1. LOAD DEMAND ANALYSIS AND FORECAST

There are many forecasting methods and their applicability depends on the available data, nature of the forecast, planning horizon, etc. For power and energy demand forecasting, the following three basic methods are most commonly used:

- Trend analysis
- End-use analysis
- Econometric analysis

Trend analysis is very popular and is based on analyses of historical trends. It envisages predicting the development into future based on parameters derived from past experiences. This is only applicable if a long and reliable data basis exists.

End-use analysis involves constructing demand forecasts based on expected use of the supplied resource, electricity in this case. For instance, residential end-use forecasts are compiled from estimates of electricity demand by appliance, saturation rates for each appliance, number of households, etc. It is strongly based on power market surveys.

Econometric analysis is based on the relationships between electricity demand and its inter-relationship with other sectors of the economy. It requires comprehensive information about the energy sector and other sectors of the economy as well.

1.1 GENERAL

Within the context of planning of generation projects, the purpose of a load demand analysis is to determine the need and timing of proposed new additions. The need in this case refers to the already existing or expected occurrence of power and/or energy deficits. This happens when the present and/or forecasted power and energy demand including reserve requirements exceed the supply capabilities. Timing in this context refers to the time, when the need for additional generation occurs.

Forecasts are generally made for peak loads and energy demand. Preliminary generation planning for most electric systems is based on the analysis (balance) between available generating capacity and peak demand (includes loads, reserve and losses). The analysis of energy needs is also carried out to ensure that the demand is satisfactorily covered, which is very important for electric systems having energy-limited resources.

The sophistication of the analysis depends on the degree of development of the electric system. In developed areas relevant data such as number and geographic distribution of consumers, consumer categories, consumption patterns, etc. is normally available. On the other hand, in rural areas the data tends to be scarce and its availability is often affected by difficult access.

Keeping in view the need to operate economically, power utilities have their own methods and procedures to assess the power market and carry out demand forecasts especially in urban areas, where the larger population centers and loads are located.

A methodology was developed and applied to estimate the electricity demand in rural areas under a Project of Peruvian-German Technical Co-operation between Electroperu and GTZ in the year 1982. These were then adapted to the special requirements of mountainous regions in Central Asia. The basic idea is to provide a framework for identification and selection of projects from the point of view of the requirements. Therefore, it comprises following main steps:

- Definition of region to be studied
- Definition and identification of load centers
- Classification of load centers
- Development of parameters
- Used models and technical operation
- Forecasts for each load center
- Load isolines

In case of rural electrification it is very important to establish whether the load centers will be supplied as part of an interconnected system or in isolation. The analysis considering interconnection is more complex. For this reason, the approach will be explained on the example of rural electrification considering isolated systems.

The activities involved in the data collection in office and field are described first. Then a model is developed to forecast the future demand of electricity over a period of 20 years based for each of the identified load centers. The analysis is carried out for the most important consumer categories (domestic, commercial, industrial and public sector). Provided that the data is sufficiently reliable and the analyses are carefully carried out, the forecasted power and energy demand constitute the basis to define the most suitable strategy to electrify rural areas.

1.2 DATA COLLECTION

1.2.1 PEAK-LOAD-RESOURCE ANALYSIS

In most areas, a capacity load-resource analysis is sufficient. For other systems with limited resources, such as mountainous areas, an energy load-resource analysis shall also be carried out.

A load-resource analysis should consider the available resources against forecasted loads including reserve requirements. If hydropower projects are considered as base load projects, a simple comparison of annual loads and resources may be sufficient. However for peaking projects it may be necessary to include energy balances and the examination of daily load curves of typical days for different seasons (i.e. working days and holidays in winter and summer).

The definition of the region to be studied depends on various factors, such as:

- Geographic coverage
- Population density
- Degree of development
- Political subdivisions
- Weather conditions throughout the year
- Accessibility
- Distance to national grid
- Time frame to execute the works
- Available equipment and personnel for field work

The larger the demand in the region, the greater the required time and resources to carry out the works. Keeping in view the required logistical arrangements, in case of remote regions with poor access, a smaller geographical area may be preferred.

