1. POWER MARKET SURVEY

1.1. GENERAL

In case of low head hydropower development the load demand analysis and the power demand forecast are more complex than compared to high head developments. While high head developments, especially in rural areas, are investigated in isolated systems, low head developments are usually considered in connected systems, where the produced power of the planned hydropower station is small compared to the capacity of the grid.

Hydropower stations are bound to be constructed at the site where water can be utilized as the most economic motive power and electricity may be transmitted to the demand area at the cost of transmission lines and transmission losses. Therefore the transmission of power plays a key-role in context with the power market survey in low head developments. The National Grid provides the facility for inter-transmission of power during the whole year subject to variation of generation in the hydropower plants in parts of the grid with high altitude and zones in the plains. Together with the National Grid, other sources of power, such as thermal and nuclear also have to be considered in the power market survey.

During low flows of water, the thermal plants are run on maximum capacity to meet the national demand while during optimum hydropower generation the thermal plants may have to stand idle. Sometimes, all hydro, thermal, and nuclear power stations are run simultaneously to meet the electric demand of the country through an integrated transmission system called National Grid spreading from parts of higher altitudes, as in Pakistan the North Western Frontier Province (NWFP) to the lower areas in the plains, such as Sind Province for instance.

Discussion of power market survey will be held with help of the Rohri Canal Development in Sind Province and the Chashma HPP at Indus River, presently under construction.

1.2. DATA COLLECTION

1.2.1. POWER STATUS OF REGION

1.2.1.1. POWER DEMAND

To carry out the power market survey, the past growth of installed power and annual generation should be investigated for the whole country as well as for the region of the planned low head development. This might show, in which way the rate of percentage per annum has increased in the region compared to the region in the last approximately 20 years. This might also indicate the status of development of a region compared to the complete country. TABLE 1-1 shows the differences between Pakistan and the Sind Province in respect to the installed capacity, the maximum demand, the generated energy, and the consumed energy. Based on the table, it can be stated, that the generation of energy in Sind Province, during these 15 years, grew 58.2% more than the growth of energy in the whole country.

The power market survey should also be carried out with respect to the different sources of power generation. In TABLE 1-2 it can be seen, that the power position in Sind constituted 94.9% of thermal and 5.1% nuclear of the provincial power supply. The annual generation is 95.7% and 4.3% respectively. In Punjab, however the position in 1988 was different. 55% of the installed capacity came from hydropower, and 65.9% of the generated energy also.

Based on the same numbers, the demand of power in the region can be compared to the whole country. The result shows, that in the period of fifteen years an enormous increase can be found. The growth of energy consumption in Sind was found at 7% more than the growth of consumption in the whole country. Sources of concerned information come from the Federal Bureau of Statistics, Statistics Division, Government of Pakistan.

1.2.1.2. CONSUMPTION OF POWER

The consumption of electricity should be investigated by the different types of consumers. For a country as Pakistan, the main groups of consumers are:

- Domestic

- Commercial
- Industrial
- Agriculture

Beneath these main groups, there is also consumption as streetlights and all others types, which are summarized in one group. From the TABLE 1-3 it can be seen, that the province Sind consumes maximum power for industrial use and minimum for agricultural purpose. In NWFP, for instance, more than 40% of electricity is consumed for domestic demand. These figures give also an image about the state of development in the provinces, and its main sources of income.

The deficiency of power in the country is being felt day by day more seriously during previous decades. It also embarrasses general development process and creates enormous social and economic problems. In the consequence, many resourceful consumers are bound to use domestic generators in accordance with their demand. Some commercial and industrial units are thereby also forced to run their own generating units during severe load shedding. To observe the feelings of power scarcity and assess the quantum of self-generation for instance a “Census of Electricity Undertakings” was conducted by the governmental office in Pakistan. Such a census can be considered as suitable indicator for a severe deficiency of power supply in a country. The growth of self generation between the years 1983-84 and 1985-86 is shown in TABLE 1-4. The percentage change shows, that the self generation in the province of Sind and Baluchistan increased at 100.5% and 105.6% respectively, during the year 1985-86 as compared to the year 1983-84. While in Punjab and NWFP it decreased at 11.1% and 16.6% respectively. As a whole self-generation increased at 16.2% in the country during this period.

