REDUCTION OF INTERRUPTION DURATION IN ALEXANDRIA DISTRIBUTION NETWORK

Milad S. Deif Nazineh G. Eassa
Alexandria Electricity Company
722, Horia street, Victoria, Alexandria (Egypt)
Tel: 5878820 - Fax: 5871284 -E-mail: aedcc@alexnet.com.eg

ABSTRACT

Gaining control over large-scale failures that occur on the network is a key of quality policy of Alexandria Electricity Company. A plan for rehabilitation of distribution system was carried out with an objective of providing efficient and reliable service. One goal of the plan was the replacement of the paper insulated lead covered underground medium voltage cables with cross-linked polyethylene cables. A fault database was created and system outages were analyzed. The results showed a considerable improvement in the number of interruptions and outage duration.

INTRODUCTION

Alexandria Electricity Company (AEC) services the great Alexandria area. Alexandria is located on the Mediterranean Sea coast, with population of four million.

More than a million tourists visit this area during summer season. Industrial development is taking place along the southern edge of the city.

Twenty-two substations transform the 220 kV transmission, 66 kV sub-transmission supply voltage to the distribution voltage. Distribution voltage is 11 kV with some 20 kV at the west. Utilization voltage is 380/220 volt, three phases, 50 Hz.

Many components of the distribution system were deteriorated either on the medium or the low-voltage network. As a result, the network suffered many faults that resulted in lengthy and costly outages.

This situation necessitated a change. A major rehabilitation plan was carried out to upgrade the system in order to provide efficient and reliable service. The plan included replacement, upgrading and new design of the medium and low voltage networks.

Proper tools were provided, maintenance personnel were trained on the correct procedure for maintaining different network components.

The methodology of locating faults was improved by installing fault indicators on the medium voltage cables. The maneuver time to restore the interrupted circuits is greatly decreased as a result of the implementation of the control centers project.

To determine the effect of system improvement on the interruption frequency and outage duration, AEC has established a system for compiling the statistics for medium and low voltage network incidents. An outage program was developed which provides fault database, including number, type and location of faults as well as the time of restoration.

The presented analyses are carried out for all the incidents reported on the distribution network over the period from 1990 to 1998.

MEDIUM VOLTAGE SYSTEM

The medium voltage system comprises the distribution system components from the substation 11 kV bus through the distribution transformers. It includes cables, distribution points and transformer points. The nominal medium tension operating voltage is 11kV.

Mainly underground cables are used in the network except for some areas located in the outskirts where overhead transmission lines are used. The new distribution networks recently constructed in the west of Alexandria where feeders extend for long distance operate at 20 kV

The 11kV underground cables were all three core paper insulated lead covered cables (PILC), ranging in size from 16 mm^2 to 240 mm^2 aluminum.

A long-term plan was carried out for replacing all medium voltage (PILC) feeders and circuit sections by aluminum cross-linked polyethylene (XLPE) shielded cables. The first phase of the plan covered only the replacement of the old, undersize, thermally deteriorated cables, and was completed in 1990. Phase 2 includes the replacement of all the remaining PILC in the network; it also takes into consideration the upgrading of the existing MV network as a result of the development in the utilization of electrical power, and is planned to be completed by 2010. The criteria for replacement determined the proper cable sizes which insures adequate cable ampacity for contingency conditions, and suitable for short circuit level.

The statistics for MV cables incidents monitored over a period of 8 years from 1990 to 1998 are shown in figure (1) through (3).

Figure (1), shows the number of faults per 100 Km per year for both the (PILC) and (XLPE) medium voltage underground cables in the network, it also indicates the overall rate of faults of MV cables. The figure shows that the average fault rate of MV cables has decreased from 70 faults / 100 Km in 1990 to 13 faults / 100 Km in 1998.

The average outage time per customer per year caused by medium voltage cables incidents was reduced from one hour to 36 minutes as shown in figure (2). Figure (3) shows the corresponding average energy not supplied as a result of medium voltage cables failures.

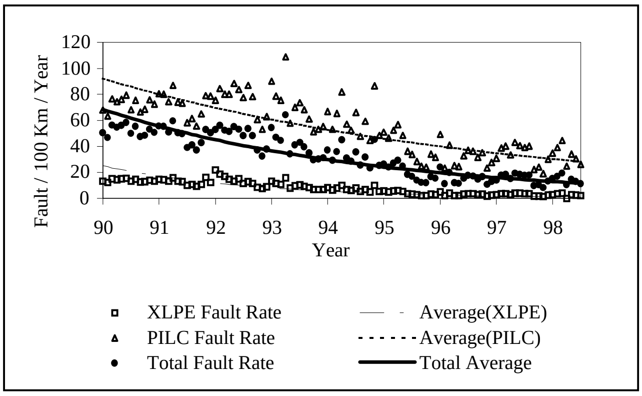

Figure 1. Medium voltage cables outage rate.

