CHAPTER 2 FACTORS

2.1 INTRODUCTION

Gellings mentions that a number of important, and sometimes countervailing, factors are acting to change the future pattern of electricity demand in the United States. Some factors reflect major structural changes in the economy and others include information about a shift in population and economic activity between regions. The extrapolation of historical trends into the future is no longer appropriated. The need for forecast results that include information about those factors that have a significant impact on the electrical network loads, are becoming more critical. [1]

This chapter describes some of the major factors in South Africa that have a significant impact on the transmission network loads. The purpose of this chapter is not to give a detailed report on those factors, - limited staff does not allow such research - but rather to use a number of different expert forecasts in the South African electrical industry. The factor impacts are integrated in those forecasts. The different forecasts vary from the maximum transmission system load, sector, area and distribution substation loads.

The reading of newspapers, articles and reports are an important aspect of electrical load forecast. Surveillance is a method to assist the forecaster to systematically develop a reference of important factors to scan and keep track of new developments. *Surveillance* can be defined in terms of three activities, i.e. scanning, monitoring and tracking.

1	**Scanning**	Scanning is used to identify, at an early stage, developments in the social, economic, political and ecological environments. It is a general, wide-ranging and ear-to-the-ground activity.

2	**Monitoring**	Monitoring focuses on a specific range of signals of interest as identified by scanning, and aims to establish where the developments they have indicated, are going. It is best done within the more formal analysis and planning function of an organisation.
3	**Tracking**	Tracking is the very specific and intense activity aimed at finding out the exact rate, direction and impact of the few really important developments. Tracking should be linked to the formal strategy formulation function in the organisation.

[2]

Relevance trees and cross-impact matrices are some techniques to support the structuring and analysing of articles, reports, research documents, etc. [3]

Relevance trees use the concepts and methodologies of decision theory and decision trees to assess the desirability of future goals and to select those areas of development that are necessary in order to achieve the desired goal. Relevance trees provide a structure to focus on relevant global and local trends to identify possible future load growths. Scenarios can play an important role in the development of relevance trees and the defining of important aspects to be included on the various levels of the tree.

A cross-impact matrix describes two types of data for a set of possible future developments. The first type estimates the probability that each development will occur within a specified time period in the future. The second estimates the probability that the occurrence of any one of the potential developments will have an effect on the likelihood of occurrence of each of the others. The data for such a matrix can generally be obtained by using either subjective assessment procedures, or a method such as the Delphi approach. Cross-impact matrix can be useful to view interaction between areas for different developments.

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The next factors are based on own experience, articles, documents, reports, etc. [4 – 21]

2.2.1 Regulatory Aspects

This section deals with the impact of decisions, legislation, programmes, etc. taken by government, the utility and regulatory bodies, that have an impact on the load forecast.

In South Africa, new regulatory policies, for example the newly established National Electricity Regulator (NER), or the Regional Electricity Distribution companies (REDS), may have an impact on the transmission load forecasts. Privately owned power stations (a future development) is important to consider for load forecast. That means, if the power stations are directly connected to the transmission network, new power stations are added to the generation pattern, or, if the power stations supply the end-use customers directly, adjustments to the expected maximum system load figures are required.

Electrification programmes have in some distribution networks significant impact on load growths in the areas. Millions of customers have received electricity in their homes over the past number of years.

Agreements with neighbouring countries is another example. Exports to neighbouring countries are approximately 3 to 4 % of the transmission system loads. Press announcements are frequently made about linking African countries to resolve frequent power cuts in the East African Countries. There are plans for inter-border power c onnections across Africa. Plans are on the table to garner world support for a large-scale renewable project at Inga on the Congo river.

Demand side management programmes and tariffs can influence end-use customer preferences. In some cases, end-use customers revise their load management schemes to obtain the optimum benefits due to the new management programmes and tariffs.

The main objective of demand side management programmes is to reduce system peaks and improve the system load factor. The success of such programmes is that the growing capacities can be met without building new generation plants or new network expansion projects. The introduction of time-of-use tariffs has played a major role in local demand research. Through these research programmes, strategies and tariffs can be formulated.

