigrid?

Appliances	Before		During		After	
	Number	Operating Hours	Number	Operating Hours	Number	Operating Hours
Lighting						
TV						
Rice Cooker						
Iron						
Freeze						
Others						

11. Do you agree that the running hours for productive end uses in different time frame of minigrid as follow?

	Before,Hr	During, Hr	After, Hr
Time	2 to 3	8 to 10	2 to 3

12. Why do you think MHIMH was constructed in your area?

   a) To overcome disadvantages of individual MHP

   b) To prevent isolated MHP from dying after accessible to grid

   c) High demand-deficit-surplus energy of different MHP

   d) Maximise use of MHP other than lighting purposes as productive end uses

   If others, specify….

13. How did society benefitted financially from MHIMG operation?

   a) Create job opportunities

   b) Increase income of MHP

   c) Boost up setting up micro-enterprises like agro-processing, saw mill, poultry, etc.

   d) Meet criterion for connecting with national grid line

14. How did MHP technically benefit from MHIMG operation ?

   a) Upgradation of MHP

   b) Use of digital equipment

c) Automatic function

d) Introduction of energy based tariff over power based tariff

15. Was there any capacity development programme during minigrid operation?

a) Yes b) No

If yes, specify….

16. Are you satisfied with the tariff system of minigrid operation?

a) Yes b) No

17. Are you satisfied with the working modality of minigrid cooperative?

a) Yes b) No

18. What do you think the major cause for halted mini grid operation?

a) Cooperative Management b) Technical

c) Political d) Socio-economic

If others, specify…

19. What technical problems did it suffer?

a) Lack of technically sound person in faulty condition

b) Lack of equipments as they need to be ordered from India

c) Little knowledge of technicality to operators and functional group

d) Unwise metering of used power through IPP model

20. Can you suggest any solutions to revive this project?

…

Annex I B: *Questionnaires for Key Informant Interview & Implementing Agency*

1. How do you perceive the role of Micro hydro in development scenario of Nepal?
2. What are overall opportunities and challenges in the sector of Micro hydro development?
3. In your opinion what will be the impact of national grid expansion on these preexisting Micro Hydro Plants?
4. In your opinion, do you think we should take steps against those challenges? If yes why?
5. What would be better option for MHP sustainability in future?
6. How can the investment done in those MHP could be saved?
7. In your experience of working in mini grid what was the major motive of mini grid synchronization done in Baglung?
8. How was the synchronization done?
9. What were the opportunities and challenges faced in the process?
10. After operating it for some time what was reaction of local people?
11. Now we saw that mini grid is not functioning, is this temporary or permanent? Is this a success story or failure experiment?
12. What were the major reason behind this halt?
13. As institution what role is REDP playing right now?
14. Future plan for Urja Upatyaka mini grid and suggestion for country.
15. Any specific suggestions for MHIMG development?

Annex I C: ***Checklist***

a) Technical:

1. ELC
2. Control
3. Switchgear and protection
4. Fuse, MCCB, Contactor
5. Relay System
6. Measurement and Instrumentation
7. Function:
8. Synchronization:

b) Socio-Economic:

9. Benefits
10. Issues
11. Revival Activities
12. Challenges
13. Future Planning
14. Format filling

Annex I D: Economic Analysis of Urja Upatyaka Mini Grid

A General **Minigrid Operation Date: 2069 kartik-2070 Chaitra**

S.N	MHS	Address	Benefited Households			Monthly Income of individual MHS per month/NPR			Monthly Salary of Operators, NPR			Monthly Tarrif, NPR			Productive End Uses numbers			Income of minigrid cooperative per month during operation period, NPR	Tarriff of minigrid, NPR	
			Before	During	After	Before	During	After	Before	During	After	Before	During	After	Before	During	After		Buying	Selling
1	Theula Khola (24 kW)	Sarkuwa-9, Sera																		
2	Urja Khola IV (14 kW)	Damek-2, Jhadi																		
3	Urja Khola II (9 kW)	Rangkhani-6, Rumta																		
4	Urja Khola I (26 kW)	Rangkhani-1, Rumta																		
5	Kalung Khola (22 kW)	Paiyunthanthap-4, Lamashu																		
6	Upper Kalung Khola (12 kW)	Paiyunthanthap-9, Bijuwa																		
	Total																			