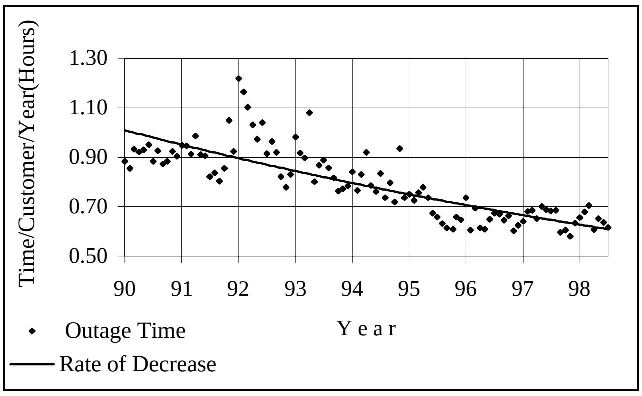

Figure 2. Outage time due to MV cables failures.

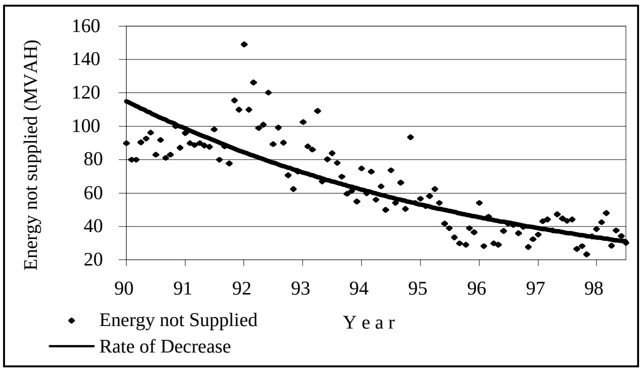

Figure 3. Total energy not supplied due to MV cables failures.

DISTRIBUTION TRANSFORMERS

Some of the distribution transformers (D.Ts) were dangerously overloaded and suffered extreme load unbalance. The work plan included field surveys to determine the circuit length, the number of consumers connected, and the type of load for each transformer. Maps were prepared for the routes of the circuits fed from the distribution transformers. The projected ultimate load was used to analyze circuit loading. Circuits were rearranged and loads were shifted, and new distribution transformers were added to meet the projected 15 years loads.

The causes for distribution transformers outages are classified into 3 categories: routine maintenance, forced maintenance and "other" a category which groups all the outages that can not be placed in one of the other causes.

Examination of the statistics for D.Ts outages showed that the routine maintenance was the most important cause for increasing the D.T outage time. Figure (4) indicates the average outage time caused by the 3 categories.

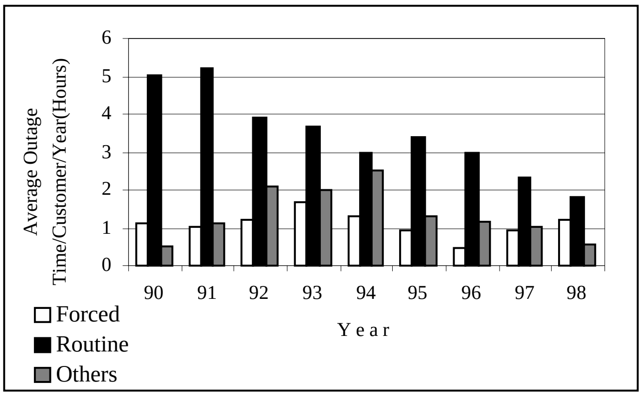

Figure 4. Comparison between the outage time of D.Ts due to the three causes of outages.

Improving the methodology for maintaining the transformer points was an important aspect for reducing the power cut time. A standard procedure for maintenance was developed and followed. Also, proper tools and instruments were provided.

This significant effort has lead to positive results: The average outage duration per customer per year due to D.Ts outages was reduced by 3.8 hours in 8 years, as indicated in Figure (5). Figure (6), shows the reduction in the energy not supplied due to D.Ts outages.

