number of boulders of various size, partially imbedded and lying loosely on the surface are observed.

The canal section from chainage 0+430 to 0+807 m passes through the moderately compact material. The slope is gentle and the canal section is expected to pass through stable zone.

3.4.2.4 Forebay

A rectangular forebay (28 m x 4 m), to regulate the flow from the headrace canal and to supply a steady flow into the penstock pipe, will be built on the middle portion of the eastern flank of the conglomeratic ridge. The conglomerate in the ridge near the forebay is grey, compact, cemented and composed of rounded to sub - rounded boulder, gravel cobble and pebble in a sandy matrix. The deposit is of glacio-fluvial origin consisting of gravel mixed silty sand. Above the forebay the slope moderate and barren with few erosion scars.

The material up to about 2 - 3 m depth from the surface datum is composed of loose glacial till and glacio-fluvial material. To overcome the water leakage from the forebay grouting measures or lining should be taken. Below the depth of 7 m quite compacted and cemented conglomeratic horizon is expected. An erosion scar on the side of the proposed forebay shows the presence of grey, silty sand at the top and brownish grey silty sand at the depth of about 1.5 m

3.4.2.5 Penstock alignment

About 400 m long penstock pipe will be aligned on the very gently sloping cultivated terrace. The penstock passes through number of cultivated terraces of different elevations. The penstock alignment is composed of glacio-fluvial deposit consisting of gravel, sand, silty sand, clayey sand with boulder, cobble and pebble. There is no possibility of bedrock up to a depth of 50 m. Natural slope of the penstock alignment is gentle and no stability problem is anticipated along the penstock alignment.

There are three major variations in the grain size on the overburden materials along the 400 m long penstock alignment, viz. i) sub-angular boulder and gravel with coarse sand matrix in the upper most section (in the vicinity of the forbay); ii) fine sand with silty clay and silty sand with subrounded to subangular boulders and gravel in the middle part (cultivated terraces); and iii) rounded to subrounded boulder and gravel with pebble & cobble in a sandy matrix in the lower most part of the penstock (barren terrace). During the design of the support blocks of the penstock pipe in the lower-most section, necessary stability measures on the slope surface as well as on the foundation of the blocks is recommended.

3.4.2.6 Powerhouse

The powerhouse area is located on the right bank of Ghami Khola about 1800 m upstream of the wooden bridge at an elevation of 3640 m. The powerhouse will be founded on the alluvial terrace. The area is made up of boulder and gravel of gneiss, granite and quartzite. The terrace consists of brownish grey moist, medium grained sandy gravel below the water table at an average depth of 1.5 m. The terrace is barren, sufficiently wide and is located at the bottom of gently sloped cultivated land. The alluvial material in the terrace is semi-compacted to loose. Judging from the local geological condition of the area expected depth to the bedrock in the powerhouse site will be more than 60 m.

3.4.2.7 Tailrace alignment

A 37 m long tailrace canal passes through the recent riverbed alluvial deposit consisting of boulder, cobble and pebble (max. size 4 m) of gneiss, granite, schist, sandstone, limestone and shale with coarse sandy matrix. The material is generally loose.

3.4.3 Geo-technical Aspects

3.4.3.1 Slope stability

No major slope stability problems are observed. Detailed study must be made along the canal alignment during detailed design stage.

3.4.3.2 Construction materials

Construction materials for the construction of the project structures are available in the vicinity of the project site. The coarse aggregates such as boulders, gravels and stones for riprap are available in the riverbed from upstream of the intake to the downstream of the powerhouse site.

The fine aggregates and sand is to be quarried from the confluence of the Ghami Khola and Kali Gandaki river, which is about 5 km downstream of the project site.

Cohesive fill material, cohesive soil can be taken from the cultivated field of Ghami area. The quarry site investigation is to be carried out during further detailed study.

3.5 SOCIO ECONOMIC STUDY

3.5.1 General Background

The project will cover four VDCs (load centres), namely Ghami, Charang and Lomangthan of Mustang district. A socio-economic household survey for the proposed project was carried out in the four VDCs to identify the socio-economic conditions mainly for energy demand pattern, willingness and the affordability of the households.

3.5.1.1 Demographic feature

The total population in the project area of three VDCs is 2,359 with total number of household 500 with household size 4.7 as per the population census 2001. Ghami and Lomanthan have the highest population (36%) of the project area population followed by Charang (28%). As per the field survey, the household size is higher with 6.2 and population structure is 55% male and 45% female (Table 3.14). Population comprises 29 percent of up to 14 years age, 65 percent of 15 to 59 years and 6 percent of above 59 years. Sixty five percent of the population is economically active population (Table 3.14).

Table 3.14: Age wise household population

Age Group	Male	Female	Total	%
0 - 14 yrs.	67	49	116	29%
15 - 59 yrs.	141	120	261	65%
Above 60 yrs.	13	12	25	6%
Total	**221**	**181**	**402**	**100%**

Table 3.15 illustrates the percentage of ethnic group households; the project area is an ethnically homogeneous community. The largest ethnic group in the project area as per households' survey is Bhote with 81.5 percent of the total population. Brahmin and Chhetri community group constitute 12.3%.

Table 3.15: Household by ethnic group

Ethnic Race	Ethnic Group	Total	
		No.	%
Indo – Aryan	Bramin	6	9.2
	Chhetri	2	3.1
Tibet – Burman	Bhote	53	81.5
	Gurung	4	6.2
	Total	**65**	**100**

3.5.1.2 Infrastructures

The infrastructures development in the project area is very poor due to remote mountainous region. The existing condition is described as follows: (Annex D, Table 1).

Transportation
The basic mode of transportation in the project area are horse, bullock, yak, mule etc. There is no vehicular access available to the project. However tractor vehicle is accessed in some VDCs. The nearest road head lies at Beni, which is about 150 km away from the project site. Jomsom, the district headquarters, is linked with air services from Pokhara. One has to walk four days to reach the project site from Jomsom. The foot trail connects the project site to the road head at Beni and it takes about 8 days to reach the site in normal walking. However, the motorable road has reached up to Lomangthan from the territory of Tibet. The total road length from Kodari in Sindhupalchowk to Lomangthan via Tibet is about 450 km.

Communication
Post offices are the major means of communication in the project area. Each VDC of the project area has one post office. The other communication facilities like telephone service, which is the modern means of communication is available in Jomsom only.

Educational and other infrastructure facilities
There are altogether 7 schools (3 in Ghami, 2 in Lomangthan and 2 in Charang), which provide educational facilities in the project area. All the VDCs are facilitated with one health post and one health service center is located in Ghami with technical management of ACAP under the financial assistance of Japanese government. One veterinary clinic located at Lomangthan VDC provides animal health services.

There is no bank service in the project area. Shops like groceries and teashops are the major commercial establishments. The total number of shops is 32 with highest number 13 in Lomangthan.

In terms of cottage industries, there are only water mills and weaving and knitting works in each VDC of the project area. There are all together seven rice and floor mills in the project area two in Charang, three in Lomangthan and two in Chhusang. The mills in Lomangthan and Chhusang are operated by electricity through installed capacity of 29 kW in Lomangthan and 16 kW in Chhusang. Two agriculture service centers located in Charang and Lomangthan, provide agricultural extension services to the farmers.

One forest office is found to be located in Charang VDC. Two police stations one in Ghami and one in Lomanthan provides security services in the project area. The project area has 21 hotels and lodges with the highest 10 numbers in Ghami VDC.

In the project area no case of permanent migrants could be found. However, the temporary migration prevails in the project area. The people in the project area are found to migrate temporarily to the urban centers of Nepal, Tibet (China) and India for trade and labour service.

3.5.1.3 Education and literacy

In the household's survey 58% of the population is illiterate. This indicates that scheme area has 42% of literacy rate, which is well below than national literacy rate of 53%. Out of total population 21% have completed standard level up to level ten class and 21% have completed SLC and IA.

Table 3.16: Literacy status

Literacy Level	Total	
	No.	%
Illiterate	234	58
Literate Up to class 10	83	21
SLC - I. A.	85	21
Total	**402**	**100**

3.5.1.4 Economic activities and ownership

Agriculture is the primary economic activities with almost 100% of the respondents. Majority of economically active population of the project area is engaged in agriculture. Major agro-products consist of maize, wheat, oilseed and potato. Besides agriculture, livestock is another major economic activity of the people for their livelihood followed by business.

More than 98% of households in community have their own residence. Only one household has no permanent house. All houses of the project area have their house permanent building type with stone and mud.

The landholding pattern in the community shows about 1.5% of the community with no land. Seventy seven percent of the households have marginal land up to 1.02 ha. Similarly 20% of the households have small land holding of 1.02 to 2.71 ha, and 1.5 percentages of households have medium land holding between 2.71 to 5.42 ha. There is no any household land holding above 5.42 ha (Table 3.17).

Table 3.17: Land holding pattern

Stratum	Farm size (ha.)	No of HH	%
Landless		1	1.5
Marginal	Upto 1.02	50	77.0
Small	> 1.02 to 2.71	13	20.0
Medium	> 2.71 to 5.42	1	1.5
Large	> 5.42	-	
Total		**65**	**100**

3.5.2 Methodology

The socio-economic survey basically deals with the methodological issues pertaining to field survey design and data analysis.

3.5.2.1 Survey questionnaire

The questionnaire is mainly developed for domestic consumer with objective to get detailed information on socio economic parameters such as income level, present energy consumption pattern and willingness and affordability to pay for electricity. Similarly checklist is developed to get information from local administrative office: VDCs, DDC, organizations, agencies, cooperatives etc. Questionnaires were designed and used to conduct socio-economic survey in the selected VDCs of the project area. The socio-economic survey was conducted for about one week. The selected VDCs of the project area include Ghami, Charang, Chhusang and Lomangthan VDCs.

A random sampling method was used in soliciting responses from households in the four selected VDCs for the survey. The average sample size of the survey is taken as 10% of the total household of four VDCs. Total of 68 households were surveyed in detail with regard to their income level, present energy consumption pattern and willingness and affordability to pay for electricity. The data analysis of the actual survey is considered at 65 households since three questionnaire have no detail information. The samples are considered as representative of all VDCs since all categorical considerations were well thought out to include households of various economic status.

3.5.2.2 Data analysis

After the survey questionnaire were thoroughly verified and reviewed so as to minimize errors. The errors in the form of missing values, conversion units, local units and other discrepancies were adjusted with appropriate statistical measures. The data is analysed and processed in the EXCEL spreadsheet format so as to access in other programs for data analysis.

3.5.3 Income Status and Affordability

3.5.3.1 Status of income level

Income is the prime determinant of the economic status of the rural households. But it is very difficult to obtain income data from the households. The household income cannot be directly derived from responses of the households because rural households do not maintain bookkeeping and hence fail to report their real annual income. It is, thus, imperative to estimate household income indirectly, especially through carefully chosen parameters responsible for income generation.

Annual agricultural production, livestock holdings and non-farm economic activities are generally considered as the sources of household income. The annual agricultural production was valued in rupees term of using the current price of respective produces. In the absence of current price, preceding year's produce prices were adjusted using consumer price index to bring to the current price. Livestock units were monetized using the average expected price of respective livestock types. This monetary value was then divided by the average expected life of the respective livestock types to get the current market value of the livestock. The sum of the current market values of all livestock types is the monetary value of livestock.

Beside the primary economic activity, the majority of the households have various mode of income from secondary and third occupations side by side. In the community households, nearly 24% of the households have income less than NRs 5,500 and 49.2 percent of households have income between NRs. 5,500 to NRs. 10,500 in the middle class stratum. The income strata shows that the incomes level higher than NRs. 10,500 constitute 26.2 percent, which is quite high in comparison to national average.

Table 3.18: Level of income

Level of income NRs. '000'	Total	
	No.	%
Less than 4.5	16	24.6%
4.5 – 10.5	32	49.2%
Above 10.5	17	26.2%
Total	**65**	**100.0%**

Estimated household income was classified into three levels of income groups as low, medium and high using frequency distribution and mean of the household income. A study by Nepal Rastra Bank (NRB) reports that half of the sample households belong to the medium income group. The income classification made in this study is close to the norms established by NRB.

The average monthly income of low, medium and high income households are calculated as NRs. 3,788, NRs. 8,063 and NRs. 16,691 respectively (Table 3.19). The average income reflects a great disparity between the low and high income groups. The average monthly income of the project area is NRs. 9,514 which is close to the average income of medium income households.

The income distribution pattern of the project area as presented in Table 3.19 shows that Charang has the highest average income of NRs. 10,971 per month followed by Ghami (NRs. 10,079 per month) and Lomangthan (NRs. 8,742 per month).

Table 3.19: Household income distribution (NRs. per month)

VDC	Low 16	Medium 32	High 17	Average 65
Charang	3,441	7,753	21,719	10,971
Chhusang	3,477	7,802	11,196	7,492
Ghami	4,447	8,633	17,157	10,079
Lomangthan	3,713	8,945	13,568	8,742
Average	3,788	8,063	16,691	9,514

3.5.3.2 Willingness to pay

The willingness of 31% in low income household have expressed to pay up to NRs. 150 per month, 63 percent at NRs. 250 per month and 6% at NRs. 350/per month for electricity bill. Consequently medium income household shows their interest to pay NRs. 150 by 12% NRs. 250 by 85% and NRs. 350 by 3% of household respectively. Similarly high income group have shown their interest to pay NRs. 150 by 20%, 250 by 67%, NRs. 350 by 7% and NRs. 450 by 6% respectively (Table 3.20).

Table 3.20: Willingness to pay by income level

		Rupees per month			
Income Level	hh	NRs. 150	NRs. 250	NRs. 350	NRs. 450
Low	16	5 (31)	10 (63)	1 (6)	0 (0)
Medium	32	4 (12)	29 (85)	1 (3)	0 (0)
High	17	3 (20)	10 (67)	1 (7)	1 (6)
Total	**65**	**12 (18)**	**49 (75)**	**3 (5)**	**1 (2)**

(Figure in the parenthesis are in percentage)

3.5.3.3 Affordability

Affordability to pay for electricity for cooking and heating originates from the income of various levels of households in the target area. The basis for determining the payment limits of the households has been the result of the analysis of data acquired from field investigations for the household levels of all income groups. The accepted and proposed guideline of affordability as the payment of monthly bill for electricity supply is 5 percent of the average household income. The affordability condition can be summarized from the following table of household income conditions. It is clearly pictured that low income group are affordable of NRs. 189 per month, medium income group with NRs. 403 and high income group with NRs. 835 per month within the acceptable and proposed guideline of affordability where monthly bill is regarded as affordable up to five percent of the monthly income. The overall average affordability of all households is NRs. 476 per month for electricity bill.

Table 3.21: Affordability by income status (NRs. per month)

VDC	Low 16	Medium 32	High 17	Average 65
Charang	172	388	1086	549
Chhusan	174	390	560	375
Ghami	222	432	858	504
Lomangthan	186	447	678	437
Average	189	403	835	476

3.5.4 Energy Characteristics

3.5.4.1 Energy sources in the project area

In the project area the socio-economic survey analysis shows that the fuel wood and animal waste are the major sources of energy of the households for cooking and heating purposes. The survey result shows that fuel wood is used by all households from all three types of income groups as the main sources of energy. Almost 90.8 percent of the households use animal waste as secondary source of energy in the area. The households use kerosene as a commercial source of energy for lighting purpose. Almost 95 percent of the household use kerosene for lighting purpose. Apart from these fuels, solar panel with dry cell batteries are used by 80 per cent of the household survey.

Fuel wood is mainly used for cooking followed by heating, agriculture residue and animal dung are used for animal feed, agro-processing. Kerosene is basically used for lighting purpose. The survey shows that 100 percent of the low, medium and high income households of the project area collect fuel wood from forest. Almost 95 percent of the household purchase kerosene for lighting purposes (Annex Table 3).