The reshaping of the utility's standard tariff structures is aimed at gradually removing cross-subsidies between industrial, residential and other consumers, while ensuring there are no shocks to the system. The utility's electricity pricing manager said the tariff restructuring was driven by the requirements set out in the Energy White Paper.

2.2.2 End-Use Load Profiles

The impact of customers is captured in this section. Customers have the option of selecting between tariffs and whether to participate in demand side management programmes or not.

People need energy to fulfill certain needs such as lighting, heating, cooking, travelling, pumping, manufacturing, or mining. In rural areas people gather wood to prepare food, but in cities most people use electricity. Urban railways are electrified and in other parts of the country diesel locomotives or steam trains are used.

It can be concluded that the energy source is not necessarily electricity, but could be wood, gas, or coal. The list of alternatives is not nearby exhausted, but the point is that electricity is not the only energy source to fulfill people's needs, as mentioned earlier.

Preferences play an important role, but factors such as availability, affordability, etc. are also aspects to consider when energy sources are selected.

Tariffs have also impacted on the transmission load forecasts. From own experience when the utility introduced an off-peak and weekend tariff some years ago, it was possible for some industrial customers to shift some of their loads to off-peak conditions. It implied a saving for the customer, but also reduced the nearby distribution substation peaks at the time of maximum system load.

2.2.3 Generation

This section is to capture latest developments and trends in electricity generation. Will coal power stations be phased out? Will smaller, more effective plants closer to the customer replace the old giants of the past?

In the early 1950s, mostly all electricity in South Africa was generated by coal power stations. Since then the utility has commissioned other power stations, using different fuel types; a nuclear power station, two hydro-electric power stations and two pumped-storage power stations (pumping during off peak hours and generating in peak hours).

A number of research projects are looking at alternative methods to generate electricity in South Africa, projects such as:

1) To pump gas from the Namibian West Coast to the Western Cape (South Africa) and generate between 1200 MW to 1600 MW.
2) The commissioning of a 100 MW solar plant in the Northern Cape. Upington is a possible site, because it has the highest recorded levels of sunny weather in South Africa. Heat transfer fluid is heated to 390 ^{o}C and then fed to a conventional steam turbine/ generator to produce electricity.
3) The Sabre-Gen project that investigates the potential of using wind energy for bulk electricity generation. Wind turbines range from anything from 60 W to 3.5 MW and new plans are being made to

develop 4 to 6 MW turbines. Opinion polls in several European countries like Denmark, Germany, Holland and the UK show that more than seventy percent of the population is in favour of using wind energy to generate electricity.

4) Pebble-bed modular reactors (PBMR) are another development. The proposed PBMR is a high-temperature helium gas-cooled nuclear reactor. Environmental impact assessment (EIA) studies are also conducted to establish whether the PMBR will comply to environmental standards.

If those projects are feasible, then smaller power stations could be commissioned closer to the end-use customers. The expected maximum system load will therefore reduce, depending on whether the smaller plants will be connected directly to the transmission network or not.

Different generation patterns can have an impact on nearby transmission substations in that area. Figure 2.2.1 shows the net power output from a power station connected to a 132 kV substation. If the power station generates (↑) (see Figure 2.2.1) then the power flows from the 132 kV bus to the 220 kV bus (↑) (see Figure 2.2.2). With no generation (↓) the power flows from the 220 kV bus to the 132 kV bus (↓) (see Figure 2.2.2).

