International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization on TPE (IOTPE)

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

September 2011	Issue 8	Volume 3	Number 3	Pages 71-75

OVERVIEW OF ENERGY SYSTEM AND MAJOR POWER QUALITY PROBLEMS IN NORTH CYPRUS

O.C. Ozerdem   S. Biricik

Department of Electrical and Electronic Engineering, Near East University, Lefkosa, Northern Cyprus
oozerdem@neu.edu.tr, samet@biricikelektrik.com

Abstract- Cyprus is the third biggest island of Mediterranean region after Sicilia and Sardinia. It has a total surface area of 9,250 km^2 and north of island is 3.355 km^2. Energy production, transmission and distribution in north side of the island are under responsibility of Cyprus Turkish Electricity Authority (KIB-TEK). Total generation capacity of KIB-TEK is 346,3 MW, and it is entirely dependent on oil and petroleum products. TRNC has no reactive power tariff. Therefore, industrial or commercial consumers do not have to install reactive power compensator or harmonic filter. This situation deeply affects the quality of power. This paper presents brief but comprehensive introduction on electrical energy status and major power quality problems of northern part of island.

Keywords: North Cyprus, Power Quality, Energy System.

I. INTRODUCTION

Active and reactive power flows in power systems must be carefully controlled. Transmission systems are obliged to secure the transmission network to the defined voltage and stability criteria, which is predominantly achieved through circuit arrangements or transformers [1]. Reactive power flows can give rise to substantial voltage changes across the transmission system, which means that the balance between the sources of generation and points of demand must be controlled locally within zones distribution systems. According to Strategies for development and diffusion of Energy Efficient Distribution Transformers (SEEDT), the losses caused by harmonics and reactive power in European Union (EU) distribution transformers are estimated at about 5000 GWh/year. However, total losses of distribution transformers in EU (European Union) reach to 38000 GWh/year [2]. North Cyprus has no stringent rules and regulations enforcing energy system for reactive power compensation and harmonic filtering. Therefore, industrial or commercial consumers have not to pay used reactive power, also industrial consumers injecting harmonic currents to utility. However government cannot obtain reactive tariff because already used mechanical counters are measuring and recording watt-hour.

The paper has summarized the series of research works on power quality and power system. This paper has two main contributions. First, it has proposed to introduce Northern Cyprus power system and future investments. Second contribution is the major power quality problem which is the reactive power.

II. ECONOMY IN THE NORTH OF ISLAND

It has to be mentioned that there are two parts in the island. A separation of the two ethnic communities inhabiting the island began following the outbreak of communal strife in 1963. This separation was further solidified after in July 1974 that attempt gave the Turkish Cypriots de facto control in the north. Greek Cypriots control only the southern part of the island since 1974. On 15 November 1983 Turkish Cypriots declared independence and the formation of a "Turkish Republic of Northern Cyprus" (TRNC). The economy of Northern Cyprus is dominated by the services sector which includes the public sector, trade, tourism, agriculture and education. It is heavily dependent on Turkish economic support because of its status and the unjust embargos. Most exports and imports have to take place via Turkey. Despite the constraints imposed by the lack of international recognition, the economy of TRNC turned in an impressive performance in the last few years. The nominal capital gross domestic product (GDP) growth rates of the economy in 2001-2005 were 5.4%, 6.9%, 11.4%, 15.4% and 10.6%, respectively.

III. OVERVIEW OF NORTH CYPRUS POWER SYSTEM

At present, transmission lines in TRNC can be categorized into three voltage level. They are 132 kV and 66 kV. The Distribution System consists of medium voltage lines of 11-22 kV and low voltage lines of 415/240V. At the end of 2008 total length of transmission lines were 554 km. The Total installed capacity started in north of island with 60 MW in March 1995, 120 MW in march 1996 and 327.5 MW in 2008. The power generation of 2008 was 1.22 GWh, at a 15.6% increase of the previous years. After 2004 construction sector developed much faster. It is estimated that development of construction sector will keep growing in the next 20 years. By 2020 total consumption is expected to exceed 1GW.