3.5.4.2 Household energy consumption pattern

The household energy consumption pattern shows that on an average each household's demand for the fuelwood and kerosene stands respectively at 3664 kg (61.1 GJ) and 25 litres (1.2 GJ) per household per annum (Table 3.22). Similarly agricultural residue and animal waste demand is 240 kg (3.0 GJ) and 2064 kg (22.5 GJ) respectively.

The survey also shows that the primary energy requirement of an average household per annum in the project area is 88 GJ that is percapita energy consumption is 14.7 GJ in the project area. Out of which 70% is required for cooking, 14.1% for heating, 12.6% for animal feed and 1% for lighting purposes.

Table 3.22: Energy consumption pattern by household (per HH per year)

End Uses	Fuelwood kg	Agri residue kg	Animal dung kg	Kerosene average ltr.	Dry cell battery units
Cooking Food	2924.0	48.0	1088.0	8.8	0
Cooking Animal Food	0.0	36.0	976.0	0.0	0.0
Agro Processing	0.0	156.0	0.0	0.0	0.0
Heating	740.0	0.0	0.0	0.0	0.0
Lighting	0.0	0.0	0.0	25.0	2
Total	**3,664.0**	**240.0**	**2,064.0**	**33.8**	**2.0**

3.6 ENVIRONMENTAL STUDY

3.6.1 Introduction and Scope

3.6.1.1 General

The present environmental study is carried out as a part of the field study of the Ghami Khola Small Hydropower Project proposed on the Ghami stream in Mustang district of the western development region.

Environmental data on the project area were collected from the primary and secondary sources to make this report. The main objectives of the environmental study are to identify the issues and relevant aspects to be considered; find out the likely negative impacts; and to suggest relevant mitigation measures.

3.6.1.2 Direct and indirect impact zone

The total area to be affected by the Ghami project is considered to be about 15 sq. kilometers. For the purpose of the environmental study, the project affected area has been divided into direct and indirect impact zones.

The direct impact zone (DIZ) is the area that will be directly and physically affected by the construction and operation activities. It will to a large degree coincide with required land take of the Ghami Khola SHP. This includes both permanent and temporary landtake in the construction period. In the operation period, DIZ can be limited to area of permanent landtake. A zone of 3 to 50 m around or along construction sites and transmission line is also included in the DIZ. In addition, the stretch of Ghami Khola between intake to powerhouse is expected to be most affected area by reduced water flow is included in the DIZ.

Indirect impact zone (INDIZ), includes area indirectly affected by the project construction and operation activities. Social effects are expected to be the effects more extended in space than biophysical impacts. The expected social impacts are therefore defining the INDIZ. In keeping with this principle, it is also logical to base the definition of INDIZ in the area is therefore defined as the outer boundary of all the four VDCs (Lomangthan, Ghami, Chhunan and Charang VDCs) where project is constructed and transmission line passes through.

This report is based on review of previous studies of the project areas and consultation with local people.

3.6.2 Existing Physical Environmental Condition

3.6.2.1 Landform and topography

Ghami project area is a part of Kali Gandaki watershed. It is characterized by broad ridges and v shaped valleys. At the intake site, the relief is dominated by the steep slopes at the left side of the river while at the right side is relatively flat. At powerhouse site, left part is gentle slope and right part is relatively flat. Flat parts along the stream are heavily cultivated, while the stream side steep slopes are covered with sporadic distributed bushes.

3.6.2.2 Climate, air quality and noise

Climatically, the project areas fall markedly into sub alpine humid climate zone. Climatological records of Nepal, DHM reported that an average annual rainfall recorded is only less than 300 mm. Entire project area is located in remote area, therefore the existing air quality of ambient air is excellent in the impact zones. Indoor air pollution due to the use of firewood for cooking is the main air pollution problem at present. The project sites and the areas immediately adjacent to them are generally calm.

3.6.2.3 Slope instability

The greater parts of the area are dominated by steep slopes (30-40 degree) and show irregular surfacial features. The cultivated slopes have gentle slopes. In general, small parts of the watershed areas are sensitive to erosion especially from wind erosion and snow melting and there are few landslide prone areas. Snow avalanches during heavy snow falls is also possible.

3.6.2.4 Water usage

Irrigation and drinking water are the important aspects of water usage. Barley and potato are cultivated as major crops along the stretch of the Ghami Khola between proposed intake and powerhouse. The crops are cultivated during March to September and mainly watering is needed during these months. March being the driest month, the water abstraction from the Ghami Khola is crucial in this month. The information regarding the command areas, population and crop patterns are obtained from the preliminary survey. Table 3.24 depicts the location of water takeoff as well as command areas of the irrigation systems.

Table 3.24: Locations and command areas of irrigation in Ghami Khola

Location of existing water intake for irrigation	Distance from the intake site	Dry season flow (m^3/s) in stream	Command areas of the Irrigation	Water demand (l/s)
Ghami irrigation	30 m	1.52	55 hectare	500

3.6.3 Existing Biological Environmental Condition

3.6.3.1 General

Nepal has set aside over 17 percent of its territory in the protected areas. Of these, the project area falls in an important conservation area, that is Annapurna Conservation Area. There are a series of ridges, valleys and basins of which the terrain is mostly occupied by the level terraces and valley cultivation with sporadic distribution of forests and regeneration bushes. The tree line falls about 4000 m which is wilderness zone dominated by bushes, grasses and medicinal plant species.

3.6.3.2 Natural vegetation

The natural vegetation of the project area ranges from sub alpine to alpine pasture towards north. Most of the project area falls into sub alpine zone (3000 - 4000 m) and the dominance of conifers and rich variety of associated species mainly characteristics this zone. *Betula utilis* (Rajpatra), *Crytomeria japonica* (Dhupi) and *Pinus wallichina* (Gobre Salla) are the common plant species of the area. Similarly, this area is marked by the occurrences of dwarf shrub berries and open grassland with occasional shrubs like *Berbaries (*Ban Chutro) species. In addition to, several medicinal plant species are also found in the areas. Example of the medicinal plant species[1] is *Dema, Manu, Ruta, Batu* etc.

Currently, the situation of forest is disturbed by the over exploitation of fuel wood and fodder collection in the some parts of the project areas. Conservation Areas Management Operation Plan prepared by ACAP reported that total forest area of the project area including INDIZ (four VDCs- Ghami, Lomagthan, Charang and Chhusan) to be found 15 km^2. Name of the forests of the project area is given in Table 3.24. However only 15 ha is in good condition. In the sub alpine forest, tree species are sporadically distributed and its density is very low which is given in Table 3.25.

Table 3.24: Forest of the project areas

S.N.	Forest name	Dominant species	Forest condition	Required time to reach to the forest from village
01	Pagnag	Pine and Dhupi	Normal	1.5 hours
02	Chumbang	Pine and Dhupi	Normal	2.5 hours
03	Keuten	Pine and Bhopatra	Deforested	2 hours
04	Chhoubar Pankha	Dhupi, pine, and Bhojpatra	Normal	1.5 hours
05	Ghuetan Dagn	Dhupi and Bhojpatra	Normal	1.5 hours
06	Bhena	Dhuphi and Bojpatra	Deforested	4 hours

Table 3.25: Density of the major plant species in the project area

Species	Density per ha				
	Tree	Sapling	Pole	Seedling	Bushes
Dhupi (*Crytomeria japonica*)	6	17	13	69	42
Bhojpatra (*Betula utilis*)	15	6	3		
Gobre Salla (*Pinus wallichina*)	5	3	9		

Plant regeneration condition in the forest area is also very low. Conservation Areas Management Operation Plan prepared by ACAP reported that seedling of 25 tree species and 69 bushes species are generally regenerated per year in the project area.

3.6.3.3 Forest resources consumption

Local people use forest product such as fuelwood, fodder and timber. Some farmers also collect roots and shoots of plant for food and firewood. Almost all household of the project area use firewood. The household use firewood depends on the family size, number of livestock raised at forest proximity and so on. Fuelwood comes from the public forest, shrub land and private land. Conservation Areas Management Operation Plan prepared by ACAP reported that 3630 *bhari* (1 *bhari* = 20-30 kg) firewood per annum is a production from the forests of the project affected areas. Demanded firewood is around to be 63145 *bhari* per year. The deficiency amount of the firewood has been found to be fulfilled by local people using dry dung of horse, yak and sheep. The most common fuelwood species in the area are: Pine and Bhojpatra, where as Timber of Bhote pipal (*Poplus spp.*) is used for house construction.

3.6.3.4 Terrestrial animal

The area is suitable for bird and mammals species. Nepal harbours 181 species of wild animals and more than 800 species of aves, within 147,181 km^2. Conservation Areas Management Operation Plan prepared by ACAP reported 6 species of mammals, 9 species

[1] The plant species are given in local Tibetian language

of aves and one species of reptiles are found in the project areas. Among them snow leopard and musk dear are endangered. These species are given in the Table 3.26.

Table 3.26: Terrestrial animals in the project area

S.No.	Class	Species		Condition		Remarks
		Local name	Scientific	Local	World	
1	Mammals	Snow leopard	*Uncia uncia*	Endangered	Endangered	
		Himalayan Rare	*Lepus sp.*	Fairly common	Common	
		Fox	*Vulpes vulpes*	Fairly common	Common	
		Jackal	*Canis aureus*	Common	Common	
		Musk dear	*Moschus sp*	Endangered	Endangered	
2	Birds	Pigeon	*Columba sp*	Common	Common	
		Sparrow	*Passer montanus*	Common	Common	
		Himalayan goldfinch	*Carduelis spinoides*	Common	Common	
		Bearded Vulture	*Gypaetus barbatus*	Common	Common	
3	Reptiles	Lizard		Rare	Common	

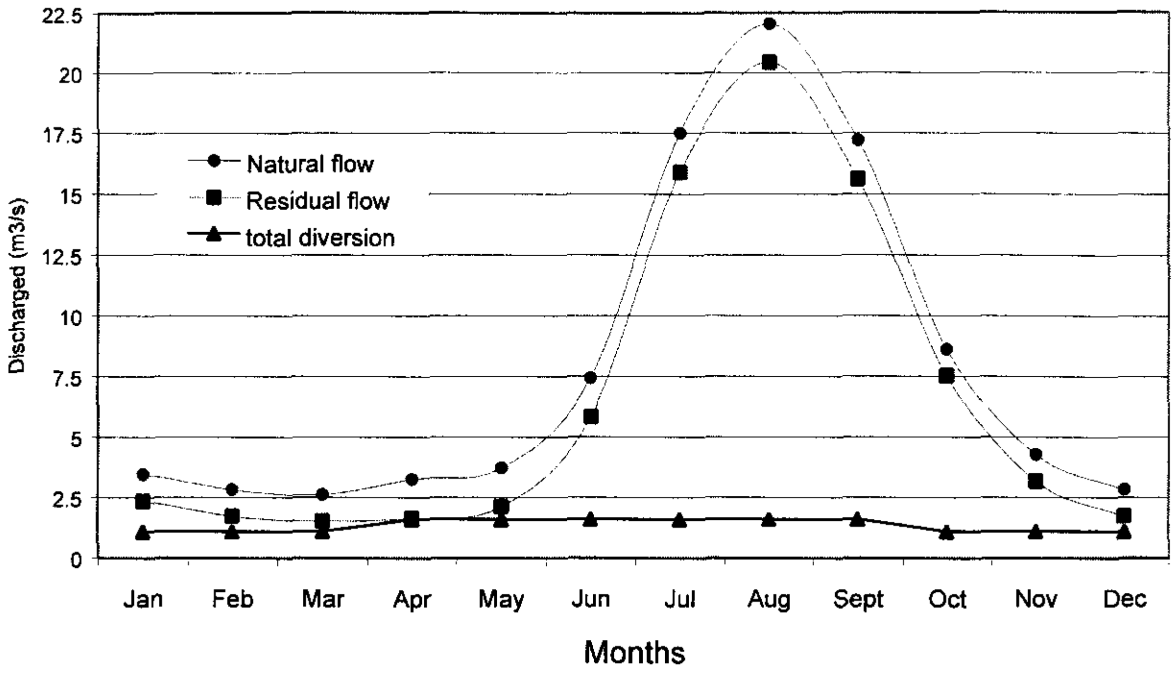
3.6.3.5 Agro-ecosystem

Crop production and livestock management are the main activities in the project area. Agricultural activities are carried out by the farm families. Since the area has no road access, inputs like fertilizer, improved seed and pesticides are not available. Horse, yak and sheep dung is used for firewood, therefore there is deficiencies of using compost manure on farming lands in the project area. Mainly villages are placed on only flat and comparatively fertile area. The main crop systems in the project area are wheat, millet, potato, bean and barley. According to the local people, overall food production is sufficient for their subsistence.

3.6.4 Impacts on Physical Environment

Physical impacts on water flow and quality, air quality, noise and on soils can be expected. Increased noise from project construction activities may also become a problem. Similarly, sanitary wastes, used oils at the maintenance yard and leakage from construction equipment are the main source of pollution in the Ghami stream. Without mitigation measures, the stream stretch between powerhouse to intake will experience a significantly reduced river flow. The reduced water flows in the Ghami Khola will not affect the existing water uses of the river. Figure 3.4 depicts average monthly flow in m^3/s as a riparian flow in the Ghami Khola after water is diverted for the electricity generation and irrigation.

Figure 3.4 Average monthly flow in Ghami Khola



Proposed diversion flow for the electricity generation is only 1.1 m^3/s while other more 0.5 m^3/s water will be diverted for irrigation from April to September. The lowest residual flow as a riparian flow in the river is 1.52 m^3/s in March. It is therefore sufficient to sustain water use at present level and also satisfy environmental need even in dry season.

Table 3.27: Average monthly flow in m^3/s in the Ghami stream after water is diverted for the electricity generation and irrigation

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Ave
Natural condition	3.46	2.84	2.62	3.26	3.72	7.43	17.5	22.03	17.21	8.68	4.28	2.84	7.73
Diversion for elec. generation	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Diversion for irrigation	0.0	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.25
Residual flow	2.36	1.74	1.52	1.66	2.12	5.83	15.9	20.43	15.61	7.52	3.18	1.74	

Table 3.27 shows that river will not run and will have ample residual water to meet with people's utilization even in the driest month of March.

3.6.5 Impacts on Biological Environment

The project will have both positive and negative impacts on the biological environment. Those impacts will be observed mainly during the construction phase.

The no action alternative indicates a trend of slow increase in the population in the project area. If it is assumed that if the present pattern of resource use does not change radically, the present forest and bush lands will be transformed into bare lands. More of the trees and bushes will be cut for firefuel, fodder and construction purposes.

The no action alternative indicates that deforestation will be continue. Local people will be compelled to use more amount of yak and horses dung for their cooking and heating purpose instead of using the dung on agriculture land. Consequently, indoor air quality and agriculture productivity will be worse than at present.

Impacts during the construction period will be speed up the ongoing processes of vegetation change as a result of the built up of labor forces. Large workforce may collect firewood for their heating systems and cooking that causes deforestation of the existing forest. Similarly, trees under the transmission line (TL) alignments will be cleared to set up the clearance between transmission line (TL) and ground. However, the impacts will be limited during the construction phase.

During the operation phase some positive impacts will take place as a result of replacement of firewood by electricity for room heating and cooking. From these activities, indoor air quality will also be improved than at present.

In general, the project will have negative impacts on birds during both the construction and operation phases. Birds are expected to be affected by the project in many different ways, such as, loss of feeding habits, increased disturbances and killing due to collisions with transmission lines.

No major impacts are foreseen to mammals in the no action alternative. A slow and gradual deterioration of mammal habits can be expected because of ongoing deforestation. Hunting will continue as about same level as at present. In contrast to the no-action alternative, project activities are expected to have a high but temporal effect during the construction phase and a lower but permanent effect in the operation phase.