NPR: Nepalese Rupees **U: Unit** **W: watt**

B Numbers of Productive Energy Use during minigrid operation (in detail)

S.N.	MHS	Agro-processing			Saw Mill			Poultry/Dana Udyog			Internet Cyber			Electronic shop			Photo Studio		
		Before	During	After	Before	During	After	Before	During	After	Before	During	After	Before	During	After	Before	During	After
1	Theula Khola (24 kW)																		
2	Urja Khola IV (14 kW)																		
3	Urja Khola II (9 kW)																		
4	Urja Khola I (26 kW)																		
5	Kalung Khola (22 kW)																		
6	Upper Kalung Khola (12 kW)																		
	Total																		

C Monthly Income Vs Savings

S.N.	MHS	Income			Saving		
		Before	During	After	Before	During	After
1	Theula Khola (24 kW)						
2	Urja Khola IV (14 kW)						
3	Urja Khola II (9 kW)						
4	Urja Khola I (26 kW)						
5	Kalung Khola (22 kW)						
6	Upper Kalung Khola (12 kW)						
	Total						
7	Minigrid Co-operative						

D Productive End Use running hours

	Before,Hr	During, Hr	After, Hr
Time			

Annex II-*Micro Hydro Connected Mini Grid Sites of Nepal(DFS, constructed, future planning)*

Name of the MHIMG, Location	**Number- Capacity kW**	**Distances between MHMGs, km**	**Excess power, kW**		**Estimated total project Cost, USD**	**Increment of Capacity Factor (CF) %**	**Incremental Energy MHIMG (kWh)**
			Peak Period	**Off peak Period**			
1. Urja Upatyaka, Baglung	6 MHPs-107 kW-	7.7	10 (3 MHMGs in deficit)	70	150,295.00	17	159,300
2. Gulmi, Gulmi	2 MHP-217kW	1.5	35 (1 MHMG in deficit)	100	128,000.00	15	285,100
3. Taplejung, Taplejung	8MHPs-660kW (12 MHPs-569kW)	43 (65)*	492** kW (229 kW)	600 (400)	570,000.00 (1,307,000.00)	32	1,850,100
4. Gaudi khola, Baglung	6 MHPs-104 kW	4.5	21 (4 MHMGs in deficit)	91	225,400.00	25	227,800
5. Bongadovan, Baglung	10MHPs-416 kW (8 MHPs-344 kW)	18	159 (2 MHIMG in deficit)	300	477,900.00	45	1,639,900
6. Girindikhola MHIMG, Baglung	8 MHPs-267 kW	12	119 (4 MHMGs in deficit)	220	443,700.00	13	304,000
7. Tikhedhunga, Kaski	2 MHPs-80 kW	0.04	1 (1 MHMG in deficit)	33	57,600.00	12	84,000
8. Ghandruk, Kaski	4 MHPs-161 kW	3.5	13 (1 MHMG in deficit)	76	153,500.00	9	126,900
9. Chhomrong, Kaski	3 MHPs-67 kW	0.6	0 (3 MHMGs in deficit)	26	80,200.00	8	46,900

Source: AEPC/RERL

Annex III: ***Salient Features of Micro -Hydro Interconnected Mini Grid Schemes***

