REACTIVE POWER COMPENSATION

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ABSTRACT

Power systems have two components of apparent power: active and reactive power. Both components are necessary for functioning of electrical systems. The active power is the average power absorbed by the resistive load. The reactive power is the measure of energy exchange between the source and reactive power of load. Energy storage devices do not dissipate or supply power, but exchange power with the rest of system.

Active power is the one that is converted to other forms of energy in the load yet reactive power is only responsible for magnetizing purposes. Power factor is a ratio depicting how much of the power supplied is real. The reactive current contribute in the value of the overall magnitude of current in transmission lines causing unnecessarily high line currents and low power factor.

Since a low power factor means higher amount of apparent power need to be supplied by the utility company, thus the company must also use bigger generators, large transformers and thicker transmission/distribution lines. This requires a higher capital expenditure and operational cost which usually result in the cost being passed to the consumer.

In this research, we seek to identify the effects of a low power factor on Swaziland Electricity Company's power

supply system and recommend possible solutions to the problem. The results are useful in determining how to optimally deliver power to a load at a power factor that is reasonably close to unity, thus reducing the utility's operational costs while increasing the quality of the service being supplied.

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CHAPTER 1: INTRODUCTION

1.1 Introduction to Research

AC electrical power system loads have resistive and reactive impedances. The electricity supply network therefore possesses an active and a reactive power component as a result of the characteristic of the load impendences [1]. The reactive component can be further subdivided into two states: a leading and lagging state. Leading reactive power comes as a result of the capacitive component of the load whereas lagging reactive power comes due to the inductive component of the load introducing a lagging phase shift in the network.

This gets us to the topic of interest, 'Power Factor'. It is a ratio that tells us how much power from that being supplied by the utility is being actually used to do useful work by the customer. Figure 1.0 below shows this relationship in a form of a right angled power triangle.

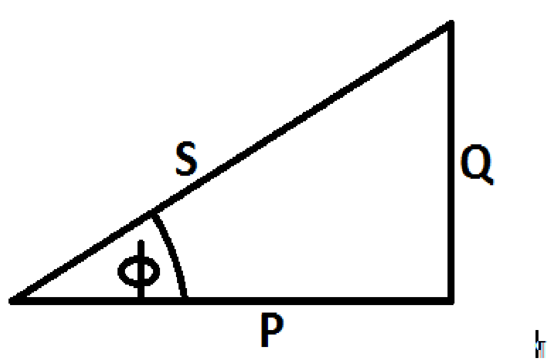

Figure 1.0: The Power Triangle [2].

Where:
S = apparent power (VA)
Q = reactive power (VAR)
P = real power (W)

Apparent power (S) is a complex combination of real power (P) and reactive power (Q). Real power, also called productive power does useful work and the reactive component of the power generates magnetic fields necessary for the operation of inductive devices such as AC motors, transformers etc. When in excess, reactive power can become detrimental to a power system as it greatly reduces the power factor, thus decreasing the distribution capacity while increasing the operational costs of the utility company.

1.2 Objectives

The main objectives of this project are:

- Identify the causes of a low PF in SEC's power system paying special attention to the eastern side of the network.

- Calculate the power factor and the component values for the affected substations of SEC's network.

- Evaluate the effects of a low power factor in SEC's network.

- Draw conclusions and make recommendations for any modifications or improvements on PFC.

1.3 Significance of Research

Whenever a power system supplies power at a low power factor, a significant percentage of the power doesn’t do useful work at the load. This implies that the network is carrying higher current than required by load to cater for amount of reactive power in the network. The high transmission/distribution current result in increased system losses and voltage drops, thus reducing the power system’s capacity. Since Swaziland is currently importing around 70% of its power from neighboring countries in order to meet the demand of its customers, so correcting power factor will help in reducing this deficit. This research will serve as a guide on how to keep a power network operating at a power factor close to unity. Though this research is based mainly on SEC’s power system as it is where most of the work was done, the results are actually valid for nearly all power systems.

1.4 Problem Statement

The network of SEC has two injection points, Mahamba and Edwaleni. Mahamba supports the Eastern network while Edwaleni II is in the Western network. The customers in the Eastern network are mainly the agriculture industry with their major load being pumps for irrigation. In the west customers are nearly balanced between industrial and domestic, the load is mainly heating equipment, small motors, ventilation and cooling systems. This explains why the power factor of SEC's network is not optimal in the eastern side of the system as it is extremely loaded with reactive power. With the company importing around 70% of its power from its neighboring countries, power factor problems should be always properly dealt with to ensure that what we have is utilized efficiently while trying to breach the gap on the amount that is being bought from Mozambique and South Africa.

Moreover, not only the system losses are increased when the system is operating at a low power factor, the voltage stability is also disturbed causing a drop in quality of supply as some electronic equipment are sensitive to voltage changes. Typically, the costs involved in installing power factor correction are paid back within a year or two and after that the savings will actually reduce the operational costs. On the other hand over-correction should be always avoided. This can be done through a thorough study and collection of enough relevant data about the network's power factor before finalizing on a suitable method of correction and deciding on the component values.