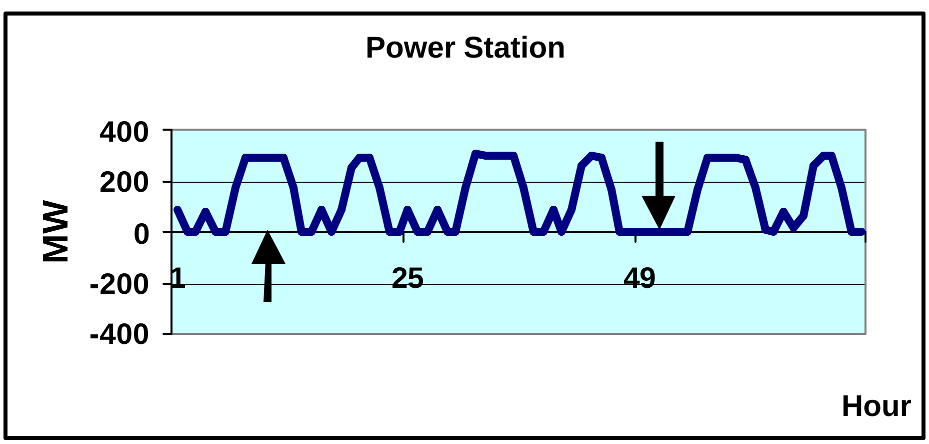

Figure 2.2.1 – Net Power Output – Power Station

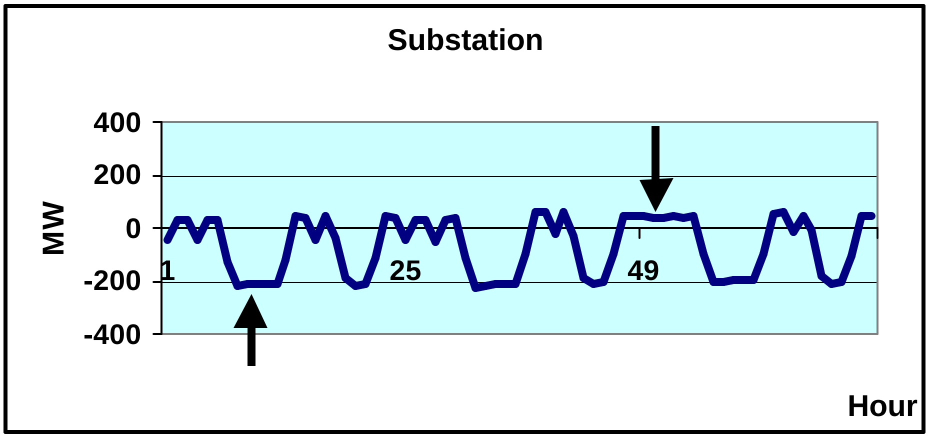

Figure 2.2.2 – Load Profile - Substation

2.2.4 Sectors

The main energy sectors are residential, commercial, industrial, mining, agricultural and traction (rail transport). Over the years the sector loads have been growing or decreasing. It can have a significant impact on the area loads.

Since the early 90s a large down-scaling of gold mining activities took place in an area. This demonstrates the importance of area- and sector load forecasts. The ques tions of where, when and how much are very important. Unnecessary network expansions could have been done if the forecasts were wrong for that area.

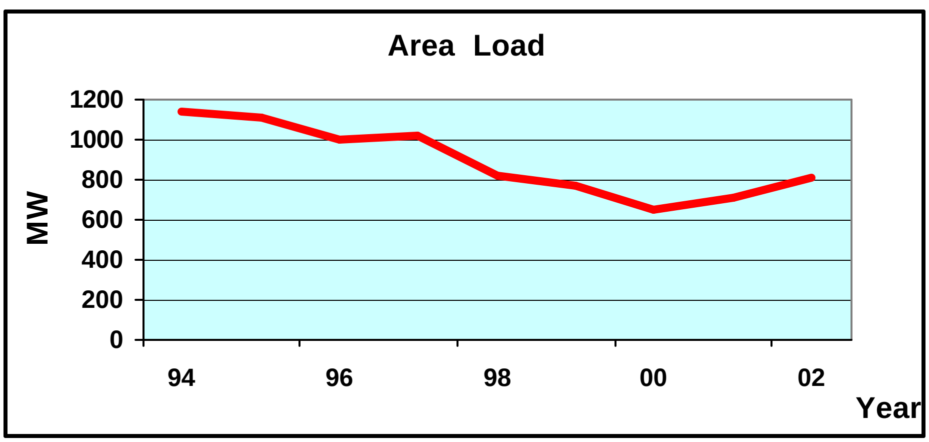

Figure 2.2.3 – Area with Large Gold Mining Operations

The next two area loads demonstrate the effect of large step load increases. In Figure 2.2.4, a new stainless steel plant has doubled the area loads.