The project implementation of hydro power plants with planning, design, and construction generally exceeds 10 years. Therefore usually a 20 year analysis from the present is required to determine the future forecast.

Once the power and energy demands are known, a load-resource analysis can be applied to identify the generating resources and imports that will be available to the system at various points in time. The first step is to establish the basic scenario, which takes into account the available generating capabilities and their expected development during the planning horizon (i.e. upgrading, de-rating or retirement) without considering addition of new projects. For this scenario peaking capability and energy production should be determined. Balances between the forecast and the system resources yield the need and timing for proposed new power projects, which occur when power or energy deficits are expected to happen.

It should be kept in mind the required time for planning, design and construction of the generation projects (earliest commissioning time) and the required transmission lines. It may happen that deficits may be expected within a short time, or already exist, but can not be avoided due to lack of new projects ready for implementation.

This methodology allows determining the energy and power demand for a given planning horizon (i.e. 20 years), for independent load centers in rural areas assuming isolated operation. It is pre-supposed that the region under consideration has been defined before, considering topographical, geographical, political aspects and other relevant aspects. Detailed information about the approach and methodology can be obtained from a DIPEO manual “Energy and Power Demand Analysis and Forecast in Rural Areas under Consideration of Isolated Power Supply”.

The most likely electricity demand estimates (autonomous load) are made separately for various load centers in the region for following consumer categories:

- Domestic
- Commercial
- Industry/Crafts
- Public services

Additionally, the possibility of promoting electricity consumption is assessed (promoted load). The idea behind is to evaluate the possibility to introduce a more rational use of available energy sources in the region, replacing the consumption of non-renewable fuels (i.e. firewood, kerosene, etc.) through more environmentally friendly sources. Therefore, the analysis considers possible existing options for following requirements:

- Heating requirements in winter
- Cooking throughout the year
- Baking
- Development projects, such a lift irrigation,

1.2.1.1 LOAD CENTERS

The preparatory office work comprises the definition and identification of load centers for which demand forecasts will be prepared. Depending on the geographic distribution of the population, clusters of villages, such as towns or concentration of population in the area are defined as load centers. For this works topographic maps are used as well as any additional relevant information available. In this connection, population, physical and social infrastructures, land use, number of households and general economics are of special interest.

The data has to be systematically collected form different sources, such as regional and local public administration, non-governmental organizations and interviews with the population. To facilitate the work, questionnaires are normally prepared to collect relevant information from different consumer groups and categories. The questionnaires for different consumers include:

- Q1, for Domestic consumers
- Q2, for industrial developments projects
- Q3, for manufactures / distributors and retailers of heaters
- Q4, for local administration and public services

1.2.1.2 FIELD INVESTIGATIONS

The questionnaires have been designed and developed for use in the field. Provided that the area is already electrified (even partially) additional analysis of the existing power supply facilities are necessary. This information is very important as it reflects the past experiences concerning the system performance. Of special interest are:

- Annual and monthly maximum power demand
- Annual and monthly energy demand
- Typical daily consumption patterns (working days, holidays) and their seasonal variations
- Development of number of consumers for each category
- Characteristics of the power station and their performance

Over and above that, the field visits should be utilized to collect all types of information, which could be of value for this kind of study. This also includes contact with local authorities and organizations, which might have general information about the study area, such as production of crops, population growth, availability of transport facilities during different seasons, safety and other factors which have an effect on the social and economic growth of the region.

In this context it shall be mentioned, that especially the questionnaire Q1 provides first-hand information on the social infrastructure as well as on the region’s economic and trade activities. This makes it possible to assess the development status and perspectives of the different sectors of each region.