source: DEECCS, Baglung, 2015

S.N.	Name of the scheme	Location	Coverage Ward	Head (m)	Flow (Lps)	Power Output (kW)	Ben HHs	Canal length (m)	Type of turbine	Total cost (Rs)	Year of completion	Installer company	No. of Operators	No. of working committee members	Remarks
1	Theula Khola	Sarkwa	Sarkuwa 5,6,7,8,9	32	150	24	290	550	Crossflow	2559261	1999	DCS	2	19	
2	Urja Khola IV	Damek	Sarkuwa 1,2,3,4	16	162	14	133	250					1	17	
3	Urja Khola II	Rangkhani	Rangkhani 6,7	17	110	9	158	190	Crossflow	1324850	2003	TEI	2	11	
4	Urja Khola I	Rangkhani	Rangkhani 1,4,5	54	100	26	272	625	Crossflow	2639866	2001	TEI	2	24	
5	Kalung Khola	Paiyunthanthap	Paiyun 3,4,5,6	54	80	22	230	550	Pelton	2383759	1999	TEI	2	22	
6	Upper Kalung Khola	Paiyunthanthap	Paiyun 1,9	60	40	12	115	300	Crossflow	1787203	2005	NMASS	2	11	
							1198						11	104	

Annex IV: ***MHS affected by National Grid in Baglung which are in operation till date***

source: DEECCS, Baglung, 2015

S.N.	VDC NAME	MHP NAME	Capacity, k W	AFFECTED/NOT AFFECTED	REMARKS
1	Amarbhumi	Khantaram Khola	7	NOT AFFECTED	community is planning to
		Aru Khola	13	NOT AFFECTED	conect both MHP & National
		Marsyangdi Khola	17	AFFECTED	Grid
2	Chhisti	Palung Khola	35	AFFECTED	Planning to connect both
		Kewai Khola	17	AFFECTED	Not planning
3	Damek	Urja Khola IV	14	AFFECTED	Member of MINI GRID
4	Dhullubaskot	Palung Khola	20	NOT AFFECTED	
5	Dudilabhati	Khaule Khola	9	AFFECTED	Planning to connect both
		Gaudi	24	NOT AFFECTED	Planning to connect both
		Gaudi II	18	AFFECTED	Planning to connect both
		Gaudi III	21	NOT AFFECTED	Planning to connect both
		Gaudi IV	15	NOT AFFECTED	Planning to connect both
		Chipleti Khola	17	AFFECTED	Planning to connect both
6	Kandebas	Litte Khola	7	NOT AFFECTED	
		Daram Khola	35	NOT AFFECTED	
		Daram Khola II	27	NOT AFFECTED	
		Pachuwa Khola	30	AFFECTED	
7	Malma	Daram Khola	50	AFFECTED	Not Planning
8	Pandavkhani	Thulo Khola	9	NOT AFFECTED	Planning to connect
		Panchadhara	7	NOT AFFECTED	Planning to connect
		Mau Khola	12	NOT AFFECTED	Planning to connect
		Ghopte Khola	16	NOT AFFECTED	Plannning to connect
9	Paiyunthanthap	Kalung Khola	22	AFFECTED	Member of MINI GRID
		Kalung Khola (upper)	12	AFFECTED	Member of MINI GRID
		Urja Khola III	25	AFFECTED	
10	Rangkhani	Urja Khola I	26	AFFECTED	Member of MINI GRID
		Urja Khola II	10	AFFECTED	Member of MINI GRID
		Palung khola(upper)	21	NOT AFFECTED	
11	Righa	Saune (Lower)	50	AFFECTED	
		Grindi (Mid)	45	NOT AFFECTED	
12	Salyan	Rushi Khola	6.5	NOT AFFECTED	Planning to connect both
		Bhaisi Khola	14	NOT AFFECTED	Planning to connect both
13	Sarkuwa	Theule Khola	24	AFFECTED	Member of MINI GRID
14	Tangram	Tangram Khola	17	COMPETELY AFFECTED	
		TOTAL	**692.5**		

NOTE : MHP is not planning to connect to National Grid but the community is planning to connect to National Grid as a individual household