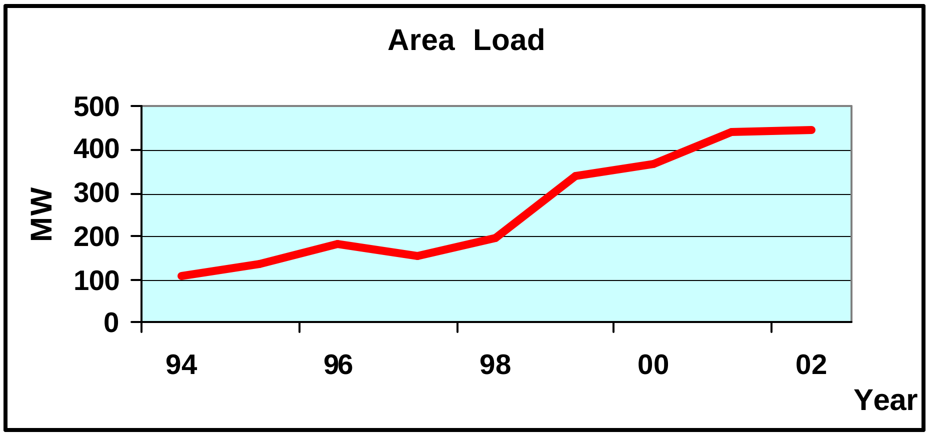

Figure 2.2.4 – Area with A Large Stainless Steel Plant Commissioned

In Figure 2.2.5, an aluminium smelter caused a larger step load increase. Further expansions to the smelter are planned that will increase the load further.

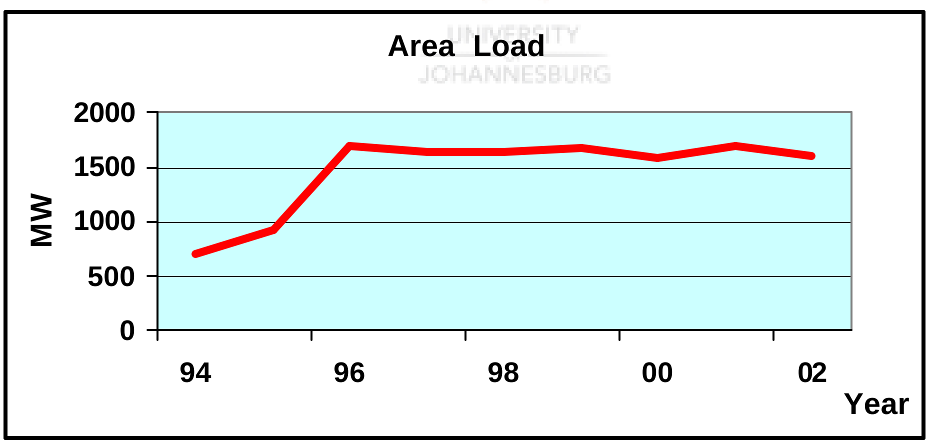

Figure 2.2.5 – Area with A Large Aluminium Plant Commissioned

The area loads (Figure 2.2.6) still show a potential for high growth. However there are signals that the mining activities will move more east. That means the loads in the area can saturate, or even decrease like the area loads, see Figure 2.2.3. This is therefore the reason why the distribution substation forecasts are checked against the national sector forecasts.