3.6.6 Mitigation measures

Following general mitigation measures for the physical and biological environment are recommended:

Project induces slope failures, vegetation clearance and irrational uses of land are major factors responsible for adverse impacts on slope stability. In order to minimize such adverse impacts on slope stability, avoid unnecessary blasting, cutting and excavation and an adequate drainage system should be established.

As far as possible the project facilities (including camps, housing etc) should occupy barren or unused land, avoiding agricultural land and areas having high density of the vegetation. Note also that there is limited productive land in the project area. Therefore people who will be displaced by the project will have little opportunity to buy or lease alternative land in the area.

Project must encourage local people for managing their forest in sustainable basis. Further, sustainable use of local resources should be preferred to bringing in timber and firewood from outside the project area. Where the project cut trees or grasses etc. from the project land, should be made available to the local community for use as fodder or timber. The project should ensure that staff and workers have ready access to kerosene or gases for cooking at normal market prices.

There is significant wildlife in the area, including some endangered species. To a large extent, these can be protected by protecting their forest habitat and providing awareness programme.

The Ghami stream is relatively clean and care should be taken to maintain the water quality during construction phase. All rubbish and sewerage disposal should be kept away from any watercourses, to avoid contamination through seepage or direct runoff. Normally a buffer of 50 m, with no direct runoff would be appropriate. Quarry sites and gravel plants should be built in such a way that there is no direct runoff to watercourses. Water used for aggregate washing should be passed through setting ponds. Waste oil and grease should be prevented from entering the rivers. Workshop facilities should be kept at least 50 m away from watercourses, and should have grease and oil traps which are properly maintained to ensure clean runoff from the sites even during periods of rain.

3.6.7 Recommendation

Environmental Protection Act (EPA), 1996 and Environmental Protection Regulation (EPR) 1997 have made a mandatory to carry out EIA as project area falls in conservation areas.

As stipulated under EPA, 1996 Section II, article 3, the concerned proponent shall conduct an Initial Environmental Examination for any development and operation of electricity generation project from 1 to 5 MW and installation and operation of transmission lines up to 66 kV capacity. However, if the project is going to be developed in the conservation area proponent require to carryout Environmental Impact Assessment. It is therefore recommended to carry out EIA of the project as per EPA and EPR.

A procedural flow chart for the EIA study is depicted in Figure 3.5.

3.7 POWER DEMAND FORECAST

3.7.1 Power Demand

Electric power demand in upper Mustang area has been created by the micro hydropower projects, solar electric panels and tourist development activities. There is 16 kW micro hydropower project in Chhusan (presently not in operation), 29 kW project in Lomangthan and 14 kW project in Charang. Many houses in upper Mustang area have solar electricity though highly expensive. Consultant conducted demand survey during field visit. Based on the survey data the demand forecast of all four VDC load centers has been done. During forecast the energy consumption in terms of unit (kWh) is linked to the income levels on the consumers in domestic and commercial sectors.

3.7.2 Existing Power System

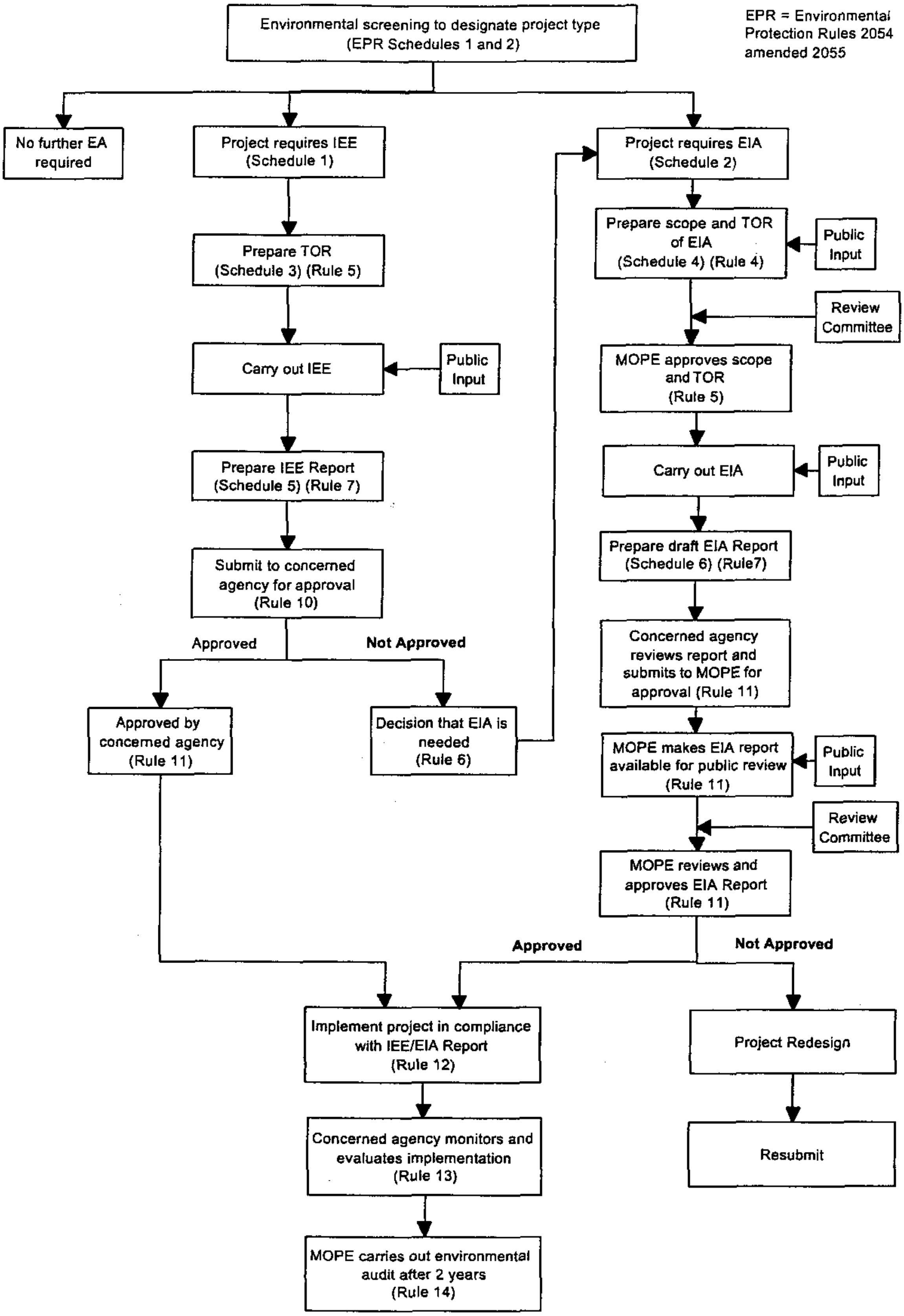
The project area is not planned to connect with national grid because of remoteness and mountainous terrain. Some micro hydropower projects exist but they are not in operation properly because of design defects and unavailability of trained operators. Some people have been using solar panel electricity for lighting though very expensive. They have been facing problems because of acid batteries and lack of repair and maintenance knowledge. Most of the people use kerosene lantern and lamps for lighting and fire woods and animal dung for cooking and heating.

3.7.3 Method of Power Demand Forecast

The load demand forecast is based on 'bottom up' from the micro level in terms of household, commercial, industrial and public sector connection. The electricity demand forecast is an autonomous growth of power consumption pattern of rural people and increase in demand due to electrification in future. The load forecast of the particular project of small hydropower is based on population and population growth of load centres. The following parameters have been considered as norm values for load demand forecast specially based on the NEA's normal practice:

- Population of the project area
- Growth of population of project area
- Household numbers and sizes in the project area.
- Household numbers of low, medium, high income groups
- Agricultural GDP growth
- Existing small-scale industries and growth

Figure 3.5


Environmental screening to designate project type (EPR Schedules 1 and 2)
EPR = Environmental Protection Rules 2054 amended 2055
No further EA required
Project requires IEE (Schedule 1)
Project requires EIA (Schedule 2)
Prepare TOR (Schedule 3) (Rule 5)
Prepare scope and TOR of EIA (Schedule 4) (Rule 4)
Public Input
Review Committee
Carry out IEE
Public Input
MOPE approves scope and TOR (Rule 5)
Prepare IEE Report (Schedule 5) (Rule 7)
Carry out EIA
Public Input
Prepare draft EIA Report (Schedule 6) (Rule7)
Submit to concerned agency for approval (Rule 10)
Approved
Not Approved
Concerned agency reviews report and submits to MOPE for approval (Rule 11)
Approved by concerned agency (Rule 11)
Decision that EIA is needed (Rule 6)
MOPE makes EIA report available for public review (Rule 11)
Public Input
Review Committee
MOPE reviews and approves EIA Report (Rule 11)
Approved
Not Approved
Implement project in compliance with IEE/EIA Report (Rule 12)
Project Redesign
Concerned agency monitors and evaluates implementation (Rule 13)
Resubmit
MOPE carries out environmental audit after 2 years (Rule 14)

The four sectors have been classified to determine the load demand in rural hills of Nepal as such:

- Domestic sector growth
- Commercial sector growth
- Industrial sector growth
- Public sector growth (public service and street light)

The applications of the parameters in load growth have been considered from household survey. The basic of the parameters for the Ghami Khola project is considered from the survey results. Some of parameters are considered as national norms if the parameters are not reasonable from survey data.

The population of VDCs of the load centres in a project area is obtained from latest national census undertaken in year 2001 from the Central Bureau of Statistics (CBS). The annual growth of population is considered as the district population growth rate available in the census and considered as constant over the project period. The household size of the project area is calculated as the average household of VDCs and is considered as constant over the project period.

The income level is categorized as three groups low, medium and high. The growth pattern of the income group is assumed that the gradual decrease in low-income group consequently increasing medium and high-income group. The rate is based on the assumption and is considered at 1.1% and 0.95% over the project period.

The number of households per commercial center is considered as 13 households. The growth rate is considered as district population growth at 0.5% per annum and remains constant over the project period. Similarly the number of households per public service unit is considered for the study is 35 households. The streetlight is assumed to be required for at least 15 households. The growth rate is assumed at 12% per annum.

The electrification coefficients are determined based on the type of consumer's rate at which the consumers take electricity service. It depends on household income group and willingness to pay and affordability. It is assumed that 60% of the low and medium income household will connect the electricity supply in the first year and 70% in the case of high income group. The coefficient values are also assumed to increases by 5.45 in the first decade and 1.64% in the second decade considering that the electrification coefficient will be 100% in 20 years period. The coefficient value is considered at 60 in the cases of commercial, public light and public services. The growth rate for the coefficients is considered at 3.54% for the first decade and 1.64% for the second decade.

3.7.4 Load Centers

According to survey and requirement of the project area following are the load centers identified for electricity supply.

1. Lomangthan VDC consisted of two villages
2. Charang VDC (including Marang)
3. Ghami VDC (including village Ghiling and Dhakmar)

3.7.5 Electricity Consumption

It is expected from the willingness to pay of household survey that the average income group will consume minimum energy block in the lifeline level of 45 kWh per month and will pay NRs. 250 per month as per their willingness of 63% of low, 85% of medium and 67% of high income groups. As per actual demand for lighting and cooking is very much higher but for the present study it is assumed that 30 kWh will consume by low, 40 kWh by medium and 70 kWh by high income groups respectively. The low income group will pay NRs. 113 per month; the medium income group will pay NRs. 226 per month. And in the same way high income group will pay NRs. 445 per month. The consumption demand is expected to increase by 2%.

In the case of commercial and public sectors, it is assumed to consume 750 kWh per month throughout the project period. The growth rate of commercial consumer and public service is assumed at 2.5% per annum. The consumption of electricity in industrial sector is assumed on the basis of NEA study norms to replace existing diesel plant and at least one unit of small-scale industry from each VDC will connect the electricity line in the initial year. The growth of energy demand is assumed at 2.66% over project period. It is assumed that an industrial unit at 7 HP electric prime movers will operate for 5 hours a day through 300 days a year consuming 7.8 MWh of electricity per annum. The assumptions are basically based on NEA norms.

The system loss is not a serious concern in the case of isolated SHP and it is assumed at 18% which is an acceptable figure for normal system in the context of Nepal and remains constant over the project period since at present total generation capacity is not fully consumed. It is assumed that the electricity initially used for 1314 hours of utilization.

The results from power demand forecast are given in Table 3.28.

3.8 POWER DEVELOPMENT STUDY

3.8.1 Power Potential

The Ghami Khola has very high power potential because of two main reasons. Firstly it is a perennial river fed by snow and possesses tremendous discharge throughout the year. Secondly, the river gradient is very high, in average above 8% in slope. It is one of the main tributaries of Kali Gandaki river, which meets at Namja Dovan. The catchment area is covered with high mountains and snow. Due to favorable conditions to develop hydropower in Ghami Khola various agencies have conducted feasibility studies. Under this study and survey works and demand growth estimate, total 600 kW power can be generated at proposed Ghami site.

3.8.2 Design Discharge

The design discharge for power generation is determined with 90% availability of flow of the river. The river flow has been calculated by various methods explained in the chapter of hydrology.

3.8.3 Gross and Net Heads

The gross head of the project has been calculated with consideration of the normal water level in the forebay and powerhouse turbine axis. Where as the net head is determined with consideration of penstock losses. According to the calculations the gross head of the plant is 85 m. The details are provided in E/M equipment chapter.

3.8.4 Power Output

Based on available discharge and head the power output per annum for various turbines are as follows:

Type of Turbine	Gross annual output	Rated power (kW)	Rated flow	Gross head
Francis	4386 MWh	600	1.0 m^3/sec	85 m
Turgo	4479 MWh	600	1.0 m^3/sec	85 m
Cross flow	3745 MWh	600	1.0 m^3/sec	85 m

Table 3.28: Load Demand Forecast : Ghami Khola SHP

Parameters	Year 2002	Growth rate 2012	Growth rate 2022	Input Parameters	Year 2002	Growth rate 1st Dec.	Growth rate 2nd Dec.
Population	2359	0.50%	0.50%	Public sector growth		2.68%	2.68%
Person per household	4.71	0.00%	0.00%	Commercial sector growth		2.68%	2.68%
				Agricultural production growth		2.88%	2.88%
Low income group (%)	25%	-1.11%	-0.95%				
Medium income group (%)	49%	0.36%	0.39%	Cons. low consumers (kWh/a)	360	3.00%	3.00%
High income group (%)	26%	0.30%	0.00%	Cons. medium cons. (kWh/a)	550	3.50%	3.50%
				Cons. high consumers (kWh/a)	850	4.00%	4.00%
Household / commercial center	13	0.50%	0.50%	Cons. per HH (weighted ave.)	593	0.00%	0.00%
Household / public service	36	0.50%	0.50%				
Household / public light	14	0.50%	0.50%	Commercial consumption (kWh/a)	750	2.68%	2.68%
				Industrial consumption (MWH/a)	7.8	2.68%	2.68%
El. coeff. low and medium cons.	60%	5.45%	1.64%				
El. coeff. high consumers	70%	1.96%	1.64%	System losses	18%	0.00%	0.00%
El. coeff. commercial centers	60%	3.54%	1.64%	Annual hours of utilization (h)	1314	3.50%	3.50%
El. coeff. public light	60%	3.54%	1.64%				
El. coeff. public services	60%	3.54%	1.64%				