1.3 DATA PROCESSING

The basic objective of data processing is to synthesize the collected information in order to derive the parameters required for forecasting. A computerized processing of the information is recommended, especially when large volumes have been compiled. A description of such type of software is given by GTZ.
The information obtained through field surveys using the above mentioned questionnaires can be used for the models developed as part of GTZ methodology, as well as for other forecasting models. For illustration purposes, in this context, the approach used in the GTZ methodology is described. It requires the determination of a certain number of parameters, making a distinctive subdivision of the system load in two basic categories:

- Autonomous load
- Promoted load

The parameters have to be developed separately for above-mentioned loads and comprise:
- Population
- Persons per household
- Households per income group (high, medium and low)

- Number of households per commercial center
- Number of households per public services unit
- Electrification coefficients, in % for:
  - Households according to income level
  - Commercial centers
  - Public service units
- Consumers consumption, in kWh for:
- Households according to income level (high, medium and low)
  - Commercial centers
  - Public service units
  - Crafts and small industries
- Growth rates:
  - Population
  - Crafts and small industries
- Losses (technical and non-technical)
- Load factors

The detailed definition of each parameter can be found in the DIPEO module covering this topic. An example for a load demand forecast for a rural area is given in the following figure.

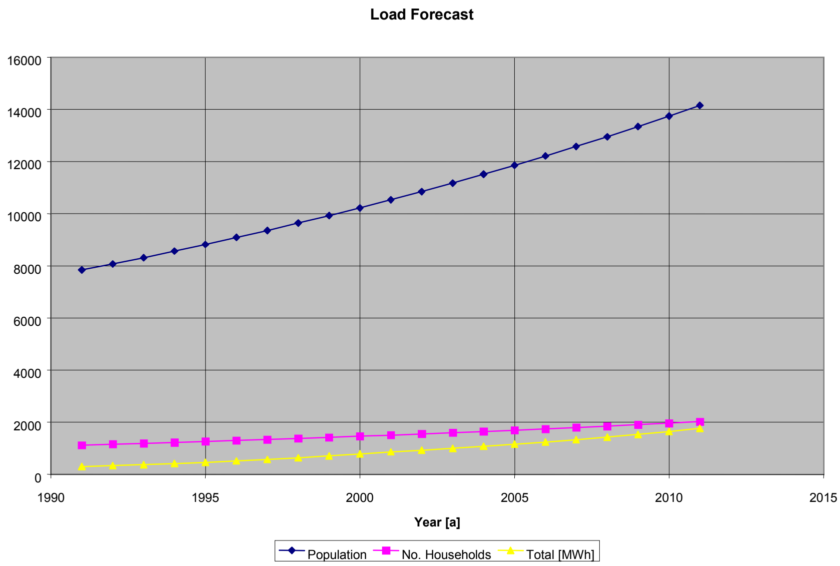

Fig. 1.1: Load Forecast in rural area for 20 years

1.3.1 AUTONOMOUS LOAD

This is the load that is expected to develop after electricity is provided to an area. It is mainly governed by three components:

- Firstly, the normal demand of the people, which increases with population growth. It assumes that the consumption patterns will remain constant or even increase but not decrease. Therefore, more electricity will be consumed when population becomes larger.
- Secondly, the load increases due to the developments in agriculture and industry and due to the growth associated with the improvement in health facilities, better educational opportunities, efficient communication system, the availability of cheaper energy etc.

- Thirdly, the developmental activities in the area lead to a change in income, tastes, etc. leading to the use of new products and electric appliances.

The autonomous load results from the following four categories of consumers:

- Domestic load: it covers the demand of households principally for lighting, fans, radios, irons, and other household appliances

- Commercial load: which principally comprises the consumption of shops, hotels, restaurants, and gas-stations

- Crafts' load: it refers to the demand of handicrafts' establishments, small-scale industry and workshops.

- Public services load: takes into account the electricity needed for schools, hospitals, police stations, administration offices, street lighting, etc.

Above-mentioned consumer categories are abbreviated as DCCP (**D**omestic, **C**ommercial, **C**rafts and **P**ublic).

If necessary, any of the above four categories can be broken down into additional sub-categories, according to specific local conditions. For instance, if it becomes clear that there is a significant difference in the consumption patterns of different households, forming corresponding categories of households can reflect this.

1.3.2 PROMOTED LOAD

This scenario assumes that the electricity consumption may be developed under special programs or by policy actions e.g. accelerating promotion of utilization of electricity for heating/cooling, baking and cooking to preserve the ecological balance through the protection of forests, reduction of emissions, etc.