Annex V: ***Technical Diagrams of MHIMG of Baglung***

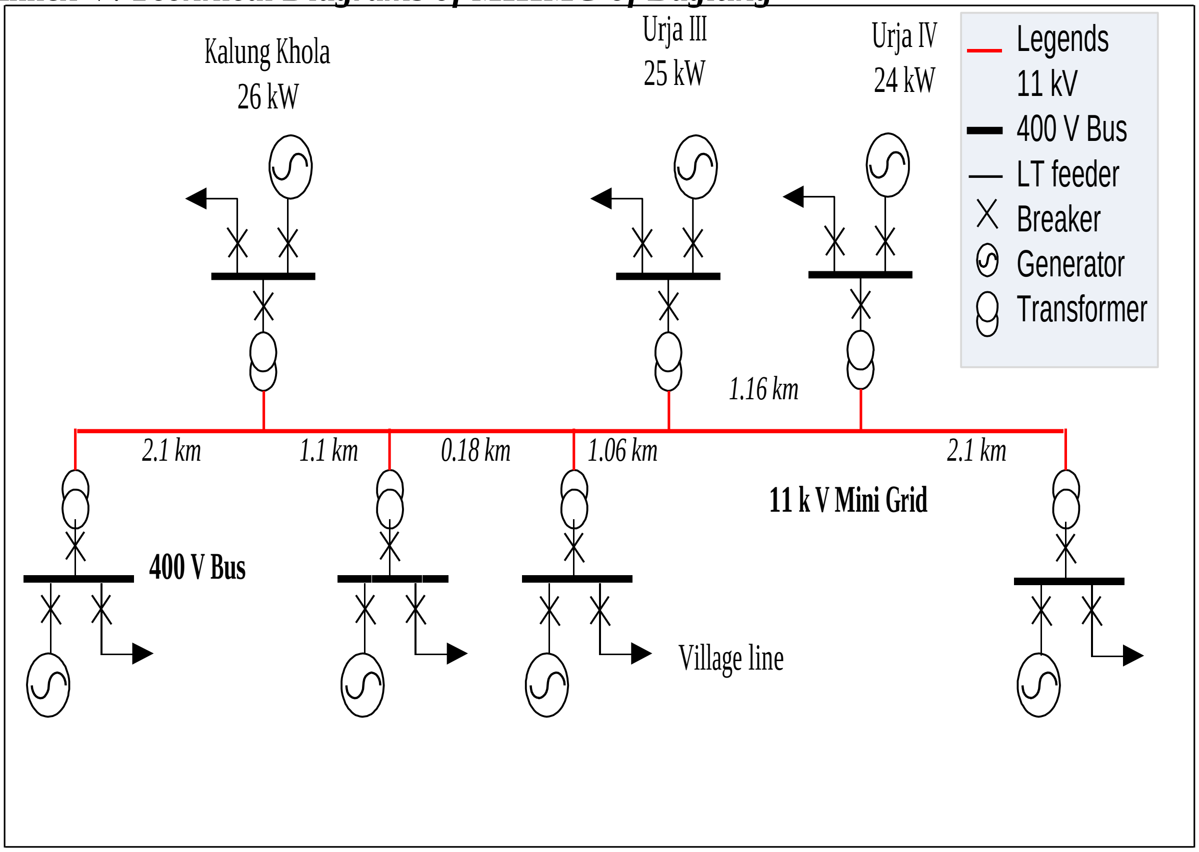


Fig: Overall single line diagram of MHIMG (source: AEPC/RERL)

