Himalayan Small Hydropower Summit
(October 12-13, 2006), Dehradun

ELECTRICAL LOAD SURVEY & LOAD FORECAST FOR A STAND ALONE SMALL HYDROPOWER STATION

S.N. Singh
Senior Scientific Officer, AHEC
Indian Institute of Technology Roorkee
Roorkee

INTRODUCTION

Energy plays a significant role in the economic and technological advancement of modern society and plays crucial role in human life standard. In hilly regions energy situation in terms of availability and demand is very different from that in the urban areas. Large parts of hilly and remotely located regions remain un-electrified. Laying of transmission lines across such regions poses a great problem because of long distances of be covered and the existence of hills, mountains, ridges, valleys etc. The maintenance of these lines is a tough job in view of frequent occurrence of storms, snow falls, land slides, ice formations etc. for such hilly isolated regions. Diesel-generating sets are not preferable because of high transportation cost of fuel for such mountain areas. There is no choice but to turn to decentralized renewable sources of energy. Amongst the renewable sources, small hydropower (SHP) occupied an important place. Hydropower potential may be calculated on the basis of available head and discharge for SHP development. but for deciding the installed capacity of small hydropower project the electrical load survey and forecast plays an important role.

HYDROPOWER POTENTIAL

Power potential can be calculated with the help of head and discharge available at a particular small hydropower (SHP) project site to be developed. The power is calculated as:

$$P = 9.81 \eta Q H \quad (1)$$

Where,

Q = design discharge in m^3/s
H = design head in m
η = overall efficiency of power conversion system

The installed capacity of the small hydropower project can be decided on the basis of power obtained as in equation (1). Accordingly civil works (like intake, power channel etc.) and electro-mechanical work (like turbine, generator etc.) would be carried out. If the generated power would be fully consumed by consumers living with in 4-10 km radial distance from the proposed SHP station then the small hydropower project is economically viable and if not then it is not viable. Therefore generated power evacuation of SHP project is necessary, therefore starting the civil work as well as E & M works, electrical load survey and load forecast is necessary before deciding the installed capacity of hydropower project.

LOAD FACTOR

For the load forecast knowledge of load factor is necessary. The load factor may be daily or monthly or annually. The annual load factor may be defined as given below.

$$\text{Annual load factor} = \frac{\textit{No. of units actually supplied in a year}}{\textit{Maximum no. of units that can be supplied in a year}}$$

$$= \frac{\text{No. of units actually supplied in a year}}{\text{Maximum power demand x 365 x 24}}$$

$$= \frac{\textit{No. of units actually supplied in a year}}{\textit{Maximum power demand x } 8760}$$

Here, maximum power demand means the value of the connected peak load and not the maximum kW installed capacity of the small hydropower station. The installed capacity of the SHP station should be such that it will be the peak load demand.

ELECTRICAL LOAD SURVEY

For the power evacuation knowledge of power requirement of near by populations are necessary. This can be achieved by taking the interview of gram pradhans, school teachers etc. The following factors may be considered during the electrical load survey of nearby villages up to 4 to 10 km distance from the location of proposed SHP station.

(i) Number of villages.
(ii) No. of houses.
(iii) Population.
(iv) No. of projected connections.
(v) Average energy consumptions.
(vi) Demand for street lighting.
(vii) No. of commercial establishment and energy demand for each establishment.
(viii) No. of schools, health centers and other community services and their energy demand.
(ix) No. of small industries with energy requirement for each.
(x) Miscellaneous demand.
(xi) Current and projected demand for electrical energy of various types of consumption.

DATA FOR VARIOUS TYPE OF CONSUMERS

Let during the load survey, with in 4 to 10 km radius we found there are eight villages & 400 houses with following data for load forecast of different type of consumers. These data are collected for a period of ten years after taking interview of local populations, gram pradhans (village heads), shop-keepers, school teachers etc.

Domestic

First year	:	150 consumers
Average consumption	:	30 kWh per month per consumer
Growth rate	:	(i) 20 new consumers per year
		(ii) 5% per annum increase in consumption

Street Lights

First year	:	40 street light points
Average consumption	:	150 kWh per annum per light point
Growth rate	:	5% per annum increase in consumption

Commercial

First year	:	15 consumers
Average consumption	:	30 kWh per month per consumer
Growth rate	:	(i) 2 consumer per year
		(ii) 5% per annum increase in consumption

Public Institutions

First year	:	5 consumers
Average consumption	:	100 kWh per month per consumer
Growth rate	:	5% per annum increase in consumption

Industry

First year	:	4 consumers
Average consumption	:	500 kWh per month per industry
Growth rate	:	1 consumer per year

Miscellaneous

First year	:	10000 kWh per year
Growth rate	:	10% per annum increase in consumption

CALCULATION OF VARIOUS TYPE OF CONSUMPTION

The consumptions of various types of consumers are calculated on the basis of above data as below:

Domestic

I year	150 x 30 x 12	=	54.0×10^3 kWh
II year	170 x 30 x 1.05 x 12	=	64.3×10^3 kWh
X year	330 x 30 x 1.45 x 12	=	172.3×10^3 kWh