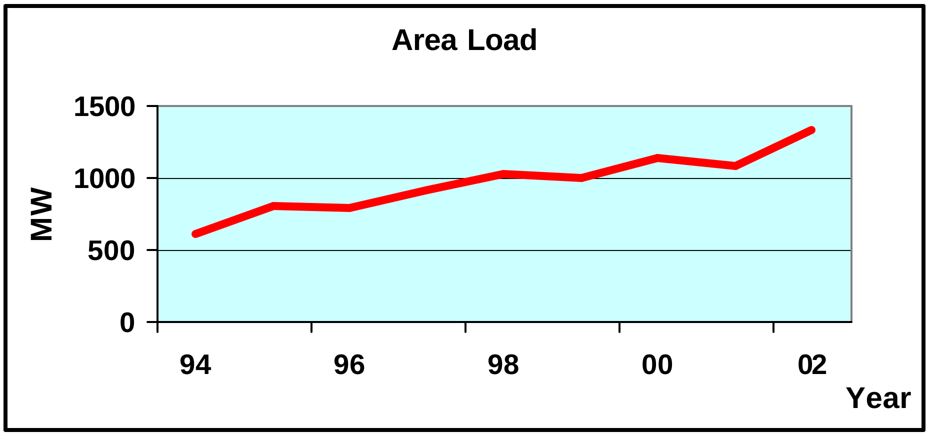

Figure 2.2.6 – Area with Platinum and Ferro-Chrome Operations

From a transmission perspective, area and sector load forecasts are the most critical and important forecasts. The idea is therefore, to structure the area and sector forecasts as a matrix, where the row totals represent the sector loads and the column totals the area loads. It is also very important that the area and the sector forecasts are done independently and compared with each other. The matrix elements are the area per sector loads and a breakdown of the individual distribution substation forecasts.

Countries, for example Norway, have conducted similar studies on sector changes and activities. Some of the findings show a steady increase in the level of comfort and convenience in the residential sector and a steady increase in the energy demand per home. The energy for the manufacturing sector is divided into six industry groups, so that the structural changes within the sector would be apparent.

Some of the significant sector trends today are:

Aluminium: Aluminium is used in the transportation sector to manufacture cars, aeroplanes, trucks, railway cars and ships. It is also for doors and windows, kitchen appliances, overhead transmission lines and packaging. Two large Aluminium smelters, Bayside and Hillside, are situated near Richards Bay.

Coal: Coal is mainly used to generate electricity and to produce iron and steel and in the metallurgical industry. More than 50 % of the coal reserves come from Witbank in the Mpumalanga province. Richards Bay has a coal terminal and is ranked as the third-largest exporter of coal in the world. The first Sasol plant was built in 1950 and the other two plants at Secunda in the early eighties.

Diamonds: Diamonds are well-known for their investment purposes and their usage in jewellery. Diamonds are still mined in the Gauteng, Limpopo, Northern Cape, Free State and North Western provinces.

Iron Ore: The mining activities are around Sishen in the Northern Cape and at Thabazimbi and Phalaborwa in the Limpopo province. The iron ore from Sishen is exported through the Saldanha harbour, as well as through Richards Bay.

Ferro Chrome: World chrome ore reserves are largely concentrated in Southern Africa. No less than 84 percent of the total ore comes from the Bushveld Complex. More than 85 percent of the chromite ore output is converted into ferro chrome for stainless steel and other metallurgical industries. The Columbus steel plant is situated near Middelburg (Mpumalanga), and the Saldanha steel plant in the Western Cape.

Gold: Despite the decline in gold mining, South Africa was still the largest gold producer in 2001. Gold continues to play a key role in the South African mining industry.

Platinum: The South Africa platinum industry is currently growing at an unprecedented rate in order to meet projected increases in demand. All existing producers, with the exception of Northam, have ambitious expansion plans. Several new black-led companies will join them in the platinum mining sector, due to the South African government's policy of black economic empowerment.

Traditionally, platinum mining in South Africa has been concentrated on Merensky Reef reserves hosted by the western limb of the Bushveld Igneous Complex. However, the eastern limb accounted for 6 percent of platinum production in 2002. This will increase to an expected 18 percent by 2006. This is of significant importance to balance the expected loads for platinum mining

2.2.5 New Technological Developments

New technological developments can change customers' preferences in selecting other energy sources to fulfill certain needs, such as lighting, heating, cooking, travelling, pumping, manufacturing, or mining.