Table 1. The KIB-TEK power per station [3]

Power Stations	Power	Units
Teknecik	2x60 MW Steam Turbine	120 MW
Teknecik	1x20 MW Gas Turbine	20 MW
Teknecik	1x10 MW Gas Turbine	10 MW
Dikmen	1x20MW Gas Turbine	20 MW
Kalecik	4x17,5 MW Diesel Generator	70 MW
Teknecik	6x17,5 MW Diesel Generator	105 MW
Güzelyurt	1.3 MWp Photovoltaic Plant	1,3 MW
Total Installed Capacity		**346,3 MW**

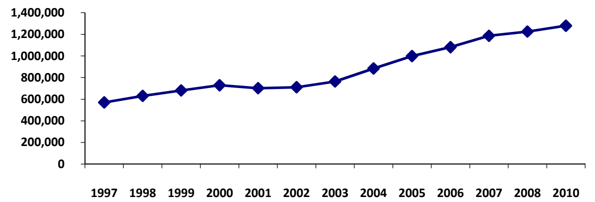

Figure 1. Electricity generation

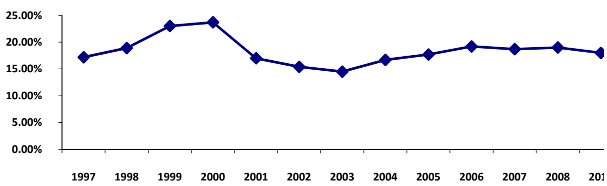

Figure 2. Power system losses

IV. FUTURE INVESTMENTS

A. Photovoltaic (PV) Plant

1.3 MWp pilot photovoltaic plant project represents the first PV installation in Cyprus and the biggest in the whole Mediterranean area.

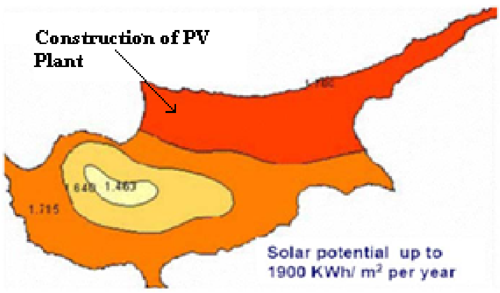

Figure 3. Solar radiation map of Cyprus

The project was financed by European Union commission and it costs close to 3.7 million € uses 6,192 solar panels each 206 watt on 20 km^2 of land Construction of PV plant was start January 2010 and it has been put into operation on May 2011. The solar system will be utilized by KIB-TEK. Project is planning to produce 2 GWh of clean energy annually. Figure 3 gives the solar radiation of the island and the PV generation plant seen in Figure 4.

B. Wind Farm

Cyprus is suitable for electricity generation from wind. Northern part of Cyprus has a wind speed of 5-7 m/s. Estimate wind potential is between 30 and 60 MW. Wind speed map of the south of the island was produced in [4]. But North Cyprus wind map preparation studies still continue.

Figure 4. View of solar plant in Serhatkoy, Cyprus

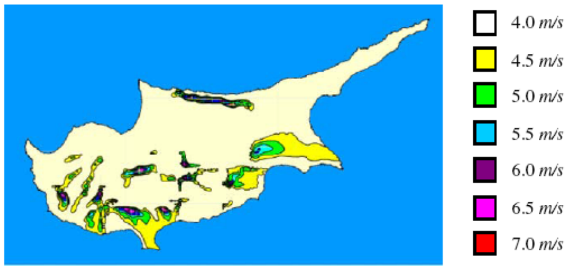

Figure 5. Wind map of Cyprus

The obtained results showed that, several areas were identified as having annual mean wind speeds greater than 5 m/s at 10m height. The ref. [4] has been collecting wind data continuously since the year 2000 and measurements taken at one location called Sadrazamkoy showed some potential for a wind turbine installation. Three other potential locations have been under investigation. Within a short time for the production of electricity from wind energy is expected to open international tender by KIB-TEK. Figure 5 presents the wind map of Cyprus.

C. HVDC Interconnection between Turkey and North Cyprus

HVDC used for electricity transmission before HVAC but it was not as popular in use as HVAC due to limitations of power electronic. In recent years HVDC begin to be more suitable for electricity transmission than HVAC due to many reasons.