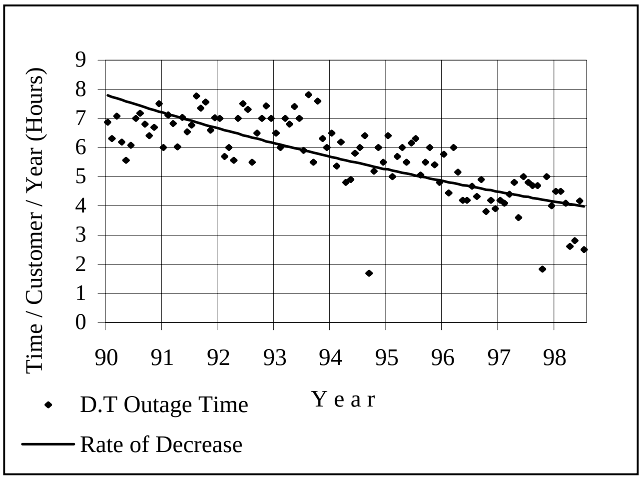

Figure 5. Outage time due to D.Ts failures.

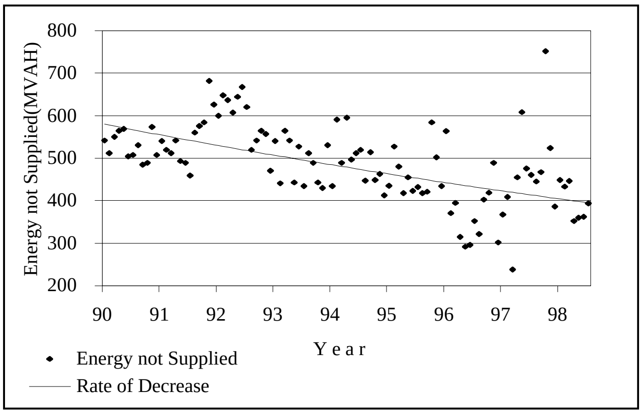

Figure 6. Energy not supplied due to D.Ts outages.

LOW VOLTTAGE NETWORK

The overhead LV system with its deteriorated condition and lack of proper maintenance suffered many faults that resulted in system outages. The system required continual maintenance just to keep it in service.

Rehabilitation of the low-tension overhead network started in 1978 and completed by the end of 1997. The rehabilitation program resulted in complete renovation of the overhead network in Alexandria. Computer aided design was introduced by training AEDC engineers to design the new low-tension overhead networks on the computer. Computer programs were prepared locally for designing the networks, taking into consideration future expansion, load growth, voltage drop, minimum loss and optimum cable size. The new low voltage overhead cables are cross-linked polyethylene insulated quadraplex, consisting of three-phase conductors supported by the full size insulated neutral conductor.

As a result, a pronounced drop in the rate of outages in the low voltage networks took place as shown in figure (7).

Underground rehabilitation included a new improved method for making splices and connections enclosed in a fiberglass enclosure. Proper electrical connections and correct tools were purchased to install the connections in compliance with the manufacturer's instructions. Figure (8), shows the improvement in the rate of outage for low voltage underground network.

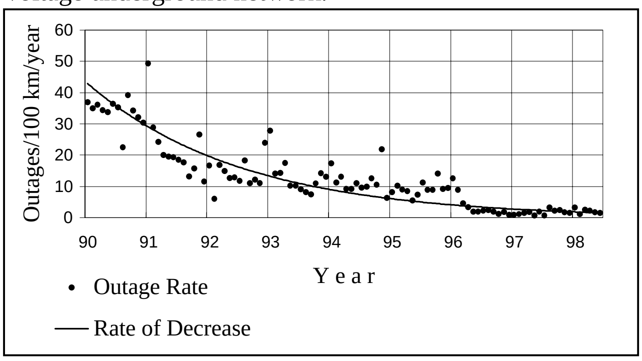

Figure7. Low voltage overhead network outages

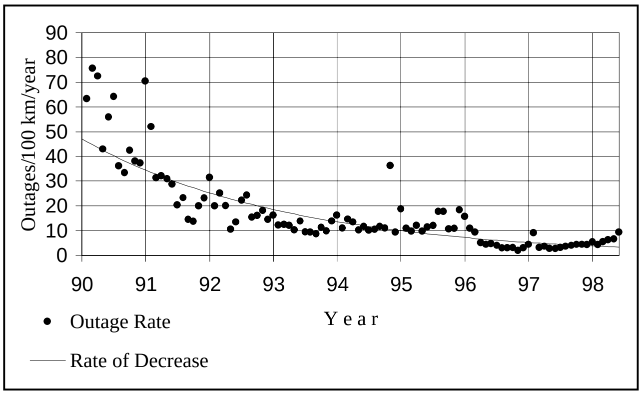

Figure 8. Low voltage underground outages.