Autonomous Demand : Domestic / Income Level

Year	Population	No. of househ	Number of Potential Consumers Low	Medium	High	Total	Unit Consumption (kWh/yr) Low	Medium	High	Domestic Demand (MWh/yr) Low	Medium	High	Total
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
2002	2359	500	74	148	92	314	360	550	850	27	81	78	186
2003	2371	503	78	158	95	331	371	569	884	29	90	84	203
2004	2383	505	82	168	98	348	382	589	919	31	99	90	220
2005	2395	508	86	179	101	366	393	610	956	34	109	97	239
2006	2407	511	90	191	104	385	405	631	994	36	121	103	260
2007	2419	513	94	203	107	404	417	653	1034	39	133	111	283
2008	2431	516	99	216	110	425	430	676	1076	42	146	118	307
2009	2443	518	103	229	113	445	443	700	1119	46	160	126	332
2010	2455	521	108	244	116	468	456	724	1163	49	177	135	361
2011	2467	523	113	259	119	491	470	750	1210	53	194	144	391
2012	2480	526	119	276	122	517	484	776	1258	58	214	154	425
2013	2492	529	120	283	125	528	498	803	1309	60	227	164	451
2014	2504	531	122	290	128	540	513	831	1361	62	241	174	478
2015	2517	534	123	298	131	552	529	860	1415	65	256	185	507
2016	2530	537	125	306	134	565	545	890	1472	68	272	197	538
2017	2542	539	126	313	137	576	561	921	1531	71	288	210	569
2018	2555	542	128	321	140	589	578	954	1592	74	306	223	603
2019	2568	545	129	329	143	601	595	987	1656	77	325	237	638
2020	2581	547	131	337	146	614	613	1022	1722	80	344	251	676
2021	2593	550	132	346	149	627	631	1057	1791	83	366	267	716
2022	2606	553	134	355	152	641	650	1094	1862	87	389	283	759

Autonomous Demand : Commercial / Public Service / Industry

Year	No. of Comm. Cons.	Comm. Unit Cons. kWh/yr	Comm. Load MWh/yr	Industry Units	Industry Load MWh/yr	No. of Public Service	No. of Public Lights	Public Service Load MWh/a	Annual Hours of Utiliz.	Net Load MWh/a	Losses MWh/a	Gross Load MWh/a	Max. Load kW	Power Factor	Industry Load Capacity KW
14	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*
2002	24	750	118	5	8	8	21	22	1314	366	66	431	328	10%	15
2003	25	770	119	7	8	9	22	23	1360	401	72	473	348	11%	22
2004	26	791	120	9	8	9	23	24	1408	439	79	517	368	12%	29
2005	27	812	122	11	8	9	24	25	1457	479	86	565	388	13%	36
2006	28	834	123	13	9	10	25	26	1508	522	94	616	408	14%	44
2007	29	856	124	15	9	10	26	27	1561	567	102	669	429	15%	52
2008	30	879	126	17	9	10	26	28	1615	616	111	727	450	16%	61
2009	31	903	128	19	9	11	27	28	1672	667	120	787	471	18%	70
2010	32	927	129	21	10	11	28	30	1730	722	130	852	493	19%	79
2011	33	952	131	23	10	11	29	31	1791	781	141	921	514	21%	89
2012	34	977	133	25	10	12	30	32	1854	844	152	996	537	22%	99
2013	35	1003	135	27	10	12	31	32	1918	899	162	1061	553	24%	110
2014	35	1030	136	29	11	12	31	33	1986	957	172	1129	569	25%	122
2015	36	1058	138	31	11	12	32	33	2055	1019	183	1202	585	27%	133
2016	36	1086	139	33	11	13	32	34	2127	1084	195	1279	601	29%	146
2017	37	1115	141	35	12	13	33	34	2201	1150	207	1357	617	30%	159
2018	38	1145	143	37	12	13	33	35	2278	1221	220	1441	632	32%	172
2019	38	1176	145	39	12	13	34	35	2358	1296	233	1529	648	34%	187
2020	39	1207	147	41	13	13	35	36	2441	1373	247	1620	664	36%	201
2021	39	1240	149	43	13	14	35	37	2526	1456	262	1718	680	38%	217
2022	40	1273	151	45	13	14	36	37	2615	1542	278	1820	696	41%	233

As Turgo turbine gives the maximum energy output, it is adopted in the project. Two number of 300 kW Turgo type of turbines with synchronous generators are used to generate electrical power for the rural supply.

3.9 DESIGN AND DIMENSIONING OF PROJECT COMPONENTS

3.9.1 Project Layout

Project layout is done considering geological, topographical and local constraints. The previous layout plan and reports prepared by the SRCL/NEA have been reviewed and verified during the field visit. The technical team conducted walkover survey and identified appropriate locations for intake, forebay and powerhouse to meet the power demand and ease for construction and operation. During project layout two options were considered. In the first option, a forebay was proposed at chainage 0+807 km and powerhouse at elevation 3642m with having 400m length penstock. Where as in second option a forebay was proposed at chainage 2+102 km and penstock was required of 710 m long. Considering the power demand of three VDCs (excluding Chhusan VDC) the first option was found appropriate for power development.

3.9.2 Description of the Structures

As observed Ghami Khola brings boulders and gravels while melting of snow. The river gradient is about 8% around the intake area. Considering the boulder flow, river gradient and freezing problems along the river following structures and locations of Ghami SHP are proposed.

3.9.2.1 Diversion weir

In order to receive design discharge permanently and with reliability, a diversion weir of low height is required along the intake cross section. As per site condition and bed load flow condition, 1.5 m high concrete weir is proposed with Tyrolean type of intake structure on right bank of the river. In order to divert the flow towards intake the Tyrolean section is lowered by 0.30 m.

3.9.2.2 Intake structures

A Tyrolean type of intake structure has been proposed on the right bank of Ghami Khola considering the site conditions and possibility of ice formation during winter season. The observed conditions are as follows.

The Ghami Khola catchment in general is unstable in terms of sediment load over the time. The river gradient in the vicinity of head works is higher than 7% in 1 km range of upstream of the river. The river carries tremendous volume of boulders. The bed composition responds to the supply of bed loads and debris across the length and width of the river. Considering the site conditions i.e. higher slope of the river, coarse bed materials during flood season and discharge to be diverted for power generation, bottom type of intake (Tyrolean type) is the most appropriate to ensure a permanent water intake.

The bottom rack weir with its top elevation of 3732.90 m and foundation elevation of 3730.0 m is set in the main river course at the right side of the river so that the water could be tapped easily.

A horizontal steel trash rack of 1.0 m width and 8.0 m length is provided with 10o inclination towards the downstream. The steel size of trash rack is of 20 mm thick trapezoidal bars with clear spacing 15 mm between bar to bar so that particles larger than 15 mm could be checked. The inclination of rack would allow the particles to be transported towards downward by the flow itself. Only silt and sand particles smaller than 15 mm could enter into the intake chamber which will be removed by the desanding basin.

The intake gallery is proposed to be constructed of concrete and is inclined towards the right bank with 1:20 slope. This slope is sufficient to transport the discharge of 1.40 m3/sec during normal flow of the river.

At the end of the gallery a sluice gate of size 1.20 m x 1.0 m is provided to control the excess of discharge during flood period. The sluice gate is protected from flood damage by the concrete wall in which its frame rests.

After the sluice gate, a covered canal with concrete lining and with 1:100 slope is provided to convey the flow from the intake to the desanding basin. A concrete lining of 15 cm thick is provided in the canal to prevent the scouring as the velocity of flow could be 2.50 m/sec under flood condition. The canal is covered with RCC slab and is backfilled with gravel mixed soil.

3.9.2.3 Desanding basin

A desanding basin is designed to remove silt and sand particles of size greater than 0.2 mm. The basin is located at flat terrace close to intake structure. The total length of basin is 30 m. Two chambers are provided and are separated by a 50 cm thick stone masonry wall with concrete lining. The width of each chamber is 3.0 m. Provision of stop log is made at both ends of each chamber. The basin comprises of an overflow spillway in order to spill out excess of discharge coming through intake during flood.

Both settling chambers are wide enough to have flow velocity of 0.2 m/sec in the chamber and is sufficient to settle the particle of size up to 0.2 mm. The bottom surface of chamber is lined with concrete and is provided a slope of maximum 1:50 towards the flushing gate which is located at the end of the chamber. All the settled particles at the bottom of the basin will be flushed away with the help of opening of flushing gates. The size of opening of flushing gate is 60 cm x 40 cm.

Slots for stop logs are provided at inlet and outlet of each chamber in order to control the flow of water during maintenance.

3.9.2.4 Headrace canal

A rectangular shaped headrace canal has been proposed to suit the topography of the canal route with minimum cutting and filling in the canal alignment.

The headrace canal is designed to carry a flow of 1.0 m^3/sec providing 1:250 as bed slope. The thickness of stone masonry to the bottom and sides is 30 cm each and inner surface of the canal is plastered using cement to make the surface smooth.

The flow velocity in canal is 1.66 m/sec which is permissible as silt clogging velocity is 0.30 m/sec and maximum velocity to avoid erosion of masonry lining is 2.5 m/sec according to recommendation of Hydropower Design Manual.

Some drops (with maximum fall 0.5 m) are provided along the canal alignment to match the existing ground conditions.

3.9.2.5 Forebay and spillways

At the end of headrace canal, a rectangular shaped forebay has been proposed. An overflow spillway of 5 m long crest is provided to spill out excess of water from the forebay. The spillway crest is fixed at elevation 3727.85 m and a spillway chute is provided to evacuate the excess of discharge. The chute ends to the valley situated right side of the tank through which the spill discharge is allowed to pass safely. Normal water level in the forebay is 3727.75 m. The forebay has been designed for 180 m^3 as live storage volume (3 minutes) to allow for sudden load acceptance by each of the turbines. A free board of 0.25 m is provided to prevent spilling of water from forebay wall during complete load rejection.

At the end of the forebay a penstock intake is provided to maintain sufficient submergence of the penstock. The bottom elevation of penstock is 3724.85 m. A steel trash rack is also provided in front of intake of penstock pipe in order to prevent the entry of floating materials. The clear gap between the fine rack strips is 2.0 cm.

A bottom outlet gate is 0.30 m below the penstock level, which will serve to remove sediment particles deposited in the forebay tank. For maintenance and repair works of forebay the bottom outlet gate can be used to evacuate the forebay water. A stop log is provided to stop the entry of inflow of water from the canal to the forebay. In addition, an overflow spillway of crest 3.0 m long is provided in front of the above stop log.

3.9.2.6 Penstock

A steel penstock of diameter 0.70 m is provided. The thickness of pipe is accepted as 7 mm considering the water hammer pressure and 2 mm additional thickness for corrosion. The pipes shall be buried under ground to protect from freezing. The total length of main pipe is 400 m while bifurcation pipe dia. 0.50 m and length of 20 m each are also required.

Considering the transportation problem the main pipes are proposed of 3 m length each with flange coupling system.

5 numbers of RCC anchor blocks are required. The anchor blocks are designed with sufficient coverage. Expansion joints are provided in penstock after each anchor blocks.

The velocity of design flow in the pipe is 2.60 m/sec which is within acceptable range.

3.9.2.7 Powerhouse

The dimension of powerhouse is 20 m long, 10 m wide and 10 m high so that electro-mechanical equipment can be accommodated and lifted easily. Two units are installed due to equipment transport problem and economic reason. The spacing between two units are determined with the turbine and generator sizes obtained from the catalogue of equipment manufacturer. Sufficient spaces are provided considering the requirement of space for E/M equipment of generating units of 300 kW each providing repairing bay, auxiliary equipment, electrical panel board and room for operator. There is an overhead-moving crane with lifting capacity of 8 tons.

Selection of location of the powerhouse area has been carried out considering the safety of building from the river flood and maximum utilization of gross head. The level of powerhouse floor is fixed at 3638.95m where as high flood level (HFL) in the river is 3633.50 m.

The main building of powerhouse is consists of RCC frame. The roof is designed with G.I. sheet over pipe trusses.

3.9.2.8 Tailrace

A tailrace canal of length 37m has been provided to discharge the tail water flow from the powerhouse. The 1.0 m^3/sec discharge from the powerhouse will be carried out by the rectangular canal of size 1.5 m width and 1.0 m height with 1:250 slope.

Gabion protection wall is provided at both sides of canal on the river banks. Similarly stone riprap has also been provided on the riverbed to protect the toe of tailrace from scouring.

3.9.3 Steel Works

The hydraulic steel works of the project consist of steel gates, trashrack and penstock pipes.

In addition to these provisions are made for a few stop logs with hoisting arrangements. The detailed size and quantities are given in bill of quantities. As per requirement and size, the suppliers should be requested to provide their own manufactured drawings which should be acceptable to the employer.

The penstock pipe should be manufactured in 3 m pieces (considered transport constraint) with flanges at both ends. The pipe with pressure bearing rubber washer between the flanges are joined by bolts. The expansion joints for penstock pipes are also included with penstock works.

3.10 OVERHEAD TRANSMISSION AND DISTRIBUTION LINES

The transmission and distribution network system is planned taking consideration the existing 11 kV distribution network in the area of Mustang district. The nearby load centers from powerhouse are supplied by a LT kV feeder from powerhouse sub-station. The total network of transmission and distribution system is shown in Appendix - B.

3.10.1 Sub Station at Powerhouse

An indoor substation of are 10 m x 8 m is provided adjoining the powerhouse. The substation has one number of 800 kVA, 400 v/11 kV 3 phase step up transformer. The low voltage side of the transformer is protected by an ACB and high voltage side of the transformer is protected by VCB circuit breaker. The substation also has 11 kV control panel protecting the 2 nos. of 11 kV transmission lines. One of the 11 kV transmission line supplies the load centre Lomanthan at north and the villages on the route and the second 11 kV transmission line supplies the load centre Chaile and the villages on the route. Whereas Ghami VDC, which is close to the powerhouse, will be supplied by 400 V feeders.

Since the insulation proporties of insulators used in various equipment such as transformer, circuit breaker, isolator, etc. will be degraded at high altitude. The insulators used in all the equipment shall be suitable for the altitude of 3,500 m. Hence the insulation of all the equipment shall be rated for 20 kV even the operating voltage level is 11 kV.

Specifications of recommended transformers

Capacity	:	400 kVA
Voltage ratio	:	400 V/11 kV
Phase	:	3 phase
Frequency	:	50 Hz
Cooling	:	'ONAN'
Connection	:	Dy_n 11

Specification of recommended circuit breaker

Type	:	Vaccum circuit breaker (indoor type)
Phase	:	Three
Frequency	:	50 Hz
Rated voltage	:	11 kV
Rated current	:	400 Amp
Rated interrupting current	:	20 kA

3.10.2 11 kV Overhead Transmission Lines

As the project area is in hilly region with limited access by road transportation, the line support pole should be such that it can be easily transported to the site with minimum effort and cost. 10 m high steel telescopic poles are most suitable for the project area. The length of the line route is measured from the topographic map (in the scale of 1:50,000) and considering the profile lengths of convenient sections. The route of the 11 kV line is shown in Appendix - B. The designs of 11 kV overhead lines are based on the ruling span of 60 m and line voltage regulation of 5%. The size of the ACSR conductor is selected keeping in the view of following factors:

i. Current carrying capacity of conductor
ii. Allowable voltage drops or line regulation
iii. Breaking strength of the conductor

While deciding the allowable tension and sag in 11 kV transmission line, ice load on the line shall be considered. The size of the ACSR conductors selected for 11 kV distribution lines given in Table 3.29

Table 3.29: Details of 11 kV transmission lines

Line route	Length	Conductor code	Normal copper area equivalent
Powerhouse - Charang - Lomangthan	22 km	Rabbit	30 sq. mm
Powerhouse – Chaile	11 km	Rabbit	30 sq. mm

3.10.3 Low Voltage Distribution Lines

The 11 kV distribution lines are tapped off at each load center through the 11 kV / 400 V step-down distribution transformers. The low voltage distribution system starts from the secondary side of these distribution transformers. 8 m high steel telescopic poles are considered at a ruling span of 40 m which provide frequent intervals of poles for take off of the service connections to consumers. ACSR conductors are used for the lines whose sizes are determined by considering voltage drop criteria (5% regulation) as well as current carrying capacity.

The distribution transformers are poles mounted with lightning arrestor and dropout fuse protection on HV side and MCCB protection on low voltage side. The size of the transformers required for various load centers along with their ratings of dropout fuse and size of ACSR conductors for distribution lines are given in Table 3.30.