Therefore, promoted load may relate to individual projects for
- irrigation
- mining
- industry
- special projects

1.4 APPLICATION

1.4.1 MODELS FOR LOAD FORECASTING

The parameters, which have been obtained for load center, constitute the basis to prepare demand forecasts. Due to the large volume of information, a computerized processing is advisable (i.e. with help of spreadsheet).

Due to the uncertainties associated with this type of work, the GTZ methodology assumes that forecasts are prepared for three different alternative scenarios, namely:
- optimistic (high)
- intermediate (most likely)
- conservative (low)

In case of promoted load the procedure is slightly different. As far as participation of electricity consumers is concerned, efforts are made in the first years of promotion (by policy decision or other reasons). In any case, a critical assessment of the income level of the population is required. It may happen that the economic situation in the region can only allow promotion of electricity through subsidies, justified by urgent requirements to protect the environment or other reasons, which can not be strictly quantified in monetary terms.

1.4.2 LOAD FORECAST

The electricity demand of each load center is established by adding all loads to be expected (domestic, commercial, industrial, public). The load forecast will principally suit following purposes of the study:

- Isolated operation: at identification stage in the initial phase of development of a regional study, determination of the possible minimum requirement to assess the capacity of the smallest thinkable power station situated in the proximity of the individual load centers

- Regional interconnected networks, assessment of timing and optimum installed capacity of the projects considering regional loads.

- Interconnection to national grid, determination of optimum installed capacity of the projects considering their power and energy output throughout the year

It may not be always efficient to establish capacity expansion plans for each individual load center. The reason is that this would require selecting projects, which should exclusively satisfy the requirements of each load center under consideration. This may not always be technically possible mainly due to the unavailability of sufficient projects. On the other hand, such a strategy can become extremely expensive and uneconomical.

Therefore, the possibility of combining the load of one or more load centers is necessary. This requires the combined consideration of the geographic location of the load centers and their associated loads, which can be done by developing maps of load isolines.

The elaboration of load isolines allows establishing the most convenient size and location of the required generation projects for single or clusters of load centers. Its principal aim is to help cutting down the time and manpower necessary at identification stage avoiding the need to search for extremely small projects, which in the long run will likely prove to be uneconomical. The basic idea is to have rational criteria, which can help to exclude certain sites without any loss of useful information.

The load isolines of a planning region help to rule out certain projects keeping in view their relative size as compared to the total demand in the load centers in the proximity. This method allows establishing lower limits for the size of the projects to be considered in the vicinity of the load centers. Thus the purpose is to ensure that the work during the identification of hydropower potential will concentrate on those sites within a reasonable range, avoiding for instance unnecessary work on sites finally offering a potential too small.

On the other hand, no upper limit is set on the capacity of the projects. The reason is that a larger project may be considered to cover the demand of one or more load centers, one or more regions and even a significant part of the load of the national grid.

A detailed procedure for the elaboration of a load isolines is given in the aforementioned DIPEO module.

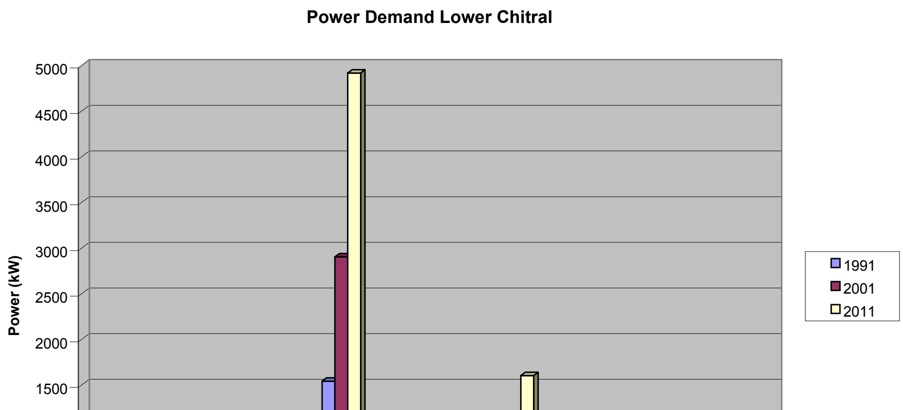

Fig. 1.2: Power Demand in different load Centers of Lower Chitral

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