FAULT INDICATORS

Fault indicators (F.Is) have been installed to detect phase to ground faults on medium voltage under ground cables. The fault indicators are required so that operation personnel can quickly detect faulted areas and minimize the maneuver time to restore the interrupted circuit.

F.Is are installed on outgoing circuits in all transformer points. They are installed so that it can be observed from outside the transformer rooms. A total of 6500 F.Is have been installed by end of 1997.

Having the F.Is guide the troubleshooter to the faulted section of cable and allow him to quickly isolate the fault reduced the outage time.

Figure (9) gives the outage time recorded for 10 medium voltage circuits in the west sector of Alexandria before and after installing F.Is. Figure (9) shows that the average outage duration caused by cable-related faults was reduced from 26 minutes to 11 minutes.

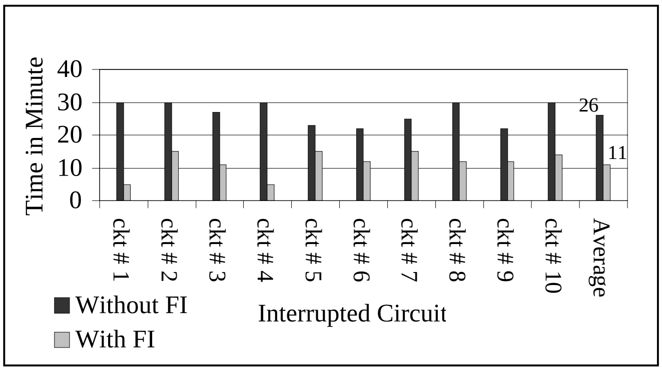

Figure.9 Average outage time recorded for 10 circuits in Alexandria before and after installing F.Is.

CONTROL CENTERS

A complete control for the whole medium voltage network in the city shall be provided through the installation and commissioning of control centers. The project started in 1995,and is planed to be finished by mid 1999.

Three control centers (East, Center & West) have been installed and connected to a supervisory control center through information channels.

Motor-operated load-break switches were provided in some selected transformer points. Remote terminal units (RTUs) were installed in substations, distribution points and the selected transformer points, to provide supervisory control and data acquisition (SCADA) capability.

Figure (10) shows the connections between the four controls centers, and indicates the number of substations, distribution points, and transformer points monitored and controlled by each center.

Each control center is designed to carry out the following functions:

- Remote operation of circuit breakers in substations and distribution points.
- Monitoring of loads, recording for events, detection of faults through relays operation.
- Discovering the medium voltage cables' faults in the transformer points connected to the control centers,
- Carrying out application analysis using advanced software programs.

This new automated system allows AEC the ability to operate the system to minimize the time of customer interruptions when switching for planned outages and when restoring regular service after system failures.

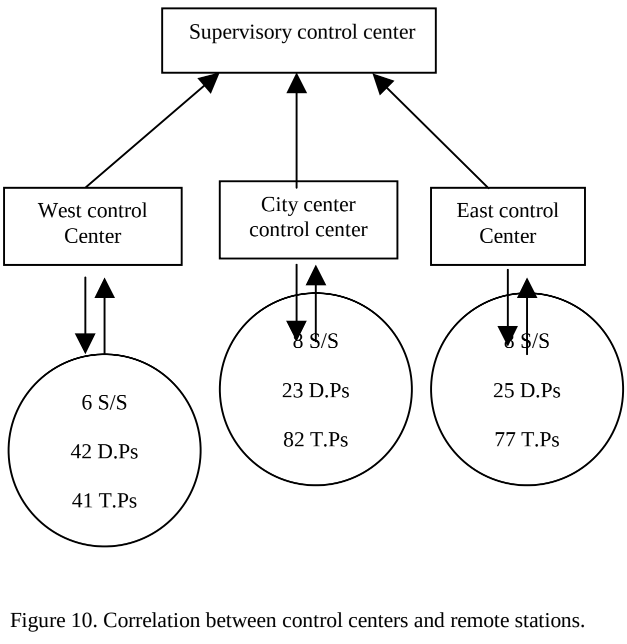

Figure 10. Correlation between control centers and remote stations.

RELIABILITY LEVELS

Compiling the statistics for AEC network incidents, made it possible to draw up the statistics at the global level, taking into account all breaks in supply for the different components of the distribution network.