Table 3.30: Details of low voltage distribution system

Load center	Capacity of transformer	Rating of dropout fuse	Rating of MCCB on L.V. side	L.V. distribution line		Length of L.V. distribution line
				Phase conductor	Neutal conductor	
Ghami	Not required	-	-	Rabbit	Weasel	3 km
Charang	5 x 25 kVA	2.5 A	40 A	Rabbit	Weasel	3 km
Lomanthang	5 x 25 kVA	2.5 A	40 A	Rabbit	Weasel	3 km
Chilim	5 x 25 kVA	2.5 A	40 A	Rabbit	Weasel	3 km
Sanboche	3 x 25 kVA	2.5 A	40 A	Rabbit	Weasel	1 km
Bhena	3 x 25 kVA	2.5 A	40 A	Rabbit	Weasel	1 km
Samar	3 x 25 kVA	2.5 A	40 A	Rabbit	Weasel	1 km
Chyakar	3 x 25 kVA	2.5 A	40 A	Rabbit	Weasel	1 km
Chaile	3 x 25 kVA	2.5 A	40 A	Rabbit	Weasel	1 km

Type	:	Outdoor type
Phase	:	3 phase
Frequency	:	50 Hz
Voltage ratio	:	11 kV/400 V
Rating	:	Continuous
Cooling	:	'ONAN'
Vector group	:	DY_n 11
Tapping range	:	Off load tap changing on H.V. side for a variation of no load voltage of ±2.5% and ±5%.

3.11 DESIGN OF TURBINE AND ANCILLARY EQUIPMENT

3.11.1 General

The main aim of this proposed project is to construct the Ghami Khola SHP for rural electrification of Mustang district. In electrical terms, the project system will ultimately consist of a hydropower plant working in isolation.

In terms of electrical design considerations, the over ruling consideration will be to resort to simple but reliable design configurations employing to the greatest extent the criteria allowable for rural electrification schemes. Such criteria allow less stringent norms in design and therefore provide for cost savings, which in turn will lead to better financial performance.

Another design consideration arises from the weight restrictions for the transport of electro-mechanical equipment to the site. With no means of motorable access, transport of equipment will need to be made by helicopters from the nearest road head or airport. This introduces the restriction that any single piece of equipment cannot normally exceed 3000 – 3500 kg. This also restricts the full application of the principles of economy of scale.

The major electrical and mechanical equipment to be installed within the powerhouse are turbines, synchronous generators, speed governors, inlet valves, LT control panels and battery cubicle with charger. Step-up transformers and high voltage switching equipment are to be located outside the powerhouse in the adjacent switchyard Appendix - B. The technical aspects of the major electrical and mechanical equipment are described in details in the following topics basic data for the selection of hydraulic equipment are as follows:

3.11.2 Type of Water Turbine

The selection of turbine has been done on the basis of the site conditions, the performance characteristics of different type of turbines, ease of handing and the availability of know-how for the repair and maintenance of the turbine.

Table 3.31 shows the performance characteristic of the turbine for mini, micro and small turbines below 5 MW capacity. Similarly Figure 3.5 (a) to Figure 3.5 (d) shows the functional range of different water turbines.

Table 3.31: Performance characteristics of turbines

Turbine type	Head application (m)		Head variation (%)		Load variation (%)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
1. Impulse						
a. Pelton	100	500	90	110	40	115
b. Turgo	40	200	90	110	40	115
c. Cross-flow	1	200	60	125	30	115
2. Reaction						
a. Francies (horizontal)	10	250	65	125	60	115
b. Francies (Vertical)	10	250	65	125	60	115

From both the Table 3.31 and Figure 3.2 (a) to Figure 3.5 (d) it becomes evident that for a site like the one selected for the present project with design net head of 80.0 m, design flow rate of 0.5 m^3/s and unit capacity of 300 kW and estimated light load of approximately 160 kW (53% of unit capacity). Turgo turbine is the most suitable choice. The choice for Turgo turbine becomes evident also from the fact that its overall efficiency as well as part load efficiency is high and it can be easily transported by dismantling the unit into several pieces.

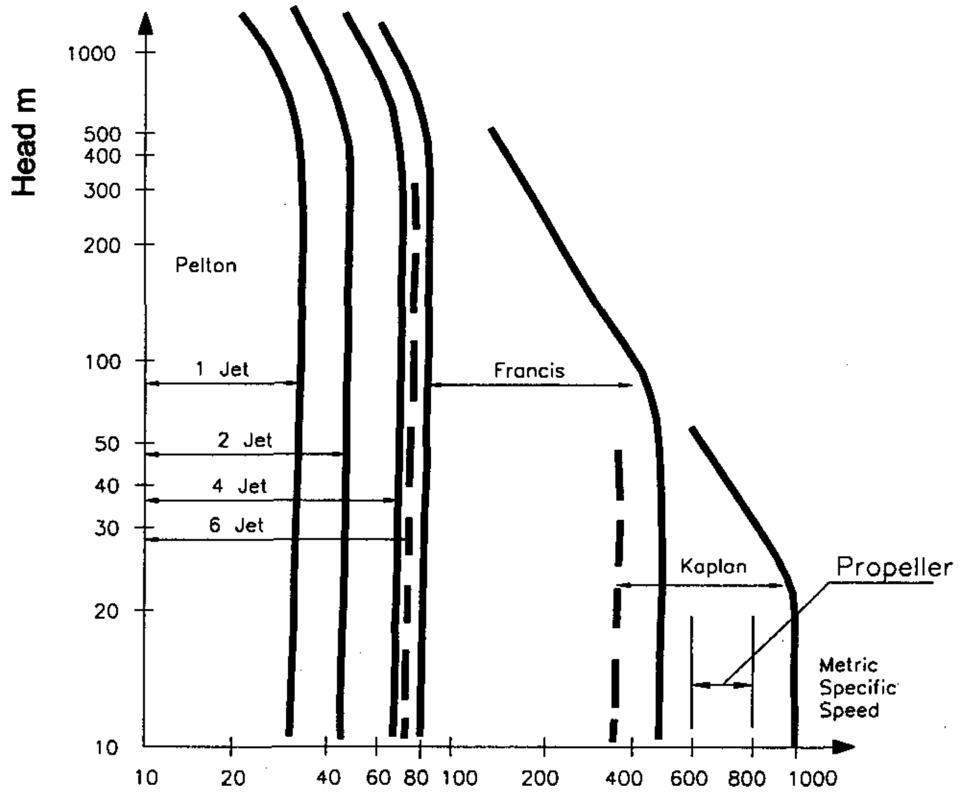


Fig. 3.5(a) Specific Speed/Head Ranges for Various Types of Turbines

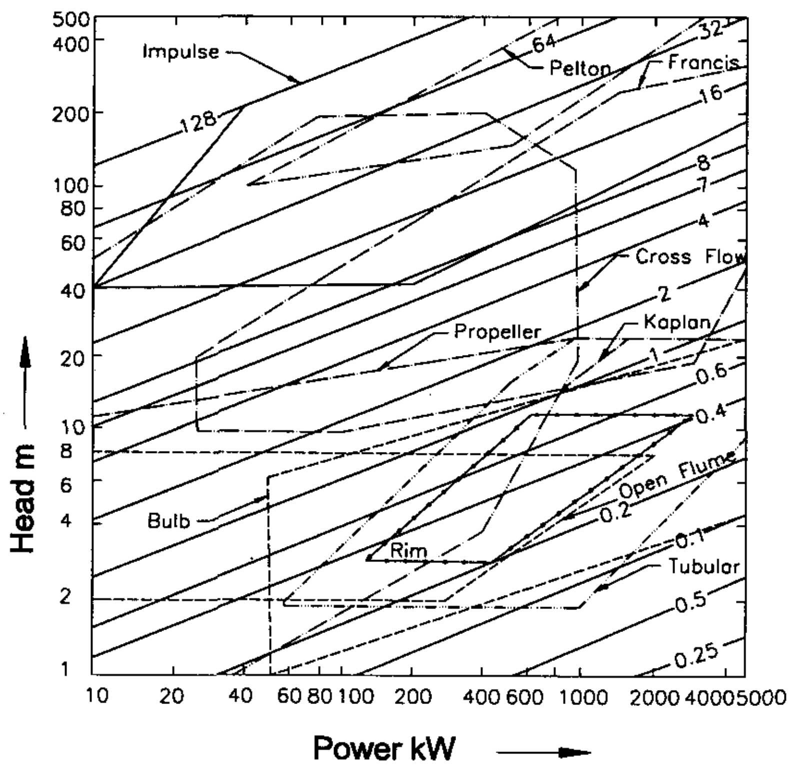


Fig. 3.5(b) Summary Chart of Commercially Available Turbines

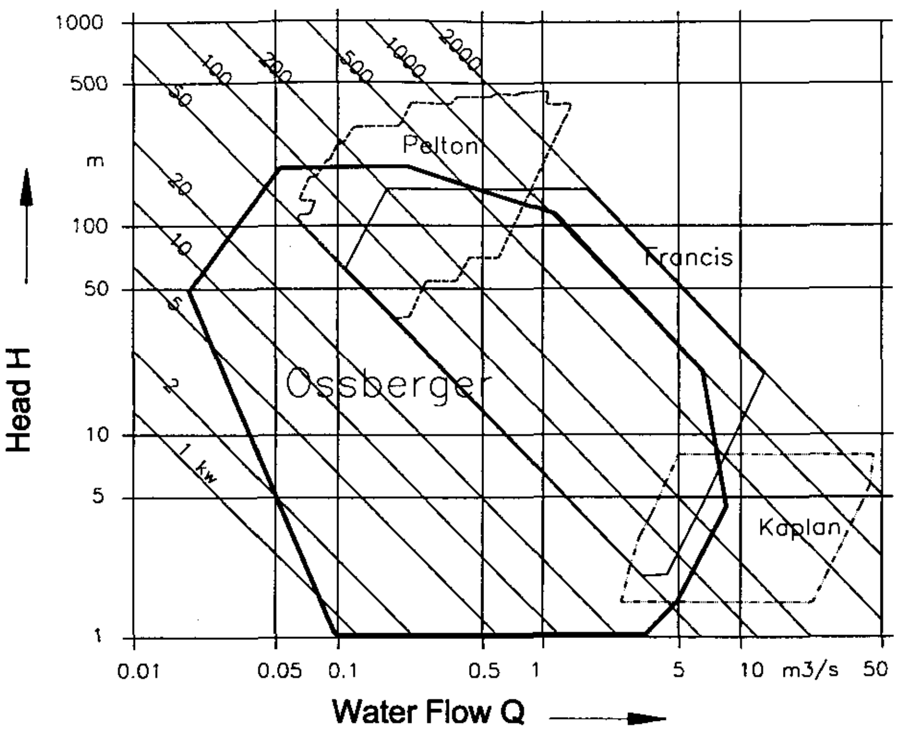


Fig. 3.5(c) A Manufacturer's Graph Showing the Range of use of a Particular Turbine. (Source: Ossberger-Turbinenfabrik GmbH & Co)

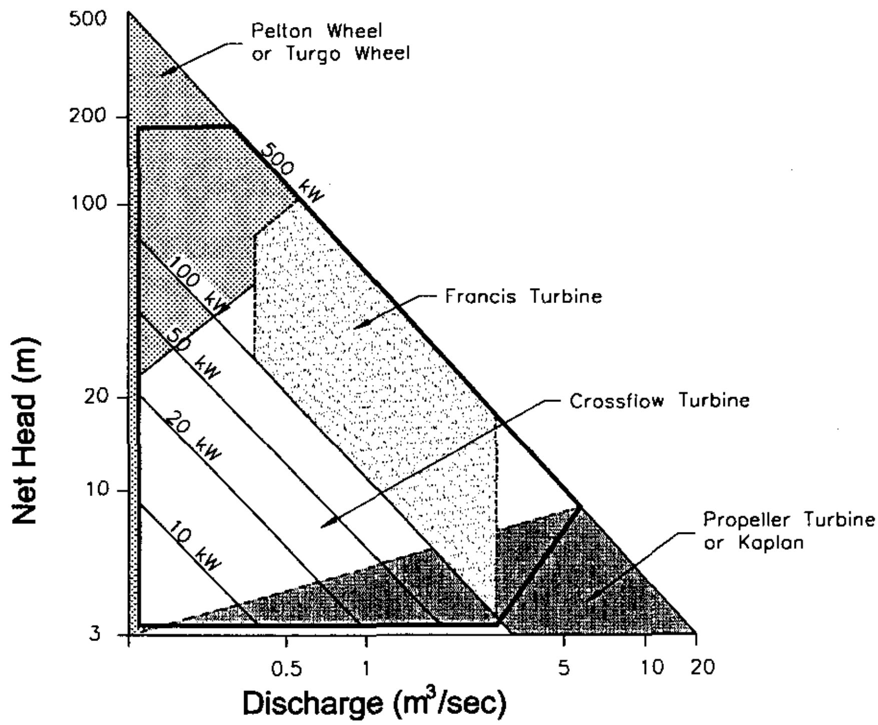


Fig. 3.5(d) Head-Flow Ranges for Different Turbine Types

3.11.3 Features of Water Turbine

The turbine selected for the project, are of the horizontal shaft with flexible coupling for direct drive, single runner with metal casing, Turgo type and has a rated output capacity of 335 kW each with full jet opening and discharge of 0.5 m^3/sec, when operating at the rated speed under the rated net head of 80.0 m with an efficiency of 85%. Altogether 2 such turbine units will be installed along with the same number of generating units with the capacity of 300 kW to bring the total output capacity of the power station to 600 kW. The turbines are to be matched this rating at the net head of 80 m. The weight of turbine has been estimated at 3.5 tonnes. Discharge is controlled by opening and closing of the needles inside the nozzles.

3.11.4 Specific and Rotational Speed of Turbines

The rotational speed (N) of the turbine has been calculated based on the net head of 80 m, the rated power output per unit 335 kW and the estimated specific speed for double jet using standard equations. The figures obtained from the calculations have been used to determine the number of poles of the generator. The specific speed (ns) has finally been determined based on N, P and H by using the standard equation Appendix - B. Thus, the specific speed and rotational speed have been found as 54.23 m - kW metric units and 750 rpm respectively.

The specific speed of the turbines has been determined based on the rotational speed.

3.11.5 Analysis of Transient Phenomena

In assuring safe and reliable operation of power stations, it is necessary to analyse the transient phenomena as part of basic design work and take the required measures.

In this process water hammer analysis is of prime importance:

Water hammer analysis
In the case of sudden load rejection, the operation of the unit must be immediately stopped. For this purpose the guide vanes (a needle in the Turgo turbine) must be closed to stop the water flow to the runner. In this process there will be a sudden rise in pressure inside the penstock pipe due to the destruction of movement of the flowing water.

This causes a wave of high pressure to be transmitted along the pipe, which creates noise known as knocking. This phenomena of sudden rise in pressure in the pipe is known as water hammer. The rise in pressure in some cases may be so large that the pipe may even burst. Therefore, it is essential to take into account this pressure rise in the design of pipes. The magnitude of the pressure rise depends on the speed at which the valve is closed, the velocity of flow, the length of pipe and the elastic properties of the pipe material as well as that of flowing water.

Water hammer has been calculated by Allervis' equation (Appendix B). For a valve closing time of 5 seconds, the pressure due to water hammer has been found as about 50%.

3.11.6 Outline of Ancillary Equipment

i. Turbine casing (housing)
The turbine casing is to be made of high quality steel with appropriate thickness and strength. The metal casing is to be designed as to safely carry the maximum stresses imposed by the manifold resulting from the maximum head and pressure rise due to surge and water hammer effect that may arise and in specific conditions and carry the test pressure without any support. The casing is half split of the horizontal centre lines. The two halves of the casing are bolted together with provision of two dowel pin for proper location.

On the bottom casing, a rectangular hand hole shall be provided near the branch pipe for inspection of nozzles, spear and deflector.