Wang et al. and Carmody et al. look at electric vehicles as an alternative to petroleum vehicles. Wang et al. looks at the U.S. transportation that accounts for 26 % of total end-use energy consumption and 65 % of petroleum use. The objective of the study is the conservation of transportation energy and the reduction of transportation petroleum. The challenge to the demand forecaster is to avoid the details of the article, but to answer the question of where in the transmission network will there be any significant electrical load changes.

Carmody et al. looks at the introduction of electric vehicles into the Los Angeles area to reduce air pollution. The argument for the U.S. example is the same: where in the transmission network will there be any significant electrical load changes?

2.2.6 Environmental Impacts

Population growths and rising standards of living have been responsible for large energy demand growths. New coal power stations are commissioned and the atmosphere is more polluted with CO_2. Fossil fuel sources are increasingly utilised for generating electricity. Decision- and policy makers are facing the challenge of how to address the problem. Should population growth cease, what about alternative technology to generate electricity, cleaner methods to generate electricity, or renewable energy sources.

The effects of escalating CO_2 concentrations and other greenhouse gases on global and regional climates become more and more of a concern to the public. What is the real economical impact of the greenhouse effect?

From this brief description it is obvious that the impact on the environment has an interactional effect on other factors, such as new power station technologies, weather impacts, economical impacts, etc.

Weather plays an import role in almost every one of the different forecasts. Some individual forecasts may not be sensitive to weather cycles, for example stainless steel smelters.

Research shows that the temperature in South Africa is increasing and scientists have agreed now, after long debates, that this is caused by global warming. One of the predicted impacts will be on the utility's coal-fired power stations that depend on vast water supplies, while South Africa has limited water resources.

The American Electric Power (AEP) System has done a study on the impact of weather on power system loads. The weather- and non-weather-sensitive components were separated. Mathematical relationships were developed to examine the influence of economic, demographic and conservation-related forces. Important is the conclusion that the residential customers and the sensitivity factor are highly correlated for the summer period. Lastly, the weather-sensitive load is a function of temperature only for the winter demand.

2.2.7 Networks

New transmission and distribution network expansions change the network topology. It will therefore change the modelling of the transmission network and the distribution networks as a hierarchical structure.

In some cases, when new transmission substations are commissioned, loads are transferred from existing substations (see Figure 2.2.7).

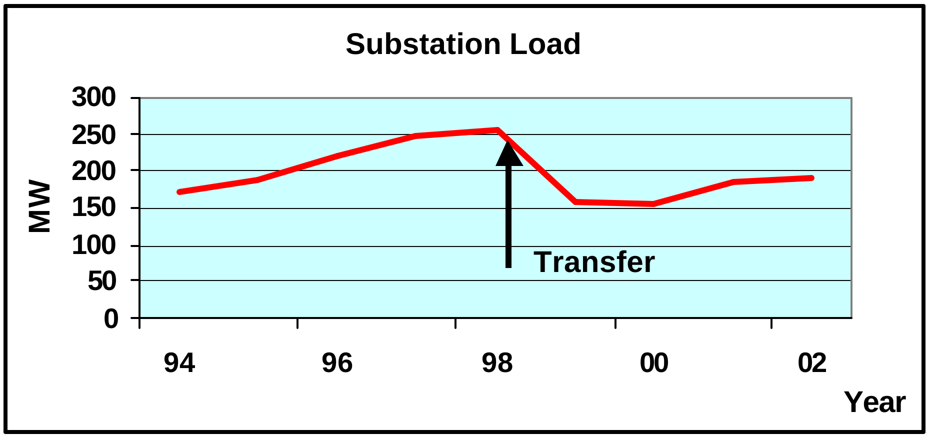

Figure 2.2.7 – Load Reduction at An Existing Substation

Different network operations can cause large load shifts between transmission substations. Figures 2.2.8 and 2.2.9 show the effect of network operations. Approximately 250 MW of load has been transferred from substation B to substation A. The impact of different networks make transmission substation forecasting extremely difficult. From a statistical point of view, it can be defined as outliers in the data. Such outliers can have a significant impact on the trend predicted from the historical data