Typical values of Alexandria electric network recorded reliability data over a range of eight years are shown in figure (11) & (12).

This data reports two important parameters:

- Supply interruptions per customer per year.
- Average interruptions duration experienced in a year by a customer.

Figure (11) & (12) show that the significant effort in improving the system performance has lead to positive results. The quality indices such as the number and size of interruptions have improved during these last few years.

It can be deduced that the average number of interruptions per customer per year was decreased from more than 5 to nearly 3 interruptions. The average power cut time, which is an indicator of the state of the network and its ability to react more or less quickly to the events generating the incident, has reduced from 8.6 to 4.6 hours.

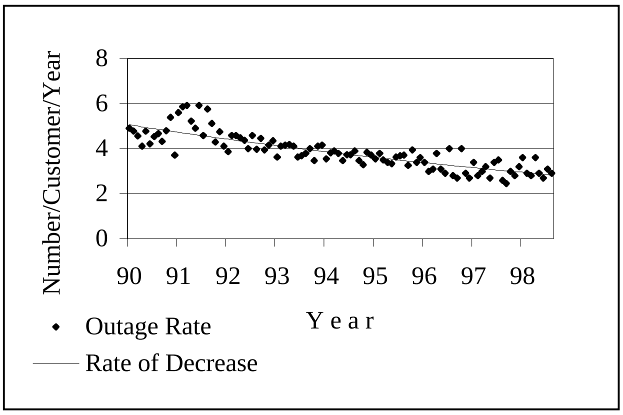

Figure 11. Number of supply interruptions due to distribution system outages.

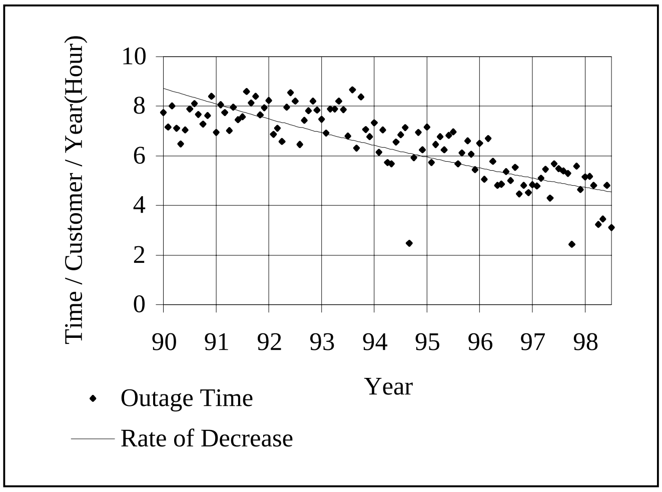

Figure 12. Evolution of interruptions duration due to distribution system outages.

CONCLUSION

Alexandria Electricity Company has carried out an extensive effort for improving the supply reliability. The results of the major upgrading and rehabilitation of the medium and low voltage network as well as the improvement in the methodology of maintenance and locating faults that took place in Alexandria were very significant.

The medium voltage cables fault rate was deceased from 70 faults / 100 Km in 1990 to 13 faults/100Km in 1998.

The outage duration / customer / year due to D.Ts outage was reduced by 3.8 hours in 8 years.

The annual low voltage overhead network fault rate was reduced to 2 faults / 100 km.

The overall outage time per customer per year was 8.6 hours in 1990 and became 4.6 hours in 1998.

The average number of interruptions per customer per year was reduced from more than 5 to nearly 3.

ACKNOWLEDGMENT

The authors are grateful to Mr. Ahmed El Mofti, chairman of AEC, for his valuable support in all the stages of this research.

REFERENCES

[1] E. W. Gunther and H. Mehta, “A Survey of Distribution System Power Quality-Preliminary Results”, IEEE Transactions on Power Delivery, Vol. 10, No. 1,1995,pp.322-329.
[2] B. M. Hughes, J. S. Chan and D. O. Koval, “Distribution Customer Power Quality Experience”, IEEE Transactions on Industry Applications, Vol. 29, No. 6,1993,pp.1204-1211.
[3] H. Joss and M. Dussart, “Cost Aspect of Power Quality in a Distribution Network”, PQA 92, Atlanta Conference, pp. A-4: 1- A-4: 11.
[4] D.S.Dorr, "Point of utilization power quality study results", IEEE Transactions on Industry Applications, vol. 31, No. 4,1995,pp.658-666.