As already mentioned, the state of more power demand than the actual supply faces problems of load shedding. The extent of daily load shedding is shown as an example for the electricity circle of Sukkur in Sind, during the period 1987-88 has been shown month wise in TABLE 1-5. During this period the maximum load shedding of 38 MW was found in June 1987 when the supply and demand of electricity showed maximum gap due to reduction of hydropower generation capability and peak demand felt, due to increase in the temperature in the hot plains of Sind. The extent of average daily load shedding ranged from 9.8 MW in April 1987 to 30.9 MW in March 1988. The annual daily extent of load shedding comes to 16.3 MW while the range of maximum load shedding, during the period 1987-88, remained 3 to 38 MW, as illustrated in the table.

1.2.2. POWER STATUS OF PROJECT AREA

1.2.2.1. GRID STATIONS

It should be investigated, in which power circle the planned low head hydropower station will generate power in future. The network of grid stations in the concerned circle and its neighborhood should be listed with the capacity of each grid station.

Moreover the power circle should be investigated concerning the daily minimum and maximum power transmitted. For the above-mentioned circle in Sukkur, for instance, the maximum power consumed ranged between 79 MW to 95.8 MW, the minimum power ranged between 25.7 MW to 43.6 MW. It is also recommended to elaborate the monthwise peak and trough load, as illustrated for the Rohri Canal development in Figure 1-1.

1.2.2.2. THERMAL POWER STATIONS

Usually thermal power stations will also be available in the concerned power circle. The circle provides power through the national grid, which is also energized by thermal stations. The annual energy statistics of the thermal power plants should be elaborated maximum generation, month wise trough and peak power, and annual generation. These figures might be used for an evaluation of the production costs of thermal power and provide valuable information about the power system.

1.2.2.3. LOCAL GRID SYSTEMS

Another important aspect in the power market survey is the existence of local grid systems in the circle. For instance, the power circle of Sukkur comprises four electricity divisions and all the four divisions comprise fifteen number of local grids. Ten of fifteen grids have 132 kV transmission capacity and the other five 66 kV. It should be investigated, which stations are nearby the proposed low head hydropower development and could be connected with the planned hydropower plant.

Suggestions should be thought of to improve the existing system. These improvements are mainly concerned to transmission lines, transformers and grid stations. There might be some transmission lines, which are over loaded or which expect to be overloaded in near future and need upgradation, replacement or reconducting. The same considerations are valid for transformers. In case of grid stations, extension might be required or low voltage might be experienced during operation in the past. It might also be possible, that grid stations need rehabilitation with reference to civil/electrical installation or even some replacement of equipment.

1.2.3. TRANSMISSION

As already mentioned the transmission is important in respect of the power market survey for low head developments. Usually power systems are a mix of hydropower and thermal generation with hydro resources located in the higher altitude and thermal in the plains. In Pakistan, for instance, although the bulk of hydropower is generated in the north of Tarbela and Mangla reservoirs, most of the load centers are located in the central and southern regions. A large quantity of hydropower is, therefore, transmitted to these centers through a network of primary transmission lines of 500 kV and 220 kV. Further dispersal of this power within the load centers is done through secondary transmission facilities of 132 kV and 66 kV spread all over the country. At June 1986 there were 457 in service grid stations in Pakistan having installed capacity of 14993 MVA. There is an interlink between the systems of WAPDA and Karachi Electric Supply Cooperation (KESC) at Jamshoro with help of 220 kV.

In high flow period surplus hydropower is exported to Karachi while during the low flow period the electric traffic is reversed. In the past WAPDA has imported more energy in low flow periods from KESC than exporting surplus energy to KESC. With the interlinking of National Grid since 1984-85, the import of energy from KESC has increased tremendously mainly to meet ever increasing demand for power.

1.2.4. LOSSES

The system losses are directly affected by the pattern of consumption of electricity. In highly industrialized countries, the losses would be low because bulk of power is transmitted over short distances from the grid stations to major cities and industries. In widely dispersed distribution facilities, where large number of residential consumers are to be supplied with power, the losses increase and the possibility of theft of electricity is also high. The problem is further compounded by tubewells and village electrification where the technical losses are high due to length of transmission lines and the pilferage of electricity is more difficult to control. The losses can be divided into technical and non-technical categories. Technical losses comprise those caused by consumption of electricity in auxiliaries which can be considered within acceptable limits in developing countries. The losses in transmission and distribution during 1985-86 were 9.38% and 15.3% respectively which can be reduced further by technical improvements provided enough resources are available.

At the time of formation of WAPDA in Pakistan, system losses were 27.8 % which increased with the expansion of transmission and distribution system due to increase in energy demand. These losses had touched an all time peak of 37.6% in 1976-77, and thereafter have started decreasing as can be seen in TABLE 1-6. The losses are being further reduced through various technical improvements and it is planned to reduce still to a minimum of 21 percent in future.