The casing is concealed to the flanged dismantling joint of the nozzle apparatus.

ii. Branch pipe
It is fitted to the bottom casing of the turbine and allows the flow of water in an efficient jet form on the runner.

iii. Bend
It is fitted to the inlet flange of the branch pipe. The inlet flange of the bend is suitable for direct bolting to the butterfly valve. This bend also serves as a dismantling device (piece) for maintenance purpose of the butterfly valve and branch pipe.

iv. Nozzle apparatus
The nozzle needles and its apparatus are to be made of stainless steel. There should not be any water leakage from nozzle apparatus when the nozzle is fully closed. Spear is operated by hydraulic oil pressure as well as by hand wheel for desired opening.

v. Water throwers
Water throwers is provided in the turbine to prevent water leakage along the shaft. This is fitted on the shaft where the shaft entered the turbine casing. This is half spilt along the horizontal centre line for easy dismantling.

vi. Deflector assembly
A deflector is provided to deflect excess water of the jet and allows only required quantity of water to flow over the runner as per load. The deflector assembly consists of the renewable deflector plate fitted to the levers which are fitted to the deflector shaft. The deflector shaft is connected to the governor through the adjustable connecting rod. The maximum deflector closing time is adjustable 1 second.

vii. Turbine guide bearing
The turbine guide bearing is self-oil lubricated complete with an oil reservoir and a water cooling coil. The bearing must be subjected to withstand operation at maximum runaway conditions. And it has to be provided with a thermometer with provision for signal on excessive bearing temperature.

viii. Turbine shaft
The turbine shaft is to be made of carbon steel with the provision of direct coupling to the generator. The turbine shaft will have the size to operate safely with the generator shaft at any speed up to the maximum runaway speed within permissible level of stress.

3.11.6.1 Governor

The governor for turbine control is an electro hydraulic cabinet actuator type. Basic design requirement for the governor is to have sufficient capacity to supply the oil required for the needle servomotors to completely open or close the needle within a minimum time of three seconds for any operating head. A preliminary selection of servomotor capacity for a small and medium size governor can be made by using the following empirical formula:

$$W = (20 \text{ to } 25)\ Q\sqrt{H_{max} \times D_1}\ \text{kgfm}$$

Where

H_{max} (Max. working head)	= 80 m
Q (Discharge under max. head)	= 0.5 m^3/sec
D_1 (Runner diameter)	= 0.77 m

Constant 20 for relatively high head units and 25 for relatively low head units

Therefore the capacity of servomotor, W = 101.12 kgfm

Using manufacturer's manual "Power Generation" by ZMEC of PR of China, a standard size governor with oil hydraulic device (YTT - 150 has been selected with following technical characteristics (this can be replaced by an equivalent type):

Type	:	Volume oil pressure tank
Capacity of servomotor	:	150 kgfm
Temporary speed droop (b_t)	:	0 - 100%
Permanent speed droop (b_p)	:	0 - 8% (adjustable)
Dashpot constant (T_d)	:	3 - 12 secs.
Closing time	:	25.6 secs. (adjustable)
Range of speed variation	:	-10 - +10%
Regulation axle	:	45°
Remote control power	:	DC/AC
Type of centrifugal pendulum	:	Asynchronous motor

The governor actuator is to be enclosed in a neat and attractive cabinet. All gauges and indicating and control devices are to be mounted in a convenient locations on the front panel of the governor cabinet.

The governor is to be designed to be suitable for manual control from the governor cabinet and for remote control of the turbine from the main control board. It should also be suitable for parallel operation with the grid supply and for black start and isolated mode of operation.

3.11.6.2 Inlet valve

On the basis of economic studies considering working head, head loss, energy loss and pressure rise, the inlet valve is to be of butterfly type with an inside diameter of 0.50 m. The inlet valve is operated by pressure oil to be supplied from the pressure oil system of the governor.

The inlet valve is to be designed and constructed so as to operate smoothly and be capable of opening and closing the valve under the maximum head, when passing the maximum flow corresponding to full output of the turbine. The inlet valve is rigidly fastened on the concrete pedestals by sufficient anchor bolts.

The inlet valve is designed to withstand the internal pressures, caused by pressure rise when the unit is shut down by a trip and to endure the bearing pressure on the both bearing hubs caused by the hydraulic moment of high speed water flow when the unit must be shut down by the inlet valve under the full load operation.

The valve rotor is to be made with valve seals on its circumference at both upstream and downstream sides for sealing water when the valve is closed. The valve rotor is to be designed to minimize flow disturbance and head loss.

The sealing at both sides is to be made of solid metal to rubber contact between the valve seals with pressure water in the penstock.

The inlet valve will to be equipped with a servomotor of sufficient capacity to operate the main inlet valve under all hydraulic conditions with the minimum oil pressure from the oil pressure supply system. The inlet valve is to be manually controlled from the governor cabinet.

3.11.6.3 By pass valve

To equalize the upstream and downstream pressure across the butterfly valve, before the butterfly valve is opened, a by pass valve is provided across the butterfly valve. Manual control by pass valve is recommended for these small units.

3.11.6.4 Pressure oil supply system

The pressure oil supply system will be designed to provide for handling, storing and transferring pressure oil for the governor and inlet valve of each unit. The pressure oil supply system will be of air supplemented type supplied from the pressure air supply system, including two oil pumps, a pressure oil tank and a sump tank for each unit.

3.11.6.5 Lubrication system

Lubricating oil system will be provided on the turbine, guide bearing and the generator thrust and guides bearings with self-oil lubricant circulation caused by the centrifugal pumping action of the turbine shaft. The lubrication system will be provided with lubricating oil sump tank with pumping set, for each three units. The lubricating oil system will be designed to use oil having the same specifications as the governor system of the turbine.

3.11.6.6 Cooling water supply system

The design of the generating equipment requires the use of water as a cooling medium for the turbine and generator bearings, and governor oil sump tank.

3.11.6.7 Drainage system

The drainage system will be designed to convey water from the various sources of leakage or discharge to the tailraces.

3.12 DESIGN OF GENERATING AND SWITCHGEAR EQUIPMENT

3.12.1 Preliminary design

The preliminary design of the plant is showing in single line diagram Appendix - B and layout diagram Appendix - B.

The electrical equipment required for the project essentially comprise of the following:

a. Generators
b. Control and protection systems
c. Line control panels
d. Battery and battery charger panel
e. Sub station equipment including transformers, switchgears and lightning protection
f. Power and control cabling and station earthing system
g. Lighting system

3.12.2 Generators

Two generators of 300 kW capacity are to be installed. Each generator is to be coupled with turbine directly. It avoids the need of speed changing device (gear box). The generators are synchronous three phase alternating current, salient pole rotating field, totally enclosed, self ventilated, horizontal type. The capacity of the generators are calculated as follow:

Generator output = Turbine output x η_g

Where, η_g = Generator efficiency (≈ 0.9)

Hence generator output = 335 kW x 0.9 = 301.5 kW each

$$\text{kVA rating of generator} = \frac{301.5kW}{Powerfactor(0.8)} = 376.875\,\text{kVA}$$

The technical specification of the generator are as follows:

i.	Rated output	:	300 kW
ii.	Rated voltage	:	400 V
iii.	Phase	:	Three
iv.	Frequency	:	50 Hz
v.	No. of poles	:	8
vi.	Rate speed	:	750 RPM
vii.	Rated current	:	513 A
viii.	Power factor	:	0.8 (lag)
ix.	Operating duty	:	Continuous
x.	Excitation	:	Brushless AC exciter with rotating diodes
xi.	Prime mover	:	Directly coupled to hydraulic turbine
xii.	Stator winding	:	Y - connected with neutral brought out to the terminal box
xiii.	Runaway speed	:	The generator to be capable of withstanding the runaway speed of the hydraulic turbine without any mechanical injury.
xiv.	Wave form	:	Distortion factor of wave form at no load should not be more than 10%.
xv.	Temperature rise	:	When operating continuously under the rated conditions, both stator and rotor windings shall not be more than 80° C above ambient temperature of 40° C, and that of bearing metal shall not be more than 65° C by thermometer.
xvi.	Dielectric strength of windings:		The windings shall be withstand the following power frequency test voltage for one minute: - Stator winding: 1830 V - Rotor winding: 10 times rated excitation voltage.
xvii.	Mechanical strength of windings:		The windings shall be capable to withstand inrush current flowing during sudden three phase and single phase short circuits at the terminal ends of the generator under full load generating condition without any deformation in the stator windings or any other injury.

Each generator is to be furnished with a brush less exciter in conjunction with an automatic voltage regulator. The excitation system is also provided with a manual voltage regulator to back up the automatic voltage regulator, testing and line charging with a regulating range of 80 - 110% of the generator voltage for a voltage regulation within ±3% at any load form no load to full load.

3.12.3 Power Transformers

The desirable aspects of power transformers for this project are as follows:

- The transformers to be suitable for indoor installation in a cold atmosphere;
- The transformers to be oil immersed and capable for operating continuously at its rated output without exceeding the temperature rise limits as specified in IEC.
- The transformers windings to be designed to withstand short circuit stresses at its terminals as per IEC;
- The transformers to be capable of continuous operation at the rated output under conditions of voltage variation of ±10% of rated and frequency variation of ±5% of rated and capability to deliver its rated output at any tap position;
- The transformers to be free from noise and vibration even during operation and voltage 10% higher than rated voltage;

- Provision for body earthing of the transformer;
- The transformers shall be protected by different protection scheme,

Selection of power transformer at substation

$$\text{Output power of transmission} = \frac{2 \times 300kW \times 0.98(transformerefficiency)}{0.8(powerfactor)}$$

= 735 kVA

The nearest standard capacity is 800 kVA whose net weight is 3 ton. This can be transported to the site by helicopter.

Hence 800 kVA power transformer is selected.

Specification Transformer

Capacity	:	800 kVA
Voltage ratio	:	400 v/11 kV
Connection	:	Δ/Y (with neutral brought out)
Frequency	:	50 Hz
Type	:	Indoor
Cooling	:	ON AN

H.V. side insulation shall be of 20 kV grade.

3.12.4 Control and Protection Equipment

The generator control panels are of the indoor type, low voltage, metal enclosed cubicles fabricated from steel sheet, the steel panels being bolted or seam welded and having all the necessary framework to make the completed structure rigid and slef-supporting.

To facilitate installation at site, all equipment is completed wired to control terminals and power circuit terminals, which are mounted backside of the cubicle.

Adequate indicating meter and fault indicators and audible alarm system are provided to enhance maintenance procedures. The indicators and alarm equipment are suitable for operation from a 48 V DC system.

Protective relays are operated surely with the operation of relays and the manual reset devices shall be able to be reset from the front of the panel.

The synchronizing equipment are designed to provide automatic control for the purpose of connecting the generator to the running line with minimum disturbance to the machinery generator on the system.

The panels receive power generated by two generators through three separate Air Circuit Breakers (ACB). Air circuit breakers used in the panels are three pole, closing by motor stored energy, fixed installation type with ratings as shown in per attached single line diagram. These ACBs are incorporated with thermal over current protection and magnetic short circuit protection. Instantaneous over current and restricted earth fault relays are also provided. Generally, the ACBs are electrically operated with a motor operated spring-loading device. Operating mechanism is provided for local and remote control.

The 11 kV outgoing line control panels shall be erected inside an indoor substation. Protective gear for outgoing feeder cables from the substation are generally vaccume circuit breakers with monitoring and instrumentation equipment. They are incorporated with thermal over current protections current protection and magnetic short circuit protection. Instantaneous over current protection are also provided in this panel.

3.12.5 Ancillary Equipment

A bank of battery and charger is provided inside the powerhouse to supply DC voltage station auxiliary circuits and for emergency lighting purposes. A battery bank of 48 V DC, at least 100 AH capacity at 10 hrs. discharge rate is suitable for the control system of the power plant. These batteries are installed in lower part of the battery charger. The battery bank is of nickel - cadmium type and battery charger with float and trickle automatic charger is recommended.

The powerhouse design covers auxiliary installations such as:

- Power cables for the feeder lines between the low tension panels and low voltage terminal of step-up transformers located outside the powerhouse;
- All low voltage AC and DC power cables from the low voltage switchboards to the various equipment and lighting and all 48 V DC power supply cables;
- Indoor and outdoor lighting fixture, switches, power sockets and distribution boards;
- Emergency lamps automatically switched on by failure of the AC supply and switched off on return of the AC supply;

An effective grid earthing station or a number of earthing stations along with a lightning arrestor provided in the vicinity of the powerhouse for electrical safety and establishment of a reference zero potential point.

3.12.6 Switchgear Equipment

A. Vacuum circuit breaker (VCB)

The vacuum circuit breakers regarded for use in the project are to be suitable for use in a cold climate and to be provided with tropical finish to prevent fungus growth.

The VCBs are to be of the indoor type, three phase, single throw, pneumatically or spring charged motor operated, trip free in any position, complete with operating mechanism and supporting structure. All auxiliary equipment are to be suitable for three phase, four wire, 50 Hz, 400 V. All controls are to be at 48 V DC or 200 V AC.

The contacts are to be designed to have adequate thermal and current carrying capacity for carrying full rated current without exceeding the allowable temperature rise as specified by IEC standards. The surfaces of the moving and stationary arcing contacts are to be faced with suitable are resisting material. The tripping mechanism and the closing control circuit mechanism is to have a nominal voltage rating of 48 V DC or 220 V AC. The tripping circuit is to operate satisfactorily for a tripping operation over a voltage range of 70 - 110%.

B. Isolators

The isolators for upright mounting on steel structure is to be three poles disconnecting ype, gang operated type so that all the poles make and break simultaneously.

All equipment, accessories and wiring are to be provided with tropical finish to prevent fungus growth. All current carrying parts are to be of such materials and treated in such a way to avoid rust, corrosion and deterioration due to atmospheric conditions. Ferrous parts are to be hot dip galvanized.

C. Fuse disconnect switch and power fuse

Fuse disconnecting switch used in the design is to be of the dropout type suitable for outdoor use in a tropical climate. The insulated stick furnished for replacing the fuse is to be 6 m long and combination type suitable for operating hook stick disconnects. The stick is of fibre glass or plastic over a wood or plastic foam cane and have voltage withstand rating of 246 kV/meter.

D. Surge arrestors

Surge arrestors designed for the project are to be of the metal oxide type suitable for nominal system of three phase, 50 Hz, system.

The arrestors need to have undergone all the routine tests in addition to the following:

- Construction test;
- Power frequency sparks over and withstand over voltage test;
- Insulation resistance test and leak current test.

Type test certificates on similar equipment and routine test certificate carried out for following tests shall be furnished.

- Voltage withstand test;
- Impulse voltage characteristic test;
- Discharge voltage characteristic test;
- Discharge current withstand test;
- Duty cycle tests;
- Pressure relief test.

3.13 CONSTRUCTION PLANNING

3.13.1 General

The project is designed as a run-of-the-river scheme without storage facilities at source. No daily pondage is provided as the plant capacity is sufficient to meet the peak evening load. The project has small height bottom rack weir, desander, 807 km long headrace canal and 400 m long penstock. The powerhouse houses 2 units of turbine generator set with ancillary control facilities. The generated power is distributed in three village development committees with 33 km long transmission line (11 kV) and 17 km long distribution lines (380/220 V).

It is anticipated that a period of 10 months will be required for detailed engineering and tendering works and while another 30 months will be required for construction and handing over to the community.

3.13.2 Transportation Method

Construction materials such as cement, steel, GI wire, CGI sheets etc. will be procured at nearest road head (i.e., Benibazar) and transported to Ghami site by mules which takes about a week.

Electromechanical equipment, transformers, electrical items and metal parts will be transported from Pokhara or Benibazar by helicopters. It is possible that transportation to site is also possible via Tibetan territory which requires about 2 days of drive (450 km) from Kodari Sino-Nepalese border.