Street Lights

I year	40 x 150	=	6.0×10^3 kWh
II year	40 x 150 x 1.05	=	6.3×10^3 kWh
X year	40 x 150 x 1.45	=	8.70×10^3 kWh

Commercial

I year	15 x 30 x 12	=	5.4×10^3 kWh
II year	17 x 30 x 1.05 x 12	=	6.4×10^3 kWh
X year	33 x 30 x 1.45 x 12	=	17.2×10^3 kWh

Public Institutions

I year	5 x 100 x 12	=	6.0×10^3 kWh
II year	5 x 100 x 1.05 x 12	=	6.3×10^3 kWh
X year	5 x 100 x 1.45 x 12	=	8.7×10^3 kWh

Industry

I year	4 x 500 x 12	=	24.0×10^3 kWh
II year	5 x 500 x 12	=	30.0×10^3 kWh
X year	13 x 500 x 12	=	78.0×10^3 kWh

Miscellaneous

I year	10000 x 1	=	10.0×10^3 kWh
II year	10000 x 1.1	=	11.0×10^3 kWh
X year	10000 x 1.9	=	19.0×10^3 kWh

CALCULATION FOR MAXIMUM DEMAND

Maximum demand in each year is as below:

$$\text{Maximum demand} = \frac{\text{Number of units actually supplied in a year}}{\text{Load factor x 8760 (hrs in one year)}}$$

$$\text{Maximum demand in I year} = \frac{116 \times 10^3}{0.5 \times 8760} = 26.48 \text{ kW}$$

$$\text{Maximum demand in II year} = \frac{137 \times 10^3}{0.55 \times 8760} = 28.43 \text{ kW}$$

$$\text{Maximum demand in X year} = \frac{334 \times 10^3}{0.75 \times 8760} = 50.84 \text{ kW}$$

LOAD FORECAST TABLE

Data obtained from 6.0 & 7.0 a load forecast table can be prepared as given in Table 1. In this table it is assumed that transmission and distribution losses are 10% of the total consumptions. The load factor is also assumed for each year.

TABLE 1: LOAD FORECAST OF PROPOSED SHP STATION FOR TEN YEARS

Sl No	Category of Consumer	I yr. x 10^3 kWh	II yr. x 10^3 kWh	III yr. x 10^3 kWh	IV yr. x 10^3 kWh	V yr. x 10^3 kWh	VI yr. x 10^3 kWh	VII yr. x 10^3 kWh	VIII yr. x 10^3 kWh	IX yr. x 10^3 kWh	X yr. x 10^3 kWh
1	Domestic	54.00	64.3	75.2	86.9	99.4	112.5	126.4	140.9	156.2	172.3
2	Street light	6.00	6.3	6.6	6.9	7.20	7.5	7.8	8.1	8.4	8.7
3	Commercial	5.4	6.4	7.5	8.7	9.9	11.3	12.6	14.1	15.6	17.2
4	Public institution	6.0	6.3	6.6	6.9	7.2	7.5	7.8	8.1	8.4	8.7
5	Industry	24.0	30.0	36.0	42.0	48.0	54.0	60.0	66.0	72.0	78.0
6	Miscellaneous	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.00	19.0
7	Sub Total (1 to 6)	105.4	124.3	143.9	164.4	185.7	207.8	230.6	254.2	278.6	303.9
8	Transmission & distribution losses 10% of at Sl. (7)	10.54	12.43	14.39	16.44	18.57	20.78	23.06	25.42	27.86	30.39
9	Energy demand at bus bar (7+8)	115.94	136.73	158.29	180.84	204.27	228.58	253.66	279.62	306.46	334.29
10	Say	116.0	137.0	158.0	181.0	204.0	229.0	254.0	280.0	306.0	334.0
11	Load factor (Assume)	0.5	0.55	0.6	0.65	0.70	0.71	0.72	0.73	0.74	0.75
12	Peak load (max demand in kW)	26.48	28.43	30.06	31.78	33.26	36.81	42.27	43.79	47.20	50.84

CONCLUSION

It is clear from the load-forecast table that the expected peak load in first year of operation is 26.48 kW which increases every year. The peak demand at the end of tenth year shall be about 50 kW. It means if the installed capacity of SHP is 50 kW then it will operate up to ninth under capacity and from tenth year onward it will operate at is installed capacity. Let us power potential available at proposed SHP project is more than 50 kW say 200 kW and we put the installed capacity of 200 kW without doing electrical load survey, then cost of civil works & E&M works will be more as compared to 50 kW. The SHP project will be under utilization of more than ten years.

REFERENCES

1. Shri R.V. Shahi Secretary, Ministry of India Govt. of India "India's Strategy to provide Electricity for all" 15th Conference on Electric Power Supply Industry (CEPSI 2004) Shangai, China, 18 October 2004.

2. Ikhupuleng Dube "Impact of energy subsidies on energy consumption and supply in Zimbabwe. Do the urban poor really benefit?" Energy Policy, Volume 31, Issue 15 December 2003, Pages 1635-1645.