In North Cyprus power grid plan, the HVDC technology will play a very important role. It will be used to interconnection between Turkey and Island. At present 300 MW HVDC project in the planning stage. The rated power of the project will be 300 MW, respectively. It will cost 150 million €. The project includes two converter substations. One of them will locate in Silifke, Turkey and other will be in Teknecik, N. Cyprus. The length of the transmission line will be 70 km and it will be built in the next 10-15 years. Figure 6 shows the map of proposed high-voltage direct-current (HVDC) project that is under evaluation between Turkey and North Cyprus.

V. MAJOR POWER QUALITY PROBLEMS

A. Uncompensated Transmission Lines Effect to Losses

In a typical power system, network losses account for 5 to 10% of the total generation in the power system. Although electricity losses in power system in 2008 were nearly 19% of the total energy injected as given in Figure 2. Power losses is one of the serious problems in the transmission and distribution systems in north of island, where the power systems have not been optimized and often uncompensated in terms of reactive power.

Figure 6. The proposed interconnection project between Turkey and North Cyprus

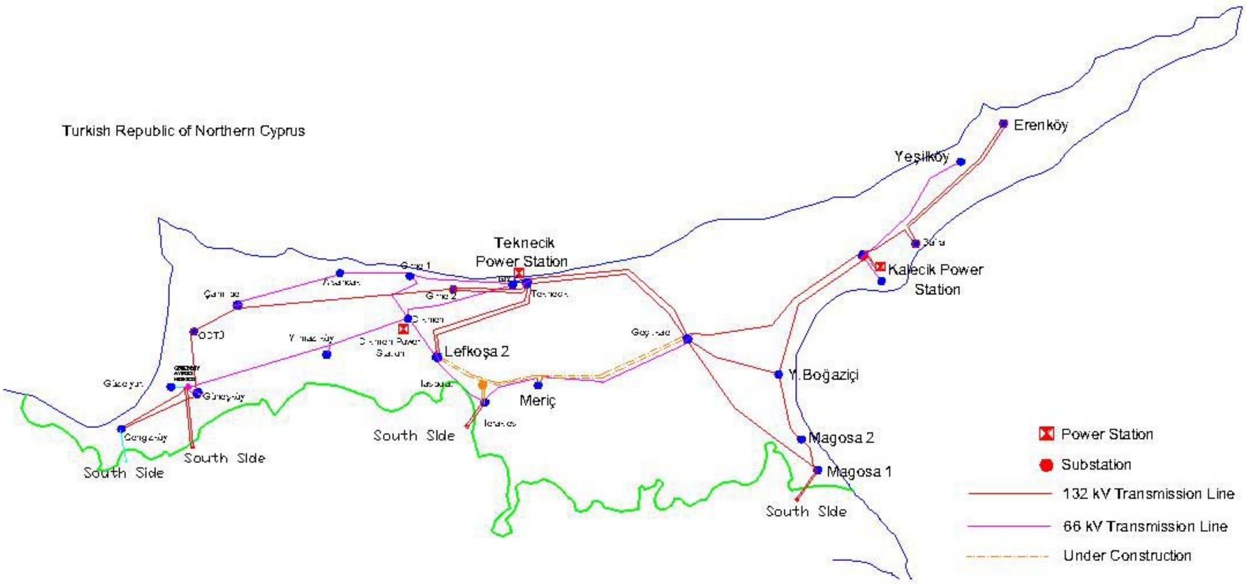

Figure 7. North Cyprus electric network structure with high voltage transmission lines

Table 2. Power analysis results of some industrial consumers

Plant Type	S (kVA)	P (kW)	Q (kVAr)	U_{L-N} (Volt)	THD_v (%)	THD_i (%)	Pf
Bozkaya Mine Co.	325	200	260	233	6	35	0,56
Perissia Hotel	355	200	256	225	9	36	0,68
Koop Milk	709	554	443	228	25	67	0,78
Dr.B.N. Hospital	475	462	110	232	3	27	0,87
Okman Ltd	184	116	143	225	4	35	0,63
Astro Market	77	58	51	222	2	17	0,75

The cost of transmission losses for KIB-TEK is not calculated or estimated scientifically until now. Power system losses can be reduced by means of reactive power compensation as shown in many papers in the literature. It has also been widely known that the maximum power transfer of the transmission system can be increased by shunt reactive power compensation, typically by capacitor banks placed at the end of the transmission lines or to the load terminals