3.13.3 Power for Construction

For construction purpose, diesel generator of capacity 30 kVA is proposed.

3.13.4 Temporary Diversion Works

Temporary diversion works will be required at intake site to facilitate construction of weir and desanders. It is anticipated that the foundation works will be completed in two working seasons March - September.

3.13.5 Project Implementation

A project implementation schedule proposed for the Ghami Khola SHP is depicted in Figure 3.6. The figure shows timings of permanent construction of civil works, E/M works, T&D works along with temporary work and software activities for institutional development.

For the implementation of the proposed Ghami Khola SHP, the following arrangement is recommended:

Implementing agency	:	JICA Nepal with Nepal Electricity Authority as counterpart agency
Construction services	:	To be undertaken by engineering consultant under the implementing agency
Construction works	:	To be undertaken by contractor under a contract with the above implementing agency and under supervision of engineering consultant
Institutional development	:	To be undertaken by the management consultant under the implementing agency.

Finally, the constructed facilities should be handed over to the institution developed for operation and maintenance of the Ghami Khola Small Hydropower Project.

3.14 COST ESTIMATE

3.14.1 Unit Rates

Rate analyses have been carried out using the latest revised HMG norms to find out the unit rates of various work items. The labour and transportation rates approved by the Mustang district for the fiscal year 2059/60 have been taken for the calculation of unit rates. The rates for the local construction materials such as stone, gravel/aggregate and sand have been calculated using HMG norms as there were no ready made rates approved by the district. However, the rate of wood has been taken from the approved district rates. Similarly, the unit rates of other construction materials such as cement, gabion, reinforcement etc. have been calculated based on the market price of these materials at Beni bazaar, which is accessible by vehicles after adding transportation cost up to construction site.

The unit rates for electro mechanical and transmission items, which can be manufactured in Kathmandu have been calculated using the Kathmandu rates of these items after adding transportation cost by truck up to Pokhara and then by helicopter from Pokhara to construction site. Where as the rates for other electro mechanical items such as generator, turbine etc have been taken from other similar projects.

The approved Mustang district rates and rate analyses for the fiscal year 2059/60 have been depicted in Appendix B.

3.14.2 Civil Works

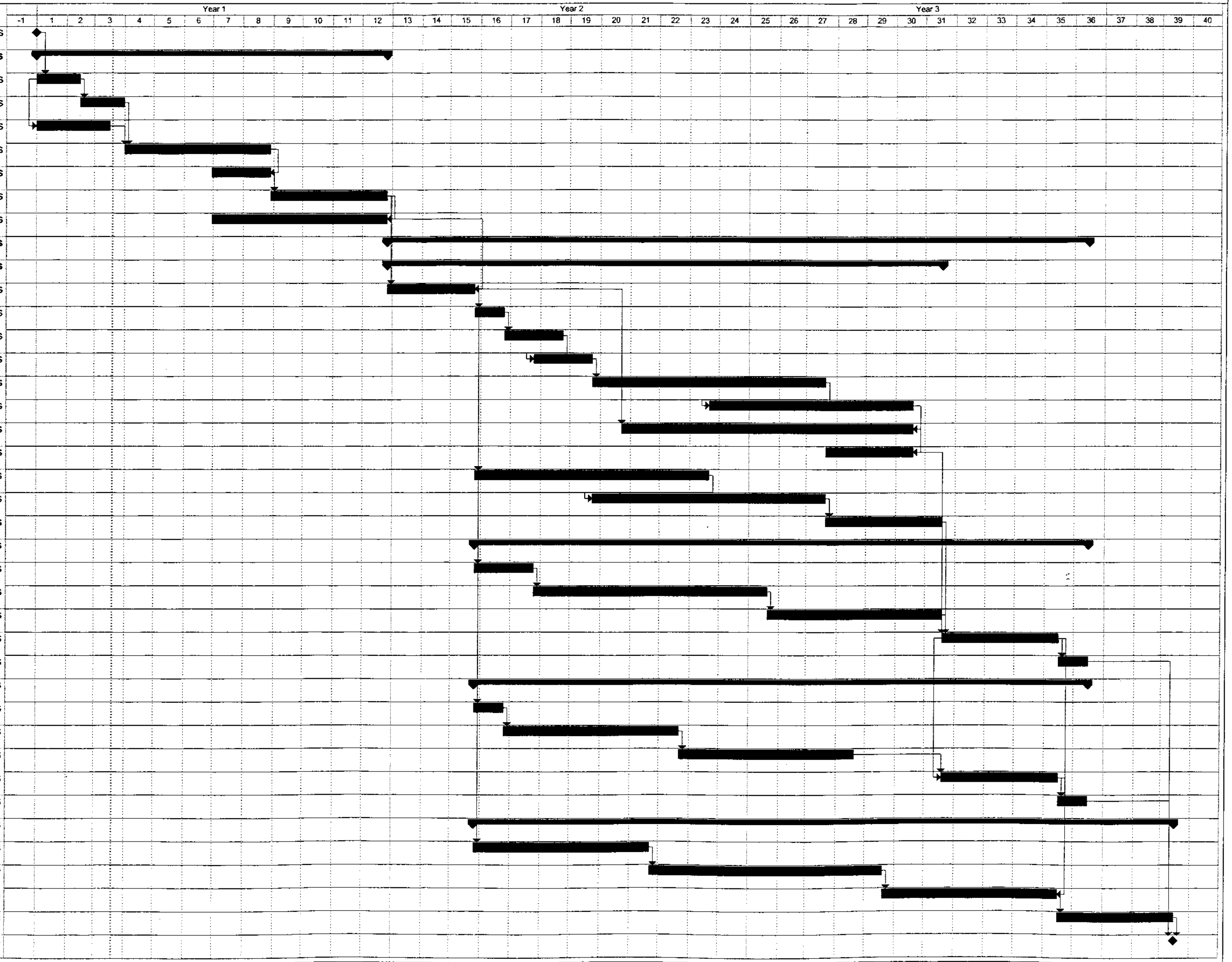
The cost of civil works has been derived using estimated quantity of various civil structures as per the design drawing after multiplying by unit rates. The total costs of different civil structures are given below in a tabular form.

S. No.	Description	Amount (NRs)	Remarks
A	General items	4,950,000.00	
B	Intake structure	17,081,049.08	
C	Disilting basin	8,086,998.72	
D	Power canal	17,398,434.48	
E	Forebay	14,786,033.82	
F	Penstock pipe line	16,014,746.38	
G	Powerhouse and tailrace	9,078,336.58	
	Total (NRs)	**87,395,599.06**	

The above indicated cost includes the contractor's overhead of 15% and VAT @ 10%

Figure 3.6
Project Implementation Schedule

ID	Task Name	Duration
1	Start of Project	0 days
2	**PRE-CONSTRUCITON PHASE**	**360 days**
3	Topographical Survey	45 days
4	Preliminary Route Survey for Transmission Lines	45 days
5	Geotechnical Investigation	75 days
6	Detailed Design	150 days
7	Preparation of Bid Documents	60 days
8	Tendering Process	120 days
9	Land Acquisition	180 days
10	**CONSTRUCTION PHASE**	**720 days**
11	**Civil Works**	**570 days**
12	Mobilization	90 days
13	Preparation of Working Drawings	30 days
14	Access Tracks	60 days
15	Diversion Works	60 days
16	Weir / Intake	240 days
17	Desander and Gravel Trap	210 days
18	Power Canal / Tunnel	300 days
19	Cross Drainage Work	90 days
20	Forebay and Spillway	240 days
21	Powerhouse and Tailrace	240 days
22	Penstock Erection	120 days
23	**Electromechanical Works**	**630 days**
24	Detailed Design of E/M Equipments	60 days
25	Manufacturing	240 days
26	Transportation	180 days
27	Erection	120 days
28	Commissioning	30 days
29	**Transmission Line Works**	**630 days**
30	Check of Route Survey	30 days
31	Procurement	180 days
32	Transporting	180 days
33	Installation	120 days
34	Commissioning	30 days
35	**INSTITUTIONAL WORKS**	**720 days**
36	Training of Operators	180 days
37	On-the-job Training of Operators	240 days
38	Formation of Institution	180 days
39	Handing Over	120 days
40	End of Project	0 days



Project: Implementation Schedule
Date: Wed 3/19/03

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

3.14.3 Electromechanical Equipment

The cost of electro – mechanical equipment has been calculated as per prevailing rates in similar other project as mentioned earlier. The cost breakdown of the electro-mechanical equipment has been shown below.

S. No.	Description	Amount (NRs)	Remarks
H	Electro – mechanical equipment	48,268,350.00	
	Total	**48,268,350.00**	

The conversion rate of 1 US $ is taken as 78 Nepalese rupees.

3.14.4 Transmission and Distribution Lines

The transmission line of only 11 kV is proposed for the electrification of 4 VDCs in the project area. Hence there is no provision of 33 kV transmission line. A total of 33 km of transmission line and 17 km of distribution line have been estimated for electrification of 3 VDCs. The total costs of transmission and distribution lines are given below.

S. No.	Description	Amount (NRs)	Remarks
I	Transmission and distribution line	24,000,000.00	
	Total	**24,000,000.00**	

3.14.5 Overall Project Cost

The present study being of feasibility level study, cost of some of the construction items are taken in lump sum basis as collection of quotations within a short period has been not possible from the past experience. The total project costs of all components including general items are shown below.

S. No.	Description	Amount (NRs)	Remarks
1	Civil works	87,395,599.05	
2	Electro – mechanical works	48,268,350.00	
3	Transmission and distribution works	24,000,000.00	
	Total	159,663,949.05	
	Contingencies @10%	15,966,394.91	
	Total project cost per kW (NRs)	**175,630,343.96**	**US$ 2,251,671.08**

3.15 ECONOMIC AND FINANCIAL ANALYSIS

3.15.1 General

One of the principal aims of the economics is to maximization of social welfare. Economic analysis of a small hydropower project will represent the cost and benefit to the society in terms of opportunity cost. All cost streams and benefit streams are changed to represent economic values. The basic assumptions of conversion factors such as foreign currency, standard conversion factor, opportunity cost of capital and traded on non-traded components at border price etc is considered as normal standard. Adjusting the estimated cost of all components to reflect the economic value performs the economic analysis considering the basic guideline for economic analysis and projects. The economic evaluation is performed to seek the feasibility of the project in national perspective.

The financial analysis is the basic of economic analyses. The financial analysis is conducted on the basis of the consideration of market values. The financial analysis is performed to seek the feasibility of the project in terms of individual investor's perspective. For a project to be economically viable, it must be financially sustainable, as well as economically efficient. If a project is not financially sustainable, economic benefits will not be realized. Financial analysis and economic analysis are therefore complementary.

3.15.2 Evaluation of the Project

The economic / financial analysis of the project is evaluated as per the results of the following terminology.

- Calculation of internal rate of returns EIRR
- Calculation of internal rate of returns FIRR
- Break even tariff (BET)
- Calculation of NPV of the capital costs, revenues and net benefit streams
- Benefit cost ratio
- Payback period

For the economic analysis, the costs and benefit streams are considered as follows: capital costs, O & M cost in cost streams and revenue from electricity supply and capacity benefit in benefit streams.

3.15.3 Assumptions

The financial analysis estimates the rate of return in terms of values where as economic analysis measures the effect of project on the social benefit in national perspective. The financial analysis is based on the prevailing market price and inflation rate. However, numerous assumptions are considered in economic analysis so as to bring better allocation of resource to reflect the real economic value. For present analysis the following general assumptions have been adopted.

- All costs and revenues are expressed in 2002 price
- The design period of the project is for 20 years.
- The costs and benefit streams considered as constant after design period
- Financial / economic analysis is evaluated on cash flow stream for 30 years.
- The social opportunity cost of capital is considered at 10%
- The financial opportunity cost of capital is considered at 10% to calculate BET

The following assumptions have been made with regards to costs

- All costs, in particular imported tradable inputs are included net duties and taxes. This includes VAT which is payable at 10% on all purchases. The VAT is not included in electricity bill.
- Capital costs include physical contingencies but exclude price contingencies.
- Official exchange rate of NRs 78.0 per US$ has been employed when converting foreign costs to local currency equivalent.
- The shadow exchange rate or standard conversion factor (SCF) of 0.90 has been applied to non-tradable inputs to convert them into economic cost.
- The shadow exchange rate or standard conversion factor (SCF) of 0.70 has been applied to local material and local labour.
- The shadow exchange rate or standard conversion factor (SCF) of 0.90 has been applied to skilled labour.

3.15.4 Estimation of Economic Costs

The investment cost (capital cost) and annual cost (operation and maintenance cost) are divided into two components foreign cost and local cost to derive at the economic cost. The foreign component includes transfer of payment of 1% hence the conversion factor to change from financial cost to economic cost is 99%. Similarly financial costs of local components are generally included local labor, material are adjusted to reflect the economic value by a standard conversion factor of 70%. The skilled manpower and locally produced items are adjusted to reflect economic value by a conversion factor of 90%.

The tariff structure is applied based on the present NEA tariff rate so as to make lifeline consumer household beneficial. The tariffs are varied with level of income and different categories. The analysis project has been prepared for cash flow streams projection for 30 years excluding construction period of 3 years. The economic benefits are classified into direct - the revenue generated from the electricity tariff and indirect – as capacity benefit normally considered by NEA (US$ 104/kW/annum) for the analysis as in the present case of isolated project.

The internal rate of return (IRR) is the major tool to measure the viability of the project. IRR is the rate of benefit incurred during the project period. FIRR is benefit incurred on a project where all costs and benefit schemes are measured in financial price. The FIRR represents the financial benefit during the project period. Economic internal rate of return (EIRR) is determined on the basis of all costs and benefits streams in economic price. For a project to be acceptable the EIRR should be greater than the economic opportunity cost of capital.

3.15.5 Interpretation of the Results

The economic analysis results are found as expected since the value of surplus energy is not considered. The analysis results depicts positive 1.3% economic internal rate of return (EIRR). The project may be considered as feasible considering the small hydropower projects as service oriented with positive EIRR but however it is principle and practice that the rate of return should be greater 10% that is social opportunity cost of capital. The internal rate of return is less than 10% in the result

3.15.6 Financial Analysis

3.15.6.1 Benefit cost ratio

In the financial analysis benefit cost ratio is one of the indicator for project feasibility. At least the ratio must be greater than one in the financial analysis under the investors perspective. The result of the analysis shows that the ratio is 0.53, quite lower than one hence the project may not be considered as financially feasible.

3.15.6.2 Payback period

The payback period is the indicator of the project worth to be returned within the number of years of the after the completion and operation of the project. Usually this term is also used in analyzing the project in financial perspective. The present analysis shows the pay back period is 30 years.

3.15.6.3 Breakeven tariff

The breakeven tariff is another indicator of economic analysis so that what tariff rate should be levied to get return of investment money at net present value. The present result shows that the tariff rate is (NRs. 22.4 / kWh or US $ 0.28 / kWh) which is much higher than NEA tariff.

The results from analysis are given in Table 3.32.

3.16 SUSTAINABLE INSTITUTIONAL PLAN

3.16.1 Sustainability of the Project

The concept of sustainability is based on the premise that the community are made up of social, economic and environment system that must be kept in balance. Sustainability is an ideal term depending upon community actions, plans, expenditure and decision. There are mainly five principles of sustainability for the community to ensure social, economic and environmental system, such as enhancement of quality of life, economic development, social equity, improvement in environment and participatory approach.