Annex V: ***Technical Diagrams of MHIMG of Baglung***

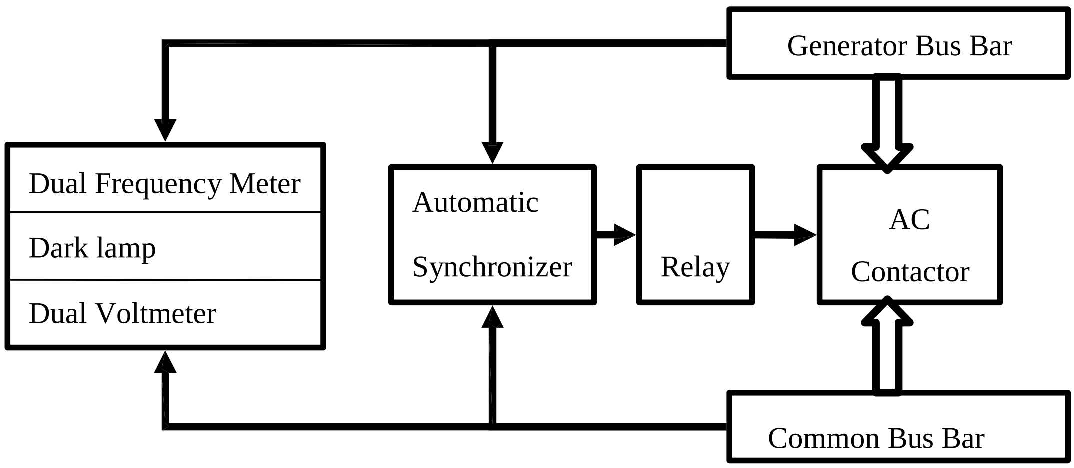


Fig: Block diagram of synchronization in automatic mode *[Source: RERL]*

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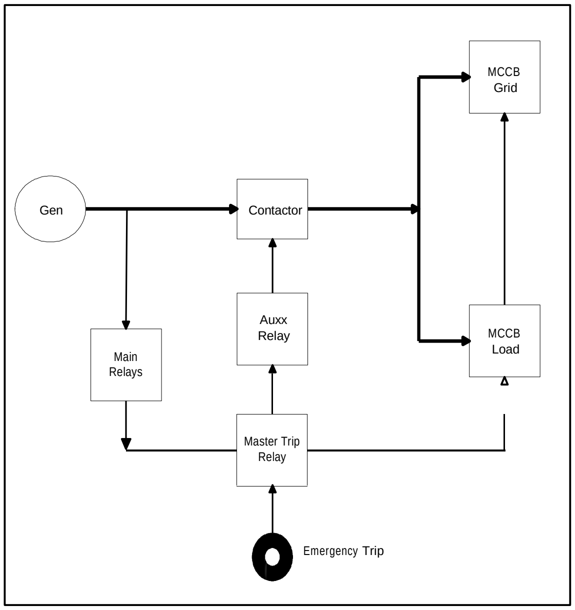
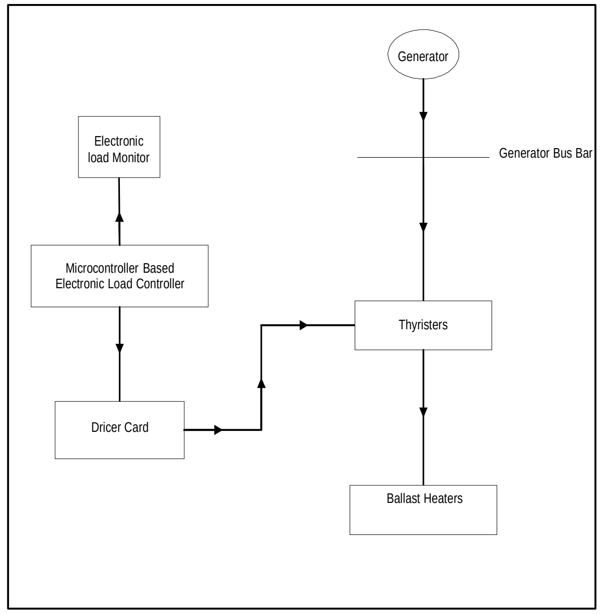
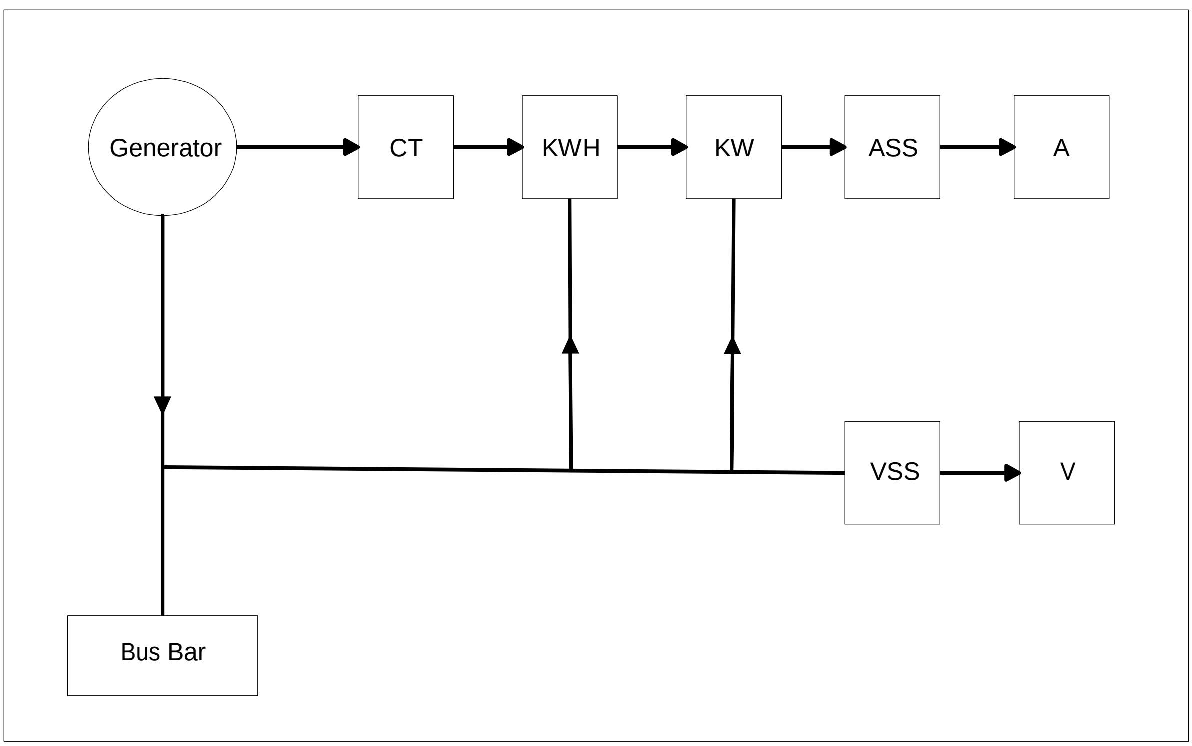
Annex V: ***Technical Diagrams of MHIMG of Baglung***