B. Low Voltage and Pure Power Factor Problems

One of the main problems of the system is very low voltages at the load sides of the lines and poor power factor value as seen in Table 2. The low voltage problems are solved until now to build additional distribution lines with the large investments. One of the main solutions is to add the reactive support at the load side. For the moment there is no reactive power support used in the consumer side. As a result of excessive voltage fluctuations are caused great harm to consumers and cause of pure power factor the distribution lines are not able to transmit the required active power. The reactive power support would help to minimize the total system losses, increase the active power transmission capabilities and at the same time solve the problem of voltages and power factor.

C. The Effect to Poor Power Quality of Consumers

In power systems, active power should be supported by reactive power for power system requirements. Reactive power is due to loaded generators and transmission lines. The technique of reactive power generation at load side is called Compensation. Unfortunately, KIB-TEK did not set rules or regulations for compensation. As a result, voltage drop, harmonics, over voltage, noises and losses often occur. This section represents analysis of power quality in terms of reactive power problems in system.

The Table 2 recorded in some industrial and commercial place to show power quality situation in consumer side. As seen in Table 2, low voltage capacitors must be installed to individual lines or consumers motors to reduce system losses and improve the power factor and capacity. In addition, they provide other advantages for the consumer, such as reduction in kVA demand. In addition to that the shunt capacitor connection to utilize equipment and switched on in accordance with the load, reduce the voltage drop in the distribution system and thus help in obtaining better voltage regulation.

Lack of regulation for compensation in the country does not force the industrial consumers to install shunt capacitors to their power system. Therefore, energy losses occur in the system between consumers and power stations. In Bozkaya mine companies reactive power measurements were mentioned in Table 2.

VI. CONCLUSIONS

This study investigates the Electrical Power system of the TRNC. The power demand of the Country is increasing regularly and as the generation is done by petroleum products cost is high. The cost is directly effecting the production at the country. There are lack of legislations in the Electrical Energy area like the Reactive Power compensation and Renewable energy generation and connection to the main grid. The paper has photographed the current situation of the TRNC both from the generation and the customer side. The solution of the energy problem of TRNC is possible through some measures like the legislations should be solved immediately. There is a need of building base power station or as a better and long term solution a Subsea cable connection from mainland Turkey should be established. The high voltage lines and the switching power stations investments should be completed immediately. The Electricity Authority management should be encouraged to take decisions more freely. Government should have less interference on the BOD decisions. Renewable energy generation should be encouraged after the legislative measures that will be put forward.

ACKNOWLEDGMENT

The authors gratefully acknowledge to KIB-TEK for providing statistical data.

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BIOGRAPHIES

Ozgur Cemal Ozerdem was born in Ankara, Turkey, on November 11, 1967. He received the B.Sc. and M.Sc. degrees in Electrical and Electronic Engineering from the Eastern Mediterranean University, G. Magusa, TRNC, in 1992 and 1994, respectively and the Ph.D. degree from the Near East University, Nicosia, Cyprus, in 2005. He is currently with the Department of Electrical and Electronics Engineering, Near East University as an Associate Professor and chairman of the department. His field of interest is in power engineering. He is a member of IEEE for 15 years.

Samet Biricik was born in Nicosia, Cyprus, on June 15, 1984. He received the B.Sc. and M.Sc. degrees in Electrical and Electronic Engineering in 2006 and 2009, respectively, from the Near East University, Nicosia, North Cyprus, where he is currently working toward the Ph.D. degree. His teaching activities and research interests include power quality, active power filters, electrical machine design, and power electronics. In 2010, he and his supervisor O.C. Ozerdem won the Best Paper Award from the IEEE sported 9th International Conference on Environment and Electrical Engineering in Check. He was a founder member of the Energy Professionals Association (EPA) and a member of the Cyprus Turkish Chamber of Electrical Engineers. He is also managing director of Biricik Electrical Engineering Ltd. He is working on the design and manufacturing of reactive power compensators, voltage regulators, asynchronous motor starters and transformers. Between 2006 and 2011, he has managed and designed more than 250 industrial and commercial electrical projects.