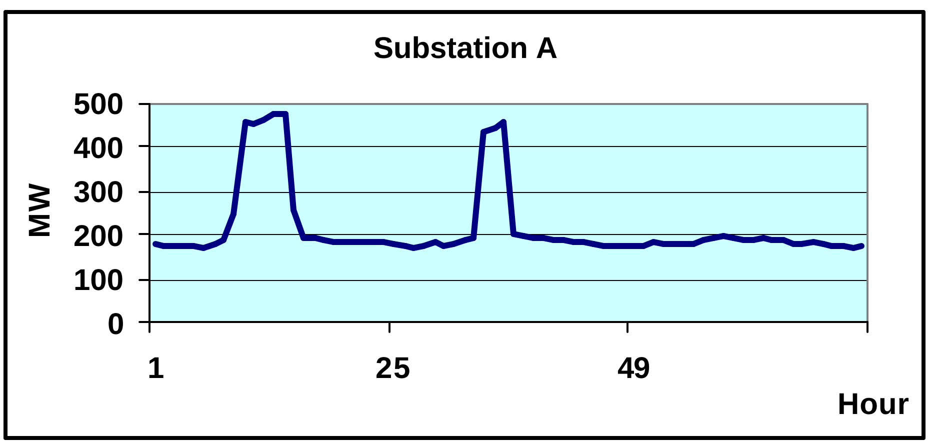

Figure 2.2.8 - Different Network Operations – Substation A

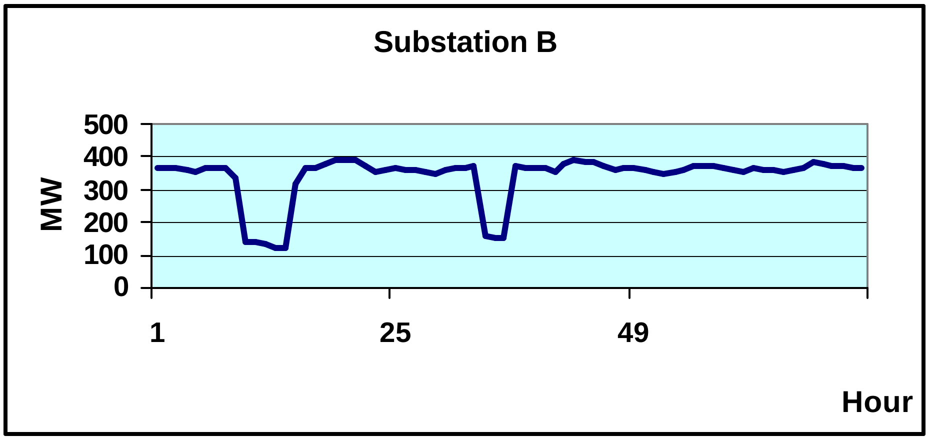

Figure 2.2.9 - Different Network Operations – Substation B

2.2.8 International and National Trends

The utility does not operate in isolation. Some international and national factors have significant influences on the utility. Some influences have an impact on the forecasting methodology and others on the expected loads.

During the sixties, straight-line extrapolations of historical data were good enough for load forecasts. The electrical industry was experiencing stable prices and planning was straightforward.

In the 1970s, fuel prices rose and regulatory pressures intensified. Structural changes in the economy made the economy more unstable and forecasting became more difficult. In the 1980s and early 1990s the forecasts had to be more accurate. Plant construction lead times varied between 7 to 12 years. Those lengthy lead times placed a major financial burden on a utility. Some other overseas utilities had not earned enough income to cover new investment costs.

Today peak load forecasts are no longer adequate. The forecasts have to be more accurate and should include more information. The reason is to meet three key goals: retain customers, enhance revenues and reduce costs.

2.3 CONCLUSION

The different factors provide a structure to scan, monitor and track the most critical and significant impact on the transmission load forecast. The factors also contribute to the development of a knowledge-based system that helps to make the transmission load forecast more informative. The knowledge is also important for the different forecasts (Chapter 3) to understand the past better, but also to capture expected load growths.

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