Block diagrams of Protection System & ELC





Block Diagram of Measurement system



*Annex VI: **Economic Analysis of Urja Upatyaka Mini Grid***

A General

Minigrid Operation Date: 2069 kartik-2070 Chaitra

S.N	MHS	Address	Benefited Households			Monthly Income of individual MHS per month/NPR			Monthly Salary of Operators, NPR			Monthly Tarrif, NPR			Productive End Uses numbers			Income of minigrid cooperative per month during operation period, NPR	Tarriff of minigrid, NPR	
			Before	During	After	Before	During	After	Before	During	After	Before	During	After	Before	During	After		Buying	Selling
1	Theula Khola (24 kW)	Sarkuwa-9, Sera	260	290	273	24000	35000	30000	4500	7000	10000	50/100W	75/12U+7/U	100/16U+7/U	6	13	10			
2	Urja Khola IV (14 kW)	Damek-2, Jhadi	121	131	134	0	14000	16000	0	6000	7000	0	75/12U+7/U	75/12U+7/U	0	5	7			
3	Urja Khola II (9 kW)	Rangkhani-6, Rumta	120	158	160	13000	9000	20000	3500	7000	7000	80/100W	75/12U+7/U	75/12U+7/U	2	4	4			
4	Urja Khola I (26 kW)	Rangkhani-1, Rumta	250	263	293	14000	28000	30000	3500	8000	10000	50/100W	75/12U+7/U	75/12U+7/U	7	13	17	45000/month	Initially 4/U; After 4.25/U	75/12U+7/U
5	Kalung Khola (22 kW)	Paiyunthanthap-4, Lamashu	230	250	250	18000	30000	25000	6000	7000	11000	50/100W	75/12U+7/U	75/12U+7/U	5	14	10			
6	Upper Kalung Khola (12 kW)	Paiyunthanthap-9, Bijuwa	110	118	113	8000	10000	13000	3000	5000	5000	50/100W	75/12U+7/U	75/12U+7/U	0	4	4			
	Total		**1091**	**1210**	**1223**	**77000**	**126000**	**134000**	**20500**	**40000**	**50000**				**20**	**53**	**52**			
	NPR: Nepalese Rupees		**U: Unit**		**W: watt**															