Table 3.32: Economic Analysis

Year	CC	O&M	Total	Energy	Capacity	Benefit	Capacity	Total	Net Cash	Accum.
	000 US$	000 US$	Cost	MWh	Generation	000 US$	Benefit	Benefit	Flow	Cash Flow
2002	472	0	472	0		0		0	-472	-472
2003	629	0	629	0		0		0	-629	-1101
2004	472	0	472	0		0		0	-472	-1573
2005		68	68	479	4479	40	65	104	36	-1537
2006		68	68	522	4479	43	65	108	39	-1497
2007		68	68	567	4479	47	65	112	43	-1454
2008		68	68	616	4479	51	65	116	47	-1407
2009		68	68	667	4479	55	65	120	51	-1355
2010		68	68	722	4479	60	65	124	56	-1299
2011		68	68	781	4479	64	65	129	61	-1239
2012		68	68	844	4479	70	65	134	66	-1173
2013		68	68	899	4479	74	65	139	71	-1102
2014		68	68	957	4479	79	65	144	75	-1027
2015		68	68	1019	4479	84	65	149	81	-946
2016		68	68	1084	4479	90	65	154	86	-860
2017		68	68	1150	4479	95	65	160	92	-769
2018		68	68	1221	4479	101	65	166	98	-671
2019		68	68	1296	4479	107	65	172	104	-567
2020		68	68	1373	4479	114	65	179	110	-457
2021		68	68	1456	4479	121	65	186	117	-340
2022		68	68	1542	4479	128	65	193	125	-215
2023		68	68	1542	4479	128	65	193	125	-90
2024		282	282	1542	4479	128	65	193	-89	-180
2025		282	282	1542	4479	128	65	193	-89	-269
2026		68	68	1542	4479	128	65	193	125	-145
2027		68	68	1542	4479	128	65	193	125	-20
2028		68	68	1542	4479	128	65	193	125	105
2029		68	68	1542	4479	128	65	193	125	229
2030		68	68	1542	4479	128	65	193	125	354
2031		68	68	1542	4479	128	65	193	125	478
2032		68	68	1542	4479	128	65	193	125	603
2033		68	68	1542	4479	128	65	193	125	728
2034		68	68	1542	4479	128	65	193	125	852
NPV	$1,433.45	$583.46	$2,016.91	$7,026.16	$42,223.15	$582	$611	$1,087		

Generation Cost	0.05	US$/kWh	**IRR**	2.4%	
	3.73	NRs./kWh	**B/C R**	0.54	
Rev/OM Cost Ratio	1.00		**BET**	0.287	US$
				22.39	NRs.

Financial / Economic Cost

	US $ (000)	NRs. (000)
Capital Cost	2252	175630
O&M Cost	90	7025
R&R Cost	653	50933
Ssub Total	743	

Exchange Rate	1	78
Foreign	871	175630
Local Material &Skille	790	7025
Labour Unskill	383	50933
Local Material	209	
Sub-total	592	
Total	2252	

Financial Costs		
1st Year	676	30%
2nd Year	901	40%
3rd Year	676	30%
Total	2252	
Economic Costs		
1st Year	472	
2nd Year	629	
3rd Year	472	
Total	1573	

Conversion Factors

R&R Cost			
565	99%	862	Foreign
	90%	711	Local
	70%	414	Local L & M
		68	O&M
	Total	1573	

Sustainability of the projects is the most important factor for small hydropower project in rural hill area. The economic and financial considerations must be worked out considering operation and maintenance cost for long-term sustainability. The project may be considered as sustainable when the project can meet the cost of operations, maintenance and rehabilitation costs. That is, at least the revenue generation per year from the project should cover the operation, maintenance and rehabilitation costs. Sustainability of the project also depends on the numerous other factors such as management of the project, availability of spare parts for maintenance, distance from project site to major market etc.

Sustainable development of environment resources-based energies is a key requirement of the hill areas of the country. One of the basic requirements for sustainability is to make available of the information of different aspects of energy and income status level, affordability and willingness to pay. The project will also be sustainable through income generating activities such as agro-processing, flour and rice mill and other possible operations in the project area with an approach of community development. For sustainable rural energy system small hydropower can be developed in order to develop (a) improved quality of life especially for women and children (b) promotion of efficient end use technologies and promotion of non farm activities. (c) conservation and restoration of natural environment.

3.16.2 Local Participation

It is widely accepted that a project in the remote rural area can be sustainable if the it is managed properly and the revenue generated out of the project is utilized properly. To do that one of the main factors is the sense of the ownership of the project with the local end users. The people should feel that the project belongs to them and they should also, some how, participate in running the project. The best way to do that is to make the local community participate in overall running of the project.

3.16.3 Revenue and Logical Tariff

Long term sustainability of the project depends upon the revenue generation whether it is sufficient to meet the operation and maintenance cost. At the same time, the tariff rate must also be within the affordability and the consumers must be willing to pay the fixed tariff. For the present situations tariff structure is considered as NEA tariff rate (Annex, Table 13). The electricity demand per household is estimated as different income groups within the range of willingness to pay and affordability. There is a possible option of subsidizing tariff rate because large portion of surplus of electricity supply will not be consumed within the project area.

3.16.4 Poverty Alleviation

One of the main objective of 10th plan of Nepal and hence the objective of this project, is poverty alleviation. Experience of the past in water supply, shallow tubewell and irrigation projects have shown that the real benefits of the project have gone to the higher echelons of the society and not to the real poor which is the real target group of the scheme. Hence care should be taken to make the electricity available to the poorest section of the population by making it real cheap albeit by making the tariff for the higher section making a little higher to subsidize for the poor.

3.16.5 Possible Institutional Models

There are numerous optional institutional modalities for operation and management of the project like this. They are private, ownership, private management, NEA management, cooperative, trust, community users group, lease management, joint ownership company etc. For each modality there are advantages and disadvantages and limitations.

Private ownership modality is based purely on profit. The tariff may be raised according the their wish after the plant is sold to private owners. The major disadvantage of this model is that there is no control on the tariff by NEA or Government and there would be no participation of the community in running of the project.

Another option is NEA management, which is one of the viable options for this project since NEA is the most experienced body in the rural electrification project. But experience shows that it has been difficult for NEA to manage small hydropower projects in remote areas and NEA is planning to sell off other small projects to private parties. Hence this option is out in the present context.

Cooperative management was widely used in agricultural sector throughout the country during sixties. But the cooperative is not a viable option in the present situation due to the staff management problem within the framework of the cooperative act.

Trust management is another options but have the drawback that the scheme will not be owned by any individual or a group either elected or selected. The executive bodies of the Trust have full control over the project hence the political or other pressure may deviate the objective of the project.

Community user's group management is being tried in ADB funded Small Town Water Supply Project. However, the outcome of such management is yet to be seen. The revenue generation and the sustainability of the Small Town Water Supply, and Ghami Khola Small Hydropower Project is similar. So, it is expected that community users group management may be one of the viable options for this project but detailed study has yet to be done.

Lease management is also a viable option for the management of small hydropower project like this. Out of 42 existing small hydropower projects owned by NEA, 11 projects have been in operation through lease basis. But the experience of NEA is not very encouraging for such option. The leased projects have to be maintained by NEA itself as many legal and other complication arise for the leasee to take care of all the maintenance / restoration activities and the burden to NEA remains the same as if it were run by NEA itself. Moreover, there is no community participation in such option and the basic objective of poverty alleviation is also not fulfilled as the leasee is likely to run the project in purely commercial basis.

Joint ownership company management is another alternative option. In this option the project is run by a company jointly owned by the local representatives, consumers, NEA and other stakeholders. The Board of Directors of such company is composed of the concerned stakeholders. The Board appoints a Managing Director who is the Chief Executive Officer of the company. Salleri Chilasa small hydropower project is successfully run on such model and is being proposed for the present project as well.

3.16.6 Proposed Institutional Setup

From the above options only two management setups are found most viable viz, management by community user's group or by a joint company. The outcome of the community user's group is yet to be seen in Small Town Water Supply Project whereas management by joint ownership company has already been proven successful in the case of Salleri – Chialsa Electricity Company (SCECO) which manages Salleri Hydropower Project in the district of Solukhumbu.

In the proposed arrangement the total shares of the project will be divided into three major parts out of which two major parts will be owned by NEA and local bodies like DDC, VDCs etc. the remaining third part will be available to potential users in the community. The management, operation and official arrangement is conducted ensuring users participation at Board of Director's level to seek maximum benefit to the beneficiaries. The shareholder users may setup one association in each VDC so as to ensure effective management at the village level.

The proposed joint company is considered to fulfill the following objectives in the operation and management system:

- Socio-economic development
- Locally responsive and self sustaining
- Use locally available manpower
- Training the locally available staffs and operators
- Staff salaries at village level
- Electricity supply to all households
- Efficient management.

3.16.6.1 Formation of the company

The company will seek to be financially self supporting and profit making, out of which common share holder receive 50% of the profit back as rebate in electricity tariffs. The remaining 50 percent of the profit will be spent for the social benefit of the local people. The share holders may include rice mills, schools, etc.

3.16.6.2 Users' association

Four users associations are conceived to be formed in each VDC; each of which will select a management committee consisting of five members, one member will be the member of Board of Directors. The users association will be actively involved in decision making process of the Company.

The association will meet semi-annually to permit all shareholders to elect their representative to management committee and main Board of Directors. The Board meeting will be scheduled semi-annually. However initially the meeting will be conducted frequently enough until the institution is set up permanently.

3.16.6.3 Share-holding

There will be two categories of shares, preferred and common. NEA will hold the preferred shares which will control the asset of the system. The operating shares will given to the Users.

The actual number of shares and the values will fixed later depending upon the local situation. The private household consumer may purchase according as their energy requirement as per their income status. The higher the energy consumption the higher will be the number of shares. As an example low income household may require to purchase 5 units of shares for consuming electricity up to 100 KWh per month, medium households 8 shares (250 KWh) and high income households 10 shares (300 KWh) and so on.

3.16.6.4 Board of directors

The board will have the normal powers of any limited company in Nepal and will ultimately be responsible for all functions of the Ghami Khola small hydropower project. All the meetings and decisions will be transparent to the common shareholders.

Directors will receive no salary except for the manager/managing director. However, funds will be provided for travel, food and lodging and meeting allowance.
The detailed set up of such company will be worked out at much later state. This is however, a conception replicated from a successful model.

3.16.6.5 Monitoring, evaluation and backstopping

As indicated earlier, the proposed model of running small hydropower plant has been tried in Salleri – Chialsa Hydropower Project and has proven to be highly successful model. Until recently when the power plant was damaged by insurgents, SCECO was running very smoothly making some profit and was an example of efficiently run small hydropower project in Nepal.

But in the beginning there may be difficulties in making the company run, especially because of the involvement of local organizations and representatives of consumers who have no experience of getting such involvement and who are also supposed to take active part in day-to-day running of the company. Therefore, it is envisaged that the company will need a lot of institutional and managerial backup and training from some external agencies. In the case of SCECO also there were difficulties in the beginning and ITECO was entrusted with the job of constantly monitoring the management of the company and solving the problems as they arise for several years. In the same manner, it is suggested that some external organization should be appointed as a facilitator for forming the company and training the staff initially. After the company is formed and the power plant starts operation this organization should also be required to constantly monitor, evaluate and facilitate smooth operation as envisaged. This should continue until it is felt that the company can function on its own without any facilitation from outside. It is estimated that such time period should be about 5 years. ITECO Nepal could very well, be such organization with their experience with SCECO. Funds should be set aside initially for the purpose.

3.17 CONCLUSIONS AND RECOMMENDATIONS

3.17.1 Conclusions

Under the study for formulation of a basic plan for the rural electrification through small hydropower development in rural hilly areas of Nepal, 21 remote hilly districts were selected to identify potential load centers and power demand forecast. 82 potential small hydropower projects were selected for review out of which 32 projects were found among the least cost alternatives to electrify priority load centers. The study team conducted detailed desk study of the 32 projects within a period of less than two and half months. Considering technical, economical, social and environmental parameters in the screening and ranking process, top ranking ten projects were selected for further investigations. Ghami Small Hydropower Project is one out of ten projects recommended for field investigation and further studies. The project is selected with a view to provide electricity in upper Mustang area where national power grid extension is not possible within the next decade.

The project area is located in most remote part of Nepal where transportation of equipment and materials to the site is the major constraints. The transport method to the project is limited to helicopters and porters. Therefore heavy equipment and materials such as electro-mechanical equipment, power transformers, poles and conductors, steel penstock, steel gates and trash racks are selected with available capacity of helicopters.

The general layout of all civil components in the present study has been carried out to suit more appropriately to the existing site conditions after studying and reviewing the general conceptual layout of civil structures at previous study conducted by the SRCL/NEA.

The design of project components is carried out to ensure safe and reliable operation, minimum maintenance cost and most economical application of local labor and material.

Field investigation of the project site was conducted by a technical team consisting of a hydropower engineer familiar with hydroelectric project design and investigation, a geologist competent in rock type, surface material and landform identification, a survey crew with survey engineer, a socio-economist well experienced to conduct socio-economical investigation and obtaining necessary field data and an environmentalist well experienced in carrying out IEE and EIA.

The engineering survey of the site has been conducted using GPS to fix the geographical easting and northing coordinates and elevations at the intake, Forbay and powerhouse locations and survey equipment such as theodolite and level machine have been used to draw the longitudinal profile and cross sections.

Local district labor and material rates have been used in estimating the cost of the project. Similarly, the power demand of the project area is determined on basis of field data and information collected during field visit.

The results of economic analysis of the Ghami Small Hydropower Project are not very encouraging. The poor economic resource bases of this district make development projects less attractive in economic terms. However, small hydropower schemes should be considered as essential infrastructure from social perspective for the development of the remote areas such as upper Mustang. It has several intangible benefits, such as improvement in health of the people, education for children, provision of opportunity for jobs and changes in life style.

A number of agencies like DANIDA, UNDP, SNV and INGOs are involved in promotion and development of micro hydropower in hilly areas of Nepal. Around 50% subsidy on micro hydropower is provided by Alternative Energy Promotion Center (AEPC) under 90% financial support from DANIDA and 10% from HMG/N to enhance micro hydropower in rural areas.

In this ground small hydropower should also be considered as essential part for rural area development and should be provided sufficient subsidy and grants to promote the projects in potential areas.

In Ghami and upper Mustang areas some INGO and NGOs like ACAP, Mustang Development Service Association and Save the Children Fund are engaged in various development activities. Solar electric panels are distributed to local users in subsidized rates for lighting. The use of solar electricity is limited for lighting only whereas the proposed hydropower project can be utilized for diverse application. The small hydropower may enhance agro-processing industries, tourism industries and other rural industries in the project areas besides room heating in winter and cooking purposes. Hence intangible benefits are also to be considered while implementing this project.

3.17.2 Recommendations

Implementation of small hydropower projects in remote areas is a difficult and challenging problem in Nepal. Adequate studies of sites are essential with geological and hydrological investigations before finalizing the projects. Especially reliable hydrological data is very essential for hydropower development, as no hydrological data of the Ghami river or similar nature of river in project area are available. Therefore a stream water level gauging station should be immediately established at suitable location in Ghami river and the gauging height readings should be correlated with stream flow measurements from current meter.

Transportation of electro-mechanical equipment is also considered difficult problem for small hydropower implementation. Therefore, large number of smaller units has been preferred so that weight of individual parts could be reduced to lifting load of available helicopters.

Though economic indicators of this project are not so encouraging because of poor local conditions and less opportunities for load increment they can be improved and the viability of project enhanced if some productive end use program of electricity, like agro-processing industries, repairing and workshop centers and other employment generating industries are introduced under this small hydropower implementation package. The community must be provided training on small entrepreneurship skills based on use of electricity.

The economic viability of the project can also be improved by reducing the plant capacity just to meet the power demand. In the present study, the plant capacity is based on 90% exceedance probability of flow.

Due to remoteness of the site transportation cost of construction materials and equipment are very high. Transport of equipment and steel parts are considered by using helicopters whereas construction materials are supposed to be transported by porters from Beni bazaar, eight days walking distance. The cost could be tremendously reduced if the transport is arranged from Chinese border Tibet side of Lomangthan one day away from the project site. As observed presently the foodstuffs and essential consumer goods are transported from Tibet side using trucks.