1.2.5. DEMAND

In a developing country, as Pakistan demand for electricity is increasing day by day. Despite quantum jumps in generation, the power demand rose quickly to meet the available demand. Experience has shown, that in an unsaturated power system like Pakistan if adequate generation is available and there are no transmission and distribution bottlenecks, the demand for power rises quickly and in a short period matches the generating capacity. As a general rule power acts as a leader of the industry because of positive relationship between consumption of energy and the growth of gross domestic products. The demand elasticity for power is estimated to be nearly 2.13 in Pakistan as compared to 1.5 in many developing countries. Analysis of historical demand for power shows a growth rate of 14 percent per annum.

For quite few years in the past peak demand had been outpacing the generation capability. Higher peak demands have also been experienced which could not be met from existing system capacity and WAPDA had to resort to load shedding and suppression of demand by frequency management. This phenomenon is already explained in context of the power circle of Sukkur.

1.3. DATA PROCESSING

1.3.1. METHODOLOGY FOR FORECASTING

The power and energy forecasts are usually carried out by planning divisions, because they are responsible for the capacity expansion analysis of the system. The following paragraphs contain a brief description of the methodology applied and the results obtained.

The methodology used to estimate yearly power and energy demand for low head hydropower stations in interconnected systems is based on the assumption of annual growth rates for the power and annual load factors to determine energy. Both the methodology and the values adopted have been provided in this case by the Power Planning Division of WAPDA.

The monthly power demand is determined applying monthly distribution factors based on historical data. These monthly distribution factors are considered constant during the whole planning period. These values are supplied by the planning division.

The monthly energy demand forecasts are based on monthly load duration curves which have been developed by the planning division, on the assumption that the monthly energy distribution remains unchanged during the whole planning horizon.

1.3.2. POWER FORECAST

The monthly power forecasts for the period 1987-2010, as derived by the planning division, includes the monthly distribution factors to estimate the maximum power demand. The annual growth rate is calculated, the adopted annual growth rate decreases with the passage of time. A graphical presentation is enclosed in the appendix in Figure 1-2.

1.3.3. ENERGY FORECAST

The monthly energy forecast should be made on the basis of annual energy forecast by a planning division. In the given example of Chashma HPP, a constant load factor of 61% has been assumed for the whole planning period. The annual growth rates are also calculated. The graph can be seen in Figure 1-3.

The monthly energy distribution is calculated by applying a constant monthly distribution factor, using the load duration curves derived by the planning division. The load duration curves for each month are also attached in the appendix.

1.3.4. FUTURE ELECTRICITY DEMAND IN SUKKUR

As aforementioned in the example of the low head development Chashma at Indus River, the future demand for the Canal development Rohri in the power circle of Sukkur is also based on the trend of power consumed in the area during the preceding years. The only difference is the size of the project area, used methodologies are the same in interconnected systems. Keeping in view the aforementioned average extent of load shedding experienced in Sukkur circle, i.e. 16 MW during this period, it has been assumed that an average of 15 MW more power is required to meet the unsatisfied demand during peak load hours. Therefore the maximum power to be made available to meet the entire requirements of the circle in the preceding year should have about 112 MW, which is assumed as a base load for future demand projections of power.

For future forecasts of power and energy demand in Sukkur circle an average annual compound growth rate of 7% is assumed against the 13.56% annual rate of overall increase in energy sold in the entire country during the period 1960-84. It can be assumed, that this annual growth rate would cover the increase of demand due to the effects of approximately 2.5% annual population growth, the growth in net value of products and the power required for future development projects in the project area.

1.3.5. FUTURE ELECTRICITY DEMAND IN ISOLATED SYSTEMS

In some cases it might be possible, that low head developments are planned in rural areas without any connection to the National Grid System. It should be mentioned in this context, that this would happen quite seldom. Nevertheless, this case should also be discussed with respect to future electricity demand.

Under these circumstances, the existence of an isolated system has a dominant impact on the forecast. The forecast is less carried out in context of the aforementioned methodology as a power market survey. In this case, the methodology of load demand analysis and forecasting, as explained in context of high head developments in rural areas should be applied. This means, that load centers with their expected load demand have to be identified by desk studies and verified by interviews in the field. Based on the analysis of the questionnaires the autonomous load and promoted load is determined. A forecast is done for a planning phase of twenty years.

Detailed information on this approach can be found in the first paragraph of “Data Collection and Data Processing” in the series of training material for High Head Hydropower Development.

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