B Numbers of Productive Energy Use during minigrid operation (in detail)

S.N.	MHS	Agro-processing			Saw Mill			Poultry/Dana Udyog			Internet Cyber			Electronic shop			Photo Studio		
		Before	During	After	Before	During	After	Before	During	After	Before	During	After	Before	During	After	Before	During	After
1	Theula Khola (24 kW)	3	4	4	1	1	1	2	8	5	0	0	0	0	0	0	0	0	0
2	Urja Khola IV (14 kW)	0	2	3	0	1	1	0	2	3	0	0	0	0	0	0	0	0	0
3	Urja Khola II (9 kW)	2	2	3	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1
4	Urja Khola I (26 kW)	2	2	3	0	1	0	3	6	12	0	1	1	0	1	0	2	2	1
5	Kalung Khola (22 kW)	3	4	4	0	1	1	2	8	5	0	0	0	0	0	0	0	1	0
6	Upper Kalung Khola (12 kW)	0	2	3	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0
	Total	**10**	**16**	**20**	**1**	**5**	**3**	**7**	**26**	**26**	**0**	**1**	**1**	**0**	**1**	**0**	**2**	**4**	**2**

C Monthly Income Vs Savings

S.N.	MHS	Income			Saving		
		Before	During	now	Before	During	now
1	Theula Khola (24 kW)	24000	35000	30000	-5000	20000	5000
2	Urja Khola IV (14 kW)	0	14000	16000	0	2000	3000
3	Urja Khola II (9 kW)	13000	9000	20000	3000	-8000	2000
4	Urja Khola I (26 kW)	14000	28000	30000	2000	4000	5000
5	Kalung Khola (22 kW)	18000	30000	25000	2000	12000	1000
6	Upper Kalung Khola (12 kW)	8000	10000	13000	-2000	-1000	-3000
	Total	**77000**	**126000**	**134000**	**0**	**29000**	**13000**
7	Minigrid Co-operative	0	167000	0	0	41000	0

D Productive End Use running hours

	Before,Hr	During, Hr	After, Hr
Time	2 to 3	8 to 10	2 to 3

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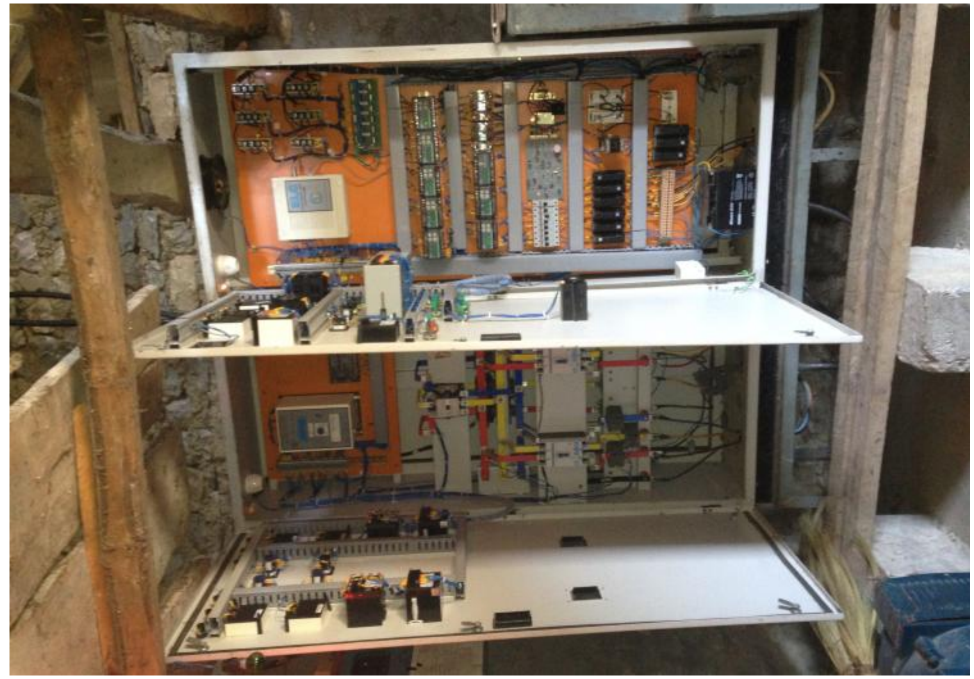
उर्जा उपत्यका मिनिग्रिड सहकारी संस्था लि.
URJA UPATYAKA MINIGRID CO-OPERATIVE SOCIETY LTD.

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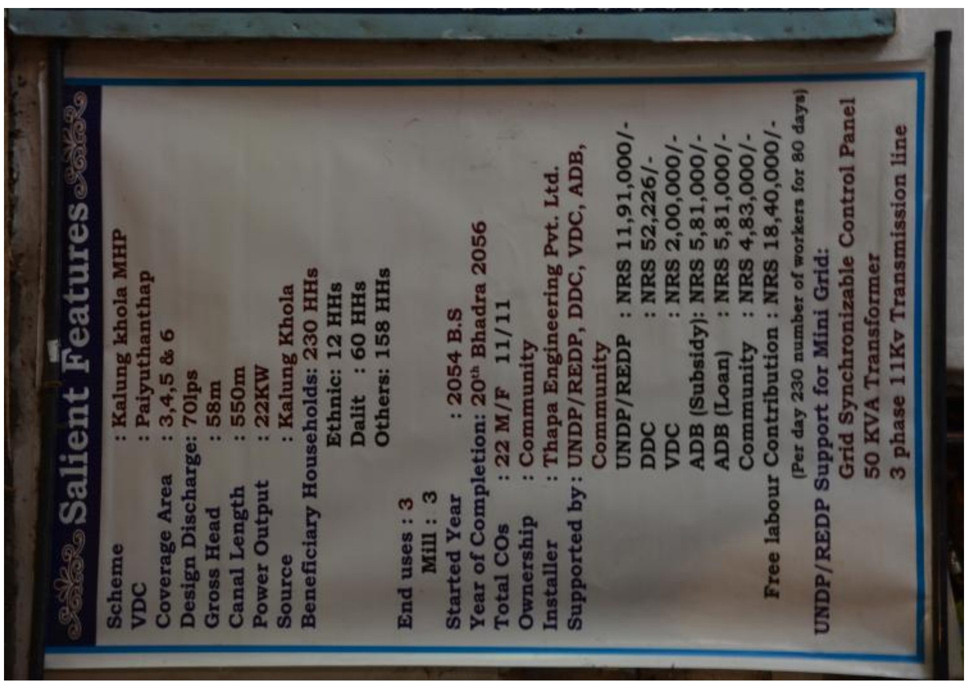
SAMSUNG


SALIENT FEATURES
Salient Features


SAMSUNG


15KW
15KW


Salient Features
Scheme : Kalung khola MHP
VDC : Paiyuthanthap
Coverage Area : 3,4,5 & 6
Design Discharge: 70lps
Gross Head : 58m
Canal Length : 550m
Power Output : 22KW
Source : Kalung Khola
Beneficiary Households: 230 HHs
Ethnic: 12 HHs
Dalit : 60 HHs
Others: 158 HHs
End uses : 3
Mill : 3
Started Year : 2054 B.S
Year of Completion: 20th Bhadra 2056
Total COs : 22 M/F 11/11
Ownership : Community
Installer : Thapa Engineering Pvt. Ltd.
Supported by : UNDP/REDP, DDC, VDC, ADB, Community
UNDP/REDP : NRS 11,91,000/-
DDC : NRS 52,226/-
VDC : NRS 2,00,000/-
ADB (Subsidy): NRS 5,81,000/-
ADB (Loan) : NRS 5,81,000/-
Community : NRS 4,83,000/-
Free labour Contribution : NRS 18,40,000/-
(Per day 230 number of workers for 80 days)
UNDP/REDP Support for Mini Grid:
Grid Synchronizable Control Panel
50 KVA Transformer
3 phase 11